Catawba-Wateree Relicensing

Detailed Water Quality Study Plan

(Water Quality 01 and 02)

INTRODUCTION

Duke Power (Duke) filed the First Stage Consultation Document (2003) with the Federal Energy Regulatory Commission (FERC) in February, 2003. After filing the document, Duke began receiving numerous study requests from stakeholder groups, including state and federal agencies. Concurrently, Duke held meetings throughout the basin to detail the relicensing process and encourage involvement by stakeholder groups. As a result of these meetings, a collaborative process (enhanced traditional approach) was established for the Catawba-Wateree Project. This process features four regional groups (AG's) and two state-level stakeholder teams (SRT's) designed to provide continuous collaboration throughout the relicensing process.

The study requests received from stakeholders were condensed to 31 studies, in six categories. (See http://www.catawbahydrolicensing.com/documents/studyplans.html for study plans.) The six study categories were developed into resource committees (RC's). The RC's are core groups of technical experts and resource agency representatives with regulatory authority in a resource specialty area. This includes Duke, Devine Tarbell and Associates (DTA), resource agency representatives, and other external consultants. The RC's develop the study plans, perform the studies, and document the results. They will also serve as ongoing technical support to the Advisory Groups and State Resource Teams to present and interpret study results.

Water quality concerns identified by stakeholders were categorized into reservoir and riverine-bypass issues. Since Duke, state water quality agencies, and other agencies have collected water quality data on the Catawba River for many years (see Duke Power, 2003, for a water quality bibliography), the two study plans were first proposed to address water quality issues and Duke's operation by using the extensive existing database, coupled with reservoir and riverine models. However, after comments provided by the Water Quality RC and consultation with state water quality agencies, these initial study plans were revised to reflect the overall approach to address the water quality of the Catawba River/Reservoirs. Consequently, the revised study plans evolved into scoping documents.

After site visits and detailed reviews of existing data with state and federal agencies, specific objectives and subsequent data requirements were identified for each hydro project. Especially relevant was the influence of flow on water quality. This document provides the details, project by project, for addressing the objectives identified for each project.

WATER QUALITY - OBJECTIVES

1. Identify the current status of water quality for each project:
    a. Reservoirs
        i. Characterize the distribution and concentrations of major chemical constituents within the reservoirs under a variety of project operations.
        ii. Identify the influence of project operations on reservoir stratification
    b. Tailrace and Riverine Sections
        i. Characterize the water quality of the hydro release
        ii. Characterize the downstream temperature and dissolved oxygen concentrations (and transport of other water quality constituents) under a variety of Project operations (flow)
        iii. Establish the extent of project influence on the downstream water quality
        iv. Determine the mixing characteristics and identify the current status of hydro operations on tailwater and downstream water quality (lateral and dynamics of longitudinal variability)
    c. Bypassed Reaches
        i. Characterize the existing water quality in applicable river bypassed reaches
2. Identify and evaluate the impact of feasible alternative operating, engineering, or policy scenarios on water quality[1]
    a. Reservoirs
        i. Identify the influence of reservoir inflow and meteorological extremes on reservoir water quality.
        ii. Evaluate the impact of reservoir water level fluctuation and outflow patterns on reservoir water quality
        iii. Establish the extent of project influence on reservoir water quality
    b. Tailrace and Riverine Sections
        i. Evaluate the hydro operations and engineering alternatives to improve downstream water quality
        ii. Establish the extent of project influence on the downstream water quality
        iii. Provide recommendations for long-term, continuous monitoring of downstream water quality
    c. Bypassed Reaches
        i. Evaluate altered flow patterns on reservoir or tailrace water quality

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[1] Many conditions would be beyond the capabilities and experimental opportunities required for empirical data collection and analysis.

WATER QUALITY – APPLICATION AND ANALYSIS OF DATA

The water quality objectives are divided into two primary areas, namely (1) the collection of data and subsequent empirical data analysis of new and existing data, and, (2) the development of appropriate computer models to evaluate water quality conditions in the reservoirs and riverine reaches. Once calibrated, the models will be used to evaluate water quality under various scenarios derived from other studies and/or stakeholder requests from the AG's or SRT's.

Since water quality typically is a function of water availability and flow, every attempt has been made to coordinate water quality data collection and data analysis with other studies addressing flow issues.

Empirical Data Analysis

Even though Duke, state water quality agencies, and the USGS have collected water quality data from the various reservoirs and river sections since 1959, past data were collected for various purposes unique to the organization. The proposed sampling program for 2004 provides a consistent regime to specifically address issues required for relicensing, and subsequent 401 certification.

Even though historical data were collected for a variety of purposes, the past data will be used to the extent possible to address the relicensing objectives. This data, coupled with the data collected in 2004 will be used to evaluate the existing water quality of the Catawba system.

Concentrations of various chemical constituents will be evaluated with respect to water quality standards or criteria. In addition, reservoir data analysis will focus on lake stratification, nutrient budgets, algal response to nutrients, dissolved oxygen distributions, and metal concentrations and their relationship to the hydro operations. Tailwater data analysis will focus on the influence of reservoir conditions and flow (hydro operations) on temperature, dissolved oxygen, nutrient, and metal releases from the hydro.

The operational characteristics (flow regimes and aeration capability) of each riverine hydro will be evaluated with respect to downstream dissolved oxygen concentrations. Lateral and longitudinal mixing characteristics will be evaluated using temperature, dissolved oxygen, and conductivity as indicators.

Although empirical data analysis is very useful to elucidate relationships between the various parameters influencing water quality, the application of computer models, in conjunction with empirical data analysis provides a very robust means to evaluate water quality. Unlike most empirical analysis where experimental conditions could not be applied, computer models permit the evaluation of single variable (or combination of variables) on individual water quality parameters. Empirical data analysis provides a 'reality' check on computer modeling, whereas computer modeling permits 'experimental testing' of water quality functions.

Computer Modeling

CE-QUAL-W2 Reservoir Model

The application of the two dimensional 'W2' reservoir model requires the following input data:

- Reservoir bathymetry[2]
- Tributary inflow (flow and water quality)
- Meteorological data (heat exchange variables)
- Reservoir outflow (flow)

The first step in the calibration of the 'W2' model requires the bathymetry data, watershed inflows and outflows compared to measured lake levels (hydrodynamic calibration). The second calibration step requires the same data, but, with the input of the meteorological data during the same time frame, the predicted temperature profiles are calibrated against the measured temperature profiles (thermal calibration). The third step incorporates nutrient addition from the watershed[3] to the reservoir; modeled outputs of nutrient levels, algal mass, and, most importantly, dissolved oxygen profiles are compared to measured values. Calibration of each step involves adjusting the physical, chemical, or biological constants and/or rate coefficients within the model. The calibration period(s) ideally would represent different hydrological years, but realistically are chosen based upon available data.

RMS River Model

The application of the one dimensional RMS river model requires the following input data:

- River channel cross-sectional geometry[4]
- Hydro releases (flow and water quality)
- Tributary inflow (flow and water quality)
- Meteorological data (heat exchange variables)

The first step in the calibration of the RMS model requires the channel cross-sectional survey data, hydro releases, and watershed inflows. These inputs are calibrated against a

[2] The bathymetry includes the elevation vs. volume function for each modeled segment, as well as the elevations of the water intakes and discharges considered significant

[3] The water quality data from the watershed should include all tributaries necessary to perform the water balance as well as wastewater discharges considered significant.

[4] The cross-sectional geometry consists of the elevation vs depth; the cross-section of the river is measured at known distances, cross-sections are located primarily at the hydrological controls and to establish pool depths

downstream control[5], measured river discharge points, and/or river stage measurements. (hydrodynamic calibration). The second calibration step requires the same data, but, with the input of the meteorological data during the same time frame, the predicted river temperatures are calibrated against the measured temperature data (thermal calibration). The third step incorporates the oxygen demanding substances[6] from the hydro release water and the watershed into the model: the modeled outputs of dissolved oxygen concentrations are compared to measured values. Calibration of each step involves adjusting the physical, chemical, or biological constants and/or rate coefficients within the model. Unlike the extensive calibration period required for the 'W2' model, the RMS calibration period is conducted under various operational scenarios at the hydro station. The typical calibration period would be conducted at the peak of the summer reservoir stratification, when the dissolved oxygen concentrations in the hydro releases were lowest, and the water quantity available for hydroelectric production was minimal.

Summary of Specific Hydro Projects

Even though many of the water quality issues are similar between the various hydro projects, each project is unique with respect to reservoir characteristics, tailwater and downstream characteristics, by-passed reaches, and hydro engineering and operations capability. In addition, data availability for each project must be considered to meet the water quality objectives. Table 1 presents a summary of data and computer model applications to address the various specific objectives.

[5] A downstream control may include the water level of a downstream reservoir, an instream weir, or other measure of water level stability

[6] Oxygen demanding substances include BOD, reduced nitrogenous substances,, and/or other reduced compounds (Fe, Mn, etc.)

Table 1. Application of Specific Data and Models to the Individual Hydro Projects on the Catawba River.

Generic Objectives			Hydro Project									
			Bridgewater	**Rhodhiss**	**Oxford**	**Lookout Shoals**	**Cowens Ford**	**Mt. Island**	**Wylie**	**Fishing Creek**	**Dearborn Cedar Creek**	**Wateree**
Empiracal Data Analysis	**Reservoirs**	*1.a.i (Characterization)*	**Duke and NCDWQ** Existing Data 2004 Data	**Duke, NCDWQ, USGS** Existing Data 2004 Data	**Duke, NCDWQ, USGS** Existing Data 2004 Data	**Duke and NCDWQ** Existing Data 2004 Data	**Duke, NCDWQ, and Meck Co.** Existing Data 2004 Data	**Duke, NCDWQ, USGS and Meck Co.** Existing Data 2004 Data	**Duke, NCDWQ, SCDHEC & Meck Co.** Existing Data 2004 Data	**Duke and SCDHEC** Existing Data 2004 Data	**Duke and SCDHEC** Existing Data 2004 Data	**Duke and SCDHEC** Existing Data 2004 Data
		1.a.ii (Stratification)	**Duke** Forebay Profile Temp Loggers 1997-2001	**Duke** Forebay Profile Temp Loggers 2004	**Duke** Forebay Profile Temp Loggers 2004	**Duke** Forebay Profile Temp Loggers 2004	**Duke** McGuire NPDES Reports	**Duke** Forebay Profile Temp Loggers 2004	**Duke** Forebay Profile Temp Loggers 1999 - 2004	**Duke** Forebay Profile Temp Loggers 2004	**Duke** Forebay Profile Temp Loggers 2004	**Duke** Forebay Profile Temp Loggers 2004
	Tailwaters and Downstream	*1.b.i (Hydro Release)*	**Duke** Tailrace Monitor 1995 - 2004	**Duke** Tailrace Monitor 1995 - 2004	**Duke** Tailrace Monitor 1995 - 2004	**Duke** Tailrace Monitor 1995 - 2002 2004	**Duke** Tailrace Monitor 1996 - 2002 2004	**Duke** Tailrace Monitor 1996 - 2002 2004	**Duke** Tailrace Monitor 1995 - 2004	**Duke** Tailrace Monitor 1996 - 2002 2004	**Duke** Tailrace Monitor 1996 - 2002 2004	**Duke** Tailrace Monitor 1995 - 2004
		1.b.ii (Downstream Temp and DO)	**Duke** Downstream Hydro Test Hydrolab Deployments 1998, 2001	**Duke** Downstream Hydro Test Hydrolab Deployments 2004	**Duke** Downstream Hydro Test Hydrolab Deployments 2004	**Duke** Downstream Hydro Test Hydrolab Deployments 2004	**Duke** Survey 1998	**N/A** (Lake to Lake)	**Duke** Downstream Hydro Test Hydrolab Deployments 1997, 2002, 2003	**Duke** Downstream Hydro Test Hydrolab Deployments 1996	**Duke** Downstream Hydro Test Hydrolab Deployments 1996	**Duke** Downstream Hydro Test Hydrolab Deployments 1999, 2004
		1.b.iii (Extent of Project Operations)	**Duke** Level Logger Deployments 2001, 2004	**Duke** Level Logger Deployments 2004	**Duke** Level Logger Deployments 2004	**Duke** Level Logger Deployments 2004	**Duke** Level Logger Deployments 2004	**Duke** Level Logger Deployments 2004	**Duke** Level Logger Deployments 2001 -2004	**Duke** Level Logger Deployments 2004	**Duke** Level Logger Deployments 2004	**Duke** Level Logger Deployments 2004
		1.b.iv (Mixing Characterization)	**Duke** Downstream Hydro Test Hydrolab Deployments 1998, 2001	**Duke** Downstream Hydro Test Hydrolab Deployments 2000, 2004	**Duke** Downstream Hydro Test Hydrolab Deployments 2004	**Duke** Downstream Hydro Test Hydrolab Deployments 2004	**N/A**	**N/A**	**Duke** Downstream Hydro Test Hydrolab Deployments 1997, 2002, 2003	**Duke** Downstream Hydro Test Hydrolab Deployments 2000	**N/A**	**Duke** Downstream Hydro Test Hydrolab Deployments 1999, 2004
	Bypassed Reaches	*1.c.i (Characterize Existing Bypasses)*	**Duke** WQ Sampling Level Logger Deployment 2004	**N/A**	**N/A**	**N/A**	**N/A**	**Duke** Level Logger Deployment 2004	**N/A**	**N/A**	**Duke** WQ Sampling Level Logger Deployment 2004	**N/A**
Modeling	**Reservoirs**	*2.a.i (Inflow - Met Scenarios)*	**Duke** Calibrated CE-QUAL-W2 Model	**Duke** Calibrated CE-QUAL-W2 Model	**Duke** Calibrated CE-QUAL-W2 Model	**Duke** Calibrated CE-QUAL-W2 Model	**Duke** Calibrated CE-QUAL-W2 Model	**Duke** Calibrated CE-QUAL-W2 Model	**Duke** Calibrated CE-QUAL-W2 Model	**Duke** Calibrated CE-QUAL-W2 Model	**N/A**	**Duke** Calibrated CE-QUAL-W2 Model
		2.a.ii (Lake Level - Outflow Scenarios)	**Duke** Calibrated CE-QUAL-W2 Model	**Duke** Calibrated CE-QUAL-W2 Model	**Duke** Calibrated CE-QUAL-W2 Model	**Duke** Calibrated CE-QUAL-W2 Model	**Duke** Calibrated CE-QUAL-W2 Model	**Duke** Calibrated CE-QUAL-W2 Model	**Duke** Calibrated CE-QUAL-W2 Model	**Duke** Calibrated CE-QUAL-W2 Model	**N/A**	**Duke** Calibrated CE-QUAL-W2 Model
		2.a.iii (Extent of Project Influence)	**Duke** Calibrated CE-QUAL-W2 Model	**Duke** Calibrated CE-QUAL-W2 Model	**Duke** Calibrated CE-QUAL-W2 Model	**Duke** Calibrated CE-QUAL-W2 Model	**Duke** Calibrated CE-QUAL-W2 Model	**Duke** Calibrated CE-QUAL-W2 Model	**Duke** Calibrated CE-QUAL-W2 Model	**Duke** Calibrated CE-QUAL-W2 Model	**N/A**	**Duke** Calibrated CE-QUAL-W2 Model
	Tailwaters and Downstream	*2.b.i (Evaluate Options)*	**Duke** Calibrated RMS Model	**Duke** Calibrated CE-QUAL-W2 Model	**Duke** Calibrated CE-QUAL-W2 Model and RMS Model	**Duke** Calibrated CE-QUAL-W2 Model and RMS Model	**Duke** Calibrated CE-QUAL-W2 Model	**Duke** Calibrated CE-QUAL-W2 Model	**Duke** Calibrated RMS Model	**N/A**	**Duke** Calibrated CE-QUAL-W2 Model	**Duke** Calibrated RMS Model
		2.b.ii (Extent of Project Operations)	**Duke** Calibrated RMS Model	**Duke** Calibrated CE-QUAL-W2 Model	**Duke** Calibrated CE-QUAL-W2 Model and RMS Model	**Duke** Calibrated CE-QUAL-W2 Model and RMS Model	**Duke** Calibrated CE-QUAL-W2 Model	**Duke** Calibrated CE-QUAL-W2 Model	**Duke** Calibrated RMS Model	**N/A**	**Duke** Calibrated CE-QUAL-W2 Model	**Duke** Calibrated RMS Model
		2.b.iii (Long-term Monitoring Recommendations)	**Duke** Calibrated RMS Model + Resullts from 1.b.iv	**Duke** Calibrated CE-QUAL-W2 Model + Resullts from 1.b.iv	**Duke** Calibrated RMS Model + Resullts from 1.b.iv	**Duke** Calibrated RMS Model & CE-QUAL-W2 + Resullts from 1.b.iv	**Duke** Calibrated CE-QUAL-W2 Model	**Duke** Calibrated CE-QUAL-W2 Model	**Duke** Calibrated RMS Model + Resullts from 1.b.iv	**N/A**	**Duke** Calibrated CE-QUAL-W2 Model	**Duke** Calibrated RMS Model + Resullts from 1.b.iv
	Bypassed Reaches	*2.c.i (Bypass Scenarios)*	**Duke** Calibrated RMS Model & CE-QUAL-W2	**N/A**	**N/A**	**N/A**	**N/A**	**Duke** Calibrated CE-QUAL-W2 Model	**N/A**	**N/A**	**Duke** Calibrated CE-QUAL-W2 Model	**N/A**

METHODS

Existing Data (Prior to 2004)

Water quality has been monitored on the Catawba River reservoirs for approximately 45 years. One task necessary to address the relicensing objectives is the consolidation of the numerous water quality databases available for the Catawba River reservoirs and tributaries. Only data from state certified laboratories were considered for consolidation into a comprehensive database.

Initially, Duke inventoried the available data from various sources and this inventory was made available to Water Quality RC members.

Presently, water quality data have been requested or obtained from Duke Power, the North Carolina Department of Environment and Natural Resources (NCDENR), the South Carolina Department of Health and Environmental Control (SCDHEC), the United States Geological Survey (USGS), and the Mecklenburg County LUESA. Data have been more or less continuously collected on the Catawba River reservoirs and tributaries by Duke Power since 1959; by NCDENR since 1968 (lake data since 1981); by SCDHEC since 1958; by USGS in 1993 and 1994; and by Mecklenburg County since 1988. All available data will be consolidated.

Data from these agencies have typically been stored within the agencies or on the USEPA STORET data archive. The data exist in diverse formats including text files, spreadsheets, SAS files, and on paper. These data are undergoing a reformatting process, the end product of which will be a consolidated set of spreadsheet files for all Catawba reservoirs and tributaries, organized by lake. These files will contain data for lake and tributary locations from all agencies in a consistent format, to facilitate data analysis and presentation. The spreadsheet will be 'wide-format', with each observation of multiple water quality parameters identified by variables typically including sampling location, date, and depth. Spreadsheets for lake profile data since 1995 will also include a variable documenting the reservoir elevation at which samples were collected. In addition to the reformatted data, the final set of consolidated data will include files of data in the original formats as obtained from the agencies or from data repositories, for quality control and reference.

2004 Data Collection

The 2004 data collection program consists of routine collections from the immediate tailwaters, reservoirs, assorted tributaries and by-passed reaches, and downstream areas. The routine data collection consists of continuous monitoring of temperature, dissolved oxygen, conductivity, and water level in the tailraces; continuous monitoring of water level and temperature at selected locations; monthly physical/chemistry sampling within the reservoirs and selected tributaries; and, bi-weekly sampling of chemical parameters in the tailraces.

Non-routine tests are planned for Rhodhiss, Oxford, Lookout, and Wateree hydros. These flow tests are designed to support both empirical data analysis and provide calibration data for the RMS computer model. The downstream temperature, dissolved oxygen, conductivity, and water level are continuously recorded during periods of low flows and generation flows.

Sampling Locations

Unlike past studies on the Catawba River, sample locations and instrument placement are identified by GIS produced river miles. The convention of starting the measurements at the mouth of the Wateree River (confluence with the Congaree River) was used to measure thalwag distances. Tributary distances were calculated beginning at the confluence with the Catawba River. Locations without a text preface are locations within the main channel of the Catawba River; locations with a text preface are located in tributaries or by-passed reaches. (See Appendix A for USGS maps with river miles, and Duke Access Maps with river mile location identifiers).

Even though these location identifiers represent a close proximity to the actual position, the sample locations will also be identified by GPS coordinates taken on site at the time of sample collection or instrument deployment. These coordinates may then be GIS referenced.

Routine Data Collection

The routine 2004 data collection program for each project (Appendix B) and methodology (Table 2) outline the specific data collection and lab analysis activities.

The continuous recording devices, e.g. Onset Tidbits and Solinst Level Loggers, are programmed to record data temperature and depth, respectively, at 15-minute intervals throughout the study period. Data will be routinely downloaded at 6-month intervals (more frequent if data is required for other studies).

Forebay temperature loggers are placed at 2-meter intervals from the surface to the bottom and suspended with a weighed rope to the bottom of the reservoir. Temperature and level loggers placed in riverine conditions, are tethered to the bank, e.g. tree, piling, etc., with ⅛" stainless steel cable with a 3-6 lb weight on the river bottom. The level logger remains on the bottom while the temperature logger is suspended ≈ one foot off the bottom with a float.

For reservoir sampling*, in situ* parameters are determined with a calibrated Hydrolab DS4. The data sonde is integrated with a Wet Lab fluorometer and a Sea Tech transmissometer. After a stability period at each depth, the readings are electronically captured, recorded, and simultaneously plotted utilizing the Hydrolab software *Profiler for Series 4 Sondes®.*

Table 2. Field and Analytical Methods Utilized for the Routine 2004 Relicensing Water Quality Program

PARAMETERS	EPA PROCEDURE	STANDARD METHODS PROCEDURE	DUKE PROCEDURE	COMMENTS
CONTINUOUS RECORDING at 15 minute intervals				
Temperature	N/A	N/A	-	Onset Tidbits (programable)[1]
Level	N/A	N/A	-	Solinst Level Loggers (programable)
***IN SITU* ANALYSES**				
Temperature	170.1	SM 2550 B	3210.1	Performed in the field with Hydrolab DS4A equiped with an *in situ* Wet Lab Fluorormeter and Sea Tech Transmissometer[1]
Dissolved Oxygen	360.1	SM 4500-O G	3210.1	
Conductivity	120.1	SM 2510 B	3210.1	
pH	150.1	SM 4500-H^+B	3210.1	
Fluorscence (Note A)	N/A	N/A	Hydrolab	
Transmissivity	N/A	N/A	SeaTech	
% Light	N/A	N/A	P-1501	Field Measurement (Licor PAR sensors)
Secchi Depth	N/A	N/A	EC 3250	Field Measurement
SOLID ANALYSES				
Chlorophyll		SM 10200 H	P-4240/50	Measured in Duke Certified Lab (NC # 248) (SC ID# 99005001)
Seston (TSS to 1 mg/l)	160.2	SM 2540 D	1410	
Ash Free Dry Weight	N/A	SM 2540 E	1410	
Turbidity	180.1	SM 2130 B	1468	Measured in Field with Hach Meter 2100P[1]
NUTRIENT ANALYSES				
Total Kjeldahl Nitrogen	351.1	SM 4500-N_{org} B	2400	Measured in Duke Certified Lab (NC # 248) (SC ID# 99005001)
Total Dissolved Kjeldahl N [2]	351.1	SM 4500-N_{org} B	2400	
Ammonia	350.1	SM 4500-NH_3 G	2400	
Nitrate+Nitrite	353.2	SM 4500-NO_3 F	2400	
Total Phosphorus	365.1	SM 4500-P F	2400	
Total Dissolved Phosphorus	365.1	SM 4500-P F	2400	
Orthophosphate	365.1	SM 4500-P F	2400	
Total Organic Carbon	415.1	SM 5310 B	2301	
Total Dissolved Org Carbon	415.1	SM 5310 B	2301	
MAJOR ANION ANALYSES				
Alkalinity	310.1	SM 2320 B	1460/TotInPt	Measured in Duke Certified Lab (NC # 248) (SC ID# 99005001)
Sulfate	300.0	SM 4110 B	1904	
Chloride	300.0	SM 4110 B	1904	
Silica	370.1	SM 4500-SiO_2 C	2400	
MAJOR CATION ANALYSES				
Calcium	200.7	SM 3120 B	2102	Measured in Duke Certified Lab (NC # 248) (SC ID# 99005001)
Magnesium	200.7	SM 3120 B	2102	
Potassium	200.7	SM 3120 B	2102	
Sodium	200.7	SM 3120 B	2102	
ELEMENTAL ANALYSES				
Al	200.7 (sec 9.4)	SM 3120 B	1235/2102	Measured in Duke Certified Lab (NC # 248) (SC ID# 99005001)
Cd	200.7 (sec 9.4)	SM 3120 B	1235/2102	
Cu	200.7 (sec 9.4)	SM 3120 B	1235/2102	
Fe	200.7 (sec 9.4)	SM 3120 B	1235/2102	
Hg	245.1	SM 3112 B	1431	
Mn	200.7 (sec 9.4)	SM 3120 B	1235/2102	
Pb	200.7 (sec 9.4)	SM 3120 B	1235/2102	
Zn	200.7 (sec 9.4)	SM 3120 B	1235/2102	

[1] As per conversations with Jimmy Owens (SCDHEC) and James Meyer (NCDWQ), field certification for DTA is in progress

[2] The parameter listed with the blue highlights are field filtered and therefore, represent the dissolved fraction

For tributary sampling, a calibrated Hydrolab mini-sonde DS4 is employed. Again, after a period of stable readings, the data is captured and stored utilizing a Surveyor 4.

Water samples are collected at the surface (0.5 meter depth) from the reservoirs, tailwaters, and tributaries, and 1-meter off the bottom in the reservoirs with a Kemmerer sampler. The appropriate bottles are filled with sample water (See Appendix C for the custody sheets describing the analysis from each bottle). In the reservoirs, a 0.5 L volume of sample water is filtered through a glass fiber filter, which is retained for Chlorophyll analysis. The filter is .wrapped and placed in a small vial for transport to the laboratory. At all sample locations, an aliquot of sample water is filtered through a 0.45μm filter for dissolved nutrients, taking care to rinse the filter with lake water prior to retaining the sample. A 0.5 L volume of filtered water is returned to the laboratory for analysis. All water samples, including the chlorophyll vials, are stored on ice in a darkened ice chest, until returned to the laboratory.

At each reservoir location, additional solids and chlorophyll samples are taken from within the reservoir profile. The relative fluorescence readings indicate the presence of algae. Two additional chlorophyll samples are filtered from depths representing the maximum, mid, or minimum readings from the *in situ* fluorometer. The same approach is taken with the additional solids sample, except representing the maximum, mid, or minimum readings observed from the *in situ* transmissometer.

Temperature, dissolved oxygen concentrations, and conductivity values have been recorded in the Catawba Hydro tailraces at ≈ 5-minute intervals since 1995-96. That data collection will continue in 2004. A calibrated Hydrolab H20®, connected to a computer at the hydro, is deployed in a 6 inch plastic pipe attached to a permanent structure at each hydro. The pipe has numerous perforations on the sensor end to allow for adequate water exchange. After a period of time (see below), the Hydrolab in the pipe is replaced with a freshly calibrated Hydrolab H2O.

Immediately prior to removal of the each 'old' hydrolab from the pipe, a freshly calibrated Hydrolab mini-sonde DS4 is lowered into the pipe to obtain readings, via a Surveyor 4, prior to the removal of the 'old' sensor unit and replacement of the 'new' Hydrolab H2O sensor[7]. The evaluation of the comparisons of 'old' sensor reading to those obtained from the mini-sonde readings over a long period of time, as well as reports from the operating personnel at the hydro[8], have resulted in a balance between replacement maintenance intervals and data accuracy[9]. An average summer deployment time of two weeks was found to be adequate from Bridgewater to Mountain Island (exception was Rhodhiss); whereas the average summer deployment times at the lower

[7] Prior to the introduction of the mini-sonde, the previously deployed Hydrolab was returned to the Environmental Center for post calibration and cleaning. This technique resulted in erroneous post deployment calibration since the material fouling the sensor was disturbed during transport.
[8] When hydro personnel have reported low oxygen concentrations, the Hydrolab would be checked. Typically it would be reading low and would be replaced, resulting in shorter deployment times.
[9] The balance of maintenance cost and dissolved oxygen accuracy has led to recording lower dissolved oxygen readings than probably existed in the tailrace, since fouling typically reduces the sensor's ability to measure dissolved oxygen.

Catawba hydro, plus Rhodhiss, was one week. Winter deployment times averaged a week longer than during the summer.

Non-Routine Data Collection

The non-routine portions of the water quality studies are designed to evaluate both the immediate tailrace and the downstream water quality responses (lateral and longitudinal mixing) to the full range of operating capability of the hydro[10]. The studies are conducted during the summer months when dissolved oxygen concentrations in the reservoirs are typically at minimum levels. The long-term monitoring of temperature, dissolved oxygen, and conductivity in the tailrace of the hydro (see previous section) forms the basis for the timing of these experimental hydro evaluations (See Appendix E for historic tailrace dissolved oxygen charts).

For hydros with downstream riverine reaches, tests are conducted considering the following criteria[11]:

- Zero release from hydro (extreme low flow condition)
- Existing generation schedule (existing conditions)
- Simulated low flow without aeration[12]
- Simulated low flow with aeration[13]
- Simulated low flow (off-peak) with aeration and 1 Unit Generation (peaking) without aeration
- Simulated low flow (off-peak) with aeration and 1 Unit Generation (peaking) with aeration
- Simulated low flow (off-peak) with aeration and Mixed Unit Generation[14] (peaking) with and without aeration

Calibrated Hydrolabs and level loggers are placed in the tailrace and downstream reaches though out the duration of the hydro tests. The placement of the Hydrolabs are designed to evaluate both the lateral and longitudinal mixing patterns of the river. In addition, placement of the instruments also takes into account the morphometric characteristics of the tailrace, e.g. large pools that could be re-regulation areas for flow. These devices are programmed to record data at 5-minute intervals.

The devices are placed in the river using a variety of deployment strategies (see Figure 1 for examples). The primary criteria are to keep the Hydrolab from settling into the river bottom, the level logger from moving, placed in representative flow, and to minimize vandalism.

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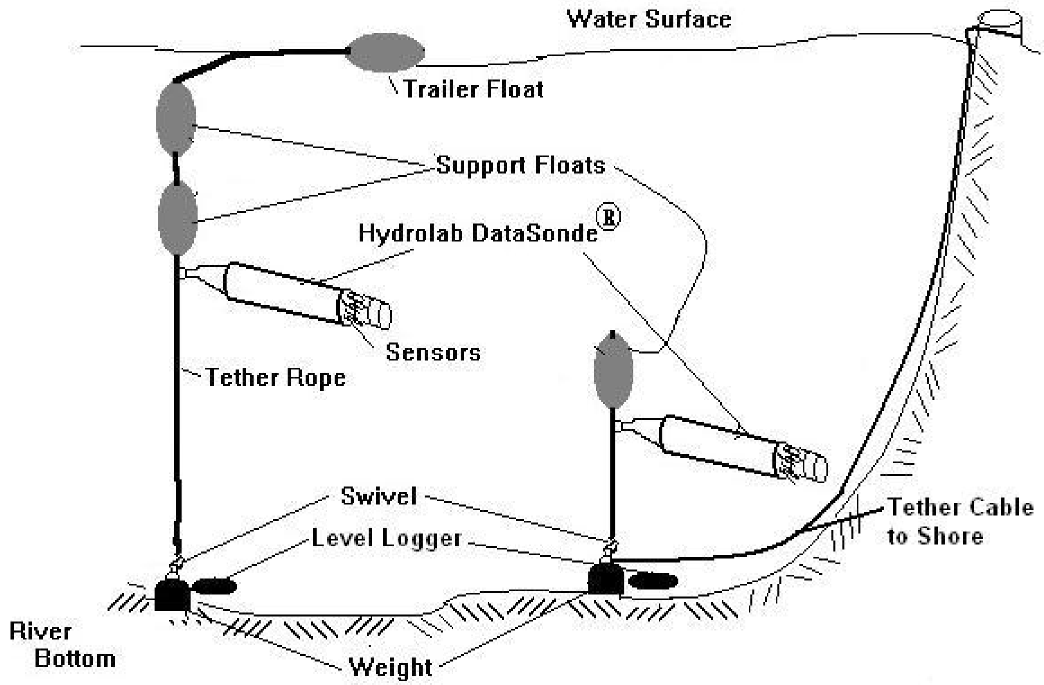
[10] Ideally, the downstream water quality would be measured under high flow conditions, however, during low flow years, the availability of water is limited preventing prolonged high flow testing
[11] Duke's hydro operating center provides the historical operational criteria and peaking recommendations to meet typical summer-time generation requirements
[12] Low flow conditions would be either continuous release (if possible for long-term) or pulsing
[13] Each hydro unit may or may not have aeration capability, the unit chosen for this test would be the unit with the highest aeration capability
[14] The exact configuration of the mixed unit generation test is a function of each individual hydro

Figure1. Deployment Strategies for Temporary Hydrolab and Level Logger Placement



Bridgewater

The initial hydro test and river deployments of hydrolabs was conducted in 1998. Emphasis was placed on the first 2.2 miles downstream of Bridgewater. In 2001, three hydro tests were performed, with river deployments of hydrolabs and level loggers placed at intervals downstream to the Morganton weir. For complete discussion and results of these hydro tests, see the Bridgewater Report (Knight, 2001)[15].

[15] This report was supplied on the CD under the directory labeled Bridgewater Report

Wylie

The initial hydro test and river deployments of hydrolabs was conducted in 1997. In 2002, hydro tests were performed, with river deployments of hydrolabs and level loggers placed at intervals downstream of Sugar Creek. This data was used for the initial calibration of the RMS model . For a preliminary discussion and results of these hydro tests, see the *Wylie Tailwater Model Calibration* report (Hauser and Ruane, 2003)[16]. Since 2002 was an extremely low water period, the river deployments were repeated in 2003, as recommended by Hauser and Ruane, to obtain conditions of higher flow. This data has not been analyzed to date.

In addition to the tests performed through out the river, tests were also conducted to evaluate the placement of the Wylie permanent monitor. The preliminary report, *Considerations for Locating a Water Quality Monitor in the Tailwater of Wylie Dam* (Ruane, et. al, 2003.)[17] and the recommendations by Hauser and Ruane, as well as the construction of reinforcing buttresses in immediate tailrace facilitate the movement of the Wylie permanent monitor. The recommended location (pending logistics and land owner approval) is downstream of the convergence point of the braided channels, approximately one-half mile downstream of Wylie Dam (Figure 2).

Figure 2. Recommended Location of the Wylie Hydro Permanent Monitor

[16] This report was supplied on the CD under the directory labeled Preliminary Wylie Model
[17] This report was supplied on the CD under the directory labeled Preliminary Wylie Monitor Location

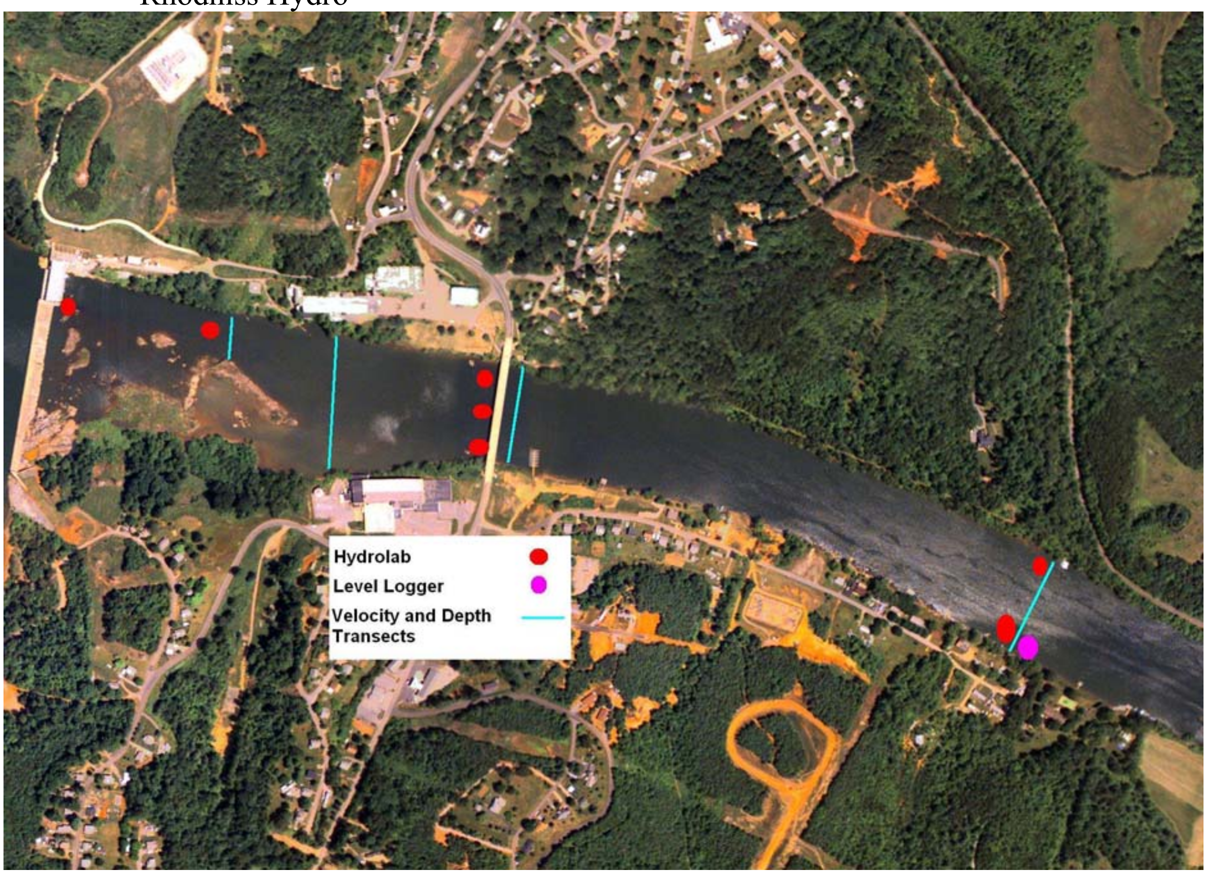
Rhodhiss

Two hydro tests are planned at Rhodhiss Hydro during the summer of 2004. These tests are planned to evaluate not only the aeration capability of the stay vanes on Unit 2, but also the mixing characteristics of the water downstream of Rhodhiss. The results of the tests should permit the evaluation of the placement of a permanent monitor on the bridge immediately downstream of the powerhouse.

The hydrolab placement (Figure 3), as well as cross sectional depth and velocity measurements, and the downstream level logger (routine studies) should address water quality but also flow considerations raised by the fisheries studies.

Four velocity and depth transects will by taken at each tested flow. A 1200Hz Acoustic Doppler Current Profiler (ADCP) will be towed across the channel recording velocity profiles and channel depth. The ADCP will also be equipped with a dGPS recorder to allow for precise positioning.

Figure 3. 2004 Instrument Placement and Velocity – Depth Transects Downstream of Rhodhiss Hydro

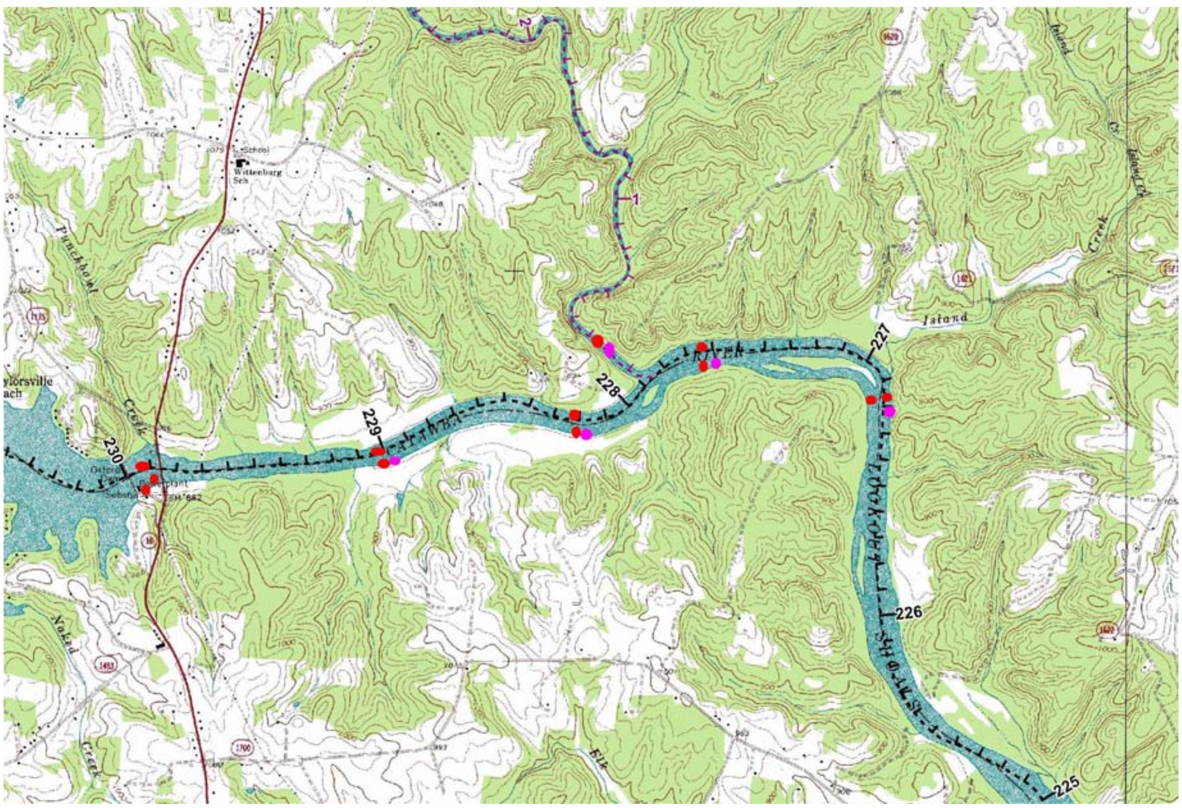


Oxford – Lookout Shoals

Two hydro tests are planned at Oxford and Lookout Shoals Hydros during the summer of 2004. The two hydros will be tested during the same time periods since, under circumstances the hydros are operated in tandem due to the limited storage of Lookout Shoals Reservoir. These tests are planned to evaluate not only the aeration capability of the turbine hub venting of both Oxford units, but also the mixing characteristics of the water downstream of both hydros. The results of the tests should permit the evaluation of the placement of a permanent monitor and the longitudinal distribution of oxygen under different flow regimes.

The hydrolab and level logger placement (Figure 4a, 4b, and 5), as well as cross sectional depth and velocity measurements (ADCP) at Lookout Shoals[18], should address water quality but also flow considerations raised by the fisheries studies.

Figure 4a. USGS Map: 2004 Instrument Placement Downstream of Oxford Hydro



[18] Velocity and Depth Measurements were determined downstream of Oxford Hydro during the 2004 IFIM

Figure 4b. Aerial View: 2004 Instrument Placement Downstream of Oxford Hydro

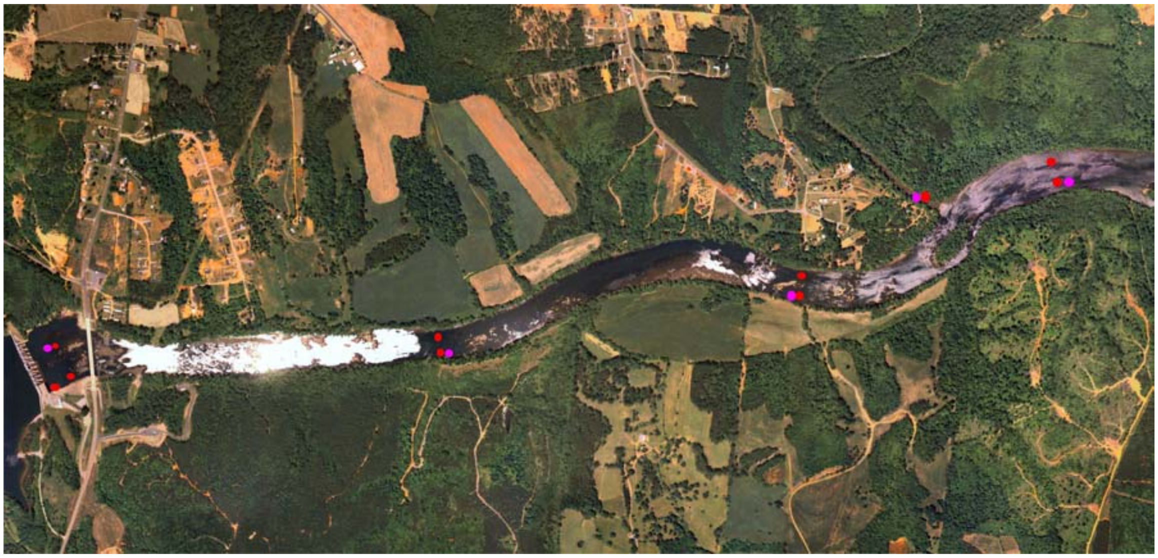
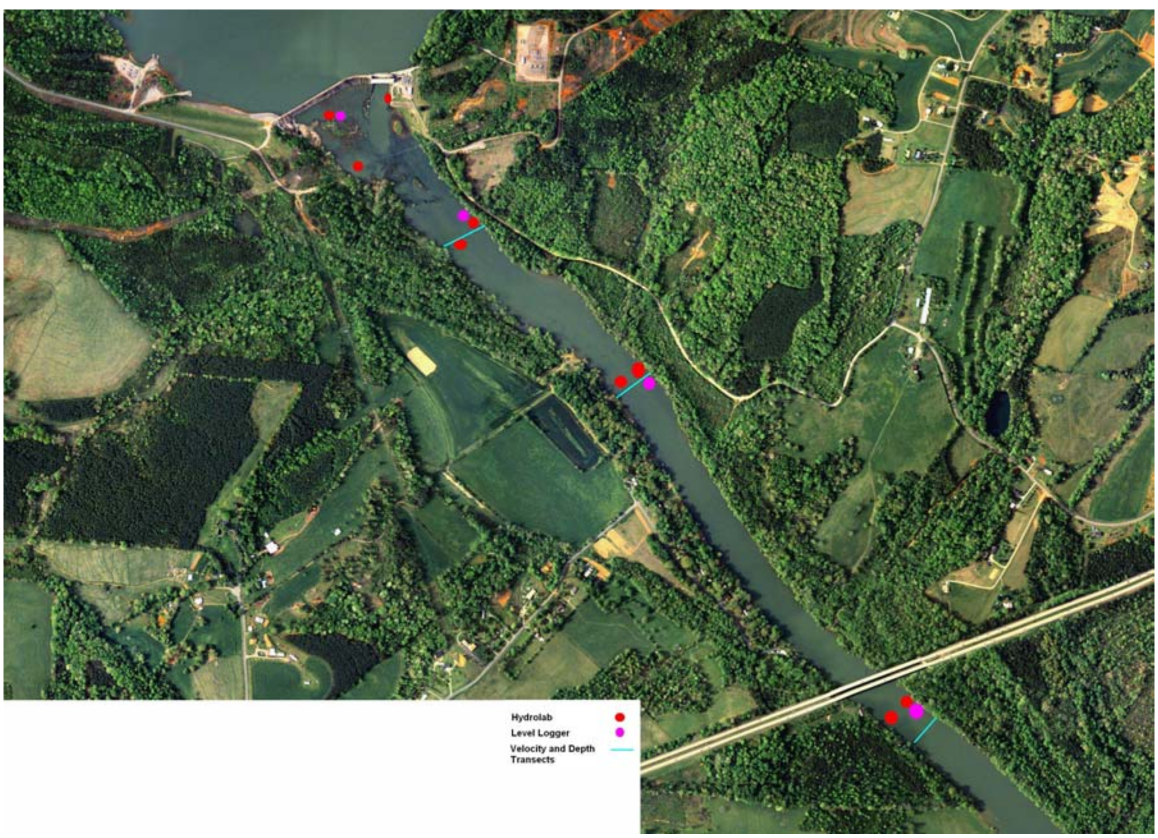


Figure 5. Aerial View: 2004 Instrument Placement and Velocity-Depth Transects Downstream of Lookout Shoals Hydro



Wateree

Three hydro tests are planned at Wateree Hydro during the summer of 2004.

The first test (with level logger deployment but without Hydrolab deployment) is designed to measure stage changes, travel times, and water depletion rates from the channel under different flow regimes. The first portion of the test is to determine these characteristics necessary to conduct an IFIM study (continuous flow). The second portion of the flow test is to determine low flow characteristics under different unit pulsing frequencies, e.g. one unit on for an hour, off for two hours, etc.

The second Wateree test involves the placement of hydrolabs and level loggers (See Appendix F for the complete set of Wateree Maps illustrating deployment locations) during the IFIM study. The addition of air by the auto venting runners of Unit 3 will be tested during the low, mid, and high flow tests needed for the IFIM.

The third Wateree test again involves the placement of both hydrolabs and level loggers (Same locations as in test 2), but, through out the third test, low flow will be provided by a unit 3 pulsing regime determined from the first test. Tests of aeration capability of Unit 3 will be tested by conducting periods with and without aeration. After this initial portion, various generation flows during peaking periods will be tested, again, with and without aeration from the various turbines.

Summary – Non-Routine Data Collection

The evaluation of lateral and longitudinal mixing of downstream waters will be evaluated under controlled hydro operations. These tests, and subsequent instrument deployments, are intended to provide information on the water quality as a function of hydro operations. These water quality evaluations are designed to be an integral portion of other flow considerations from other relicensing studies.

All of the data from these non-routine studies will not only be empirically evaluated, but also used for the calibration of the RMS hydrodynamic/water quality model. The exception is the 10 mile section of the lower Wateree River, just prior to the confluence of the Congaree River. This section of river is very prone to overbank inundation from high flows in the Wateree and Congaree Rivers. The RMS model will attempt to model the hydrodynamics of this reach, but, not the water quality. The water quality will be empirically assessed.

Schedule – 2004 Data Collection

The proposed schedule for sampling the routine and non-routine water quality programs (Appendix F) is subject to change, especially with regard to the non-routine tests as a function of water availability. However, the schedule is the current plan for meeting the 2004 water quality study goals.

QUALITY ASSURANCE / QUALITY CONTROL

This document is intended to outline the details of the Catawba-Wateree Relicensing Water Quality Studies as presented to the Water Quality Resource Committee. The results of these studies, along with the results from the five other resource committees will form the basis for the 401 Certification and future requirements established by the FERC license. This document is not intended to be a formal QAPP, but rather is a planning document to achieve the objectives of the resource committee. A formal QAPP is expected to be written after future license requirements become effective.

However, as with any data collection protocol, quality assurance documentation and quality control procedures are necessary. The QA/QC protocols for this study may be divided into the following categories::

1. Historical Data
2. 2004 Data
    a. Laboratory Analysis
    b. Field Data and Collection
3. Computer Modeling

Historical Data

Only data from North Carolina or South Carolina certified labs will be used for purposes of this program.

The data received from certified labs has presumably been reviewed and accepted by the appropriate laboratory, according to their specific QA requirements. However, as with all data, outliers and extraneous data do occur. Rigorous analysis of the data, especially relationships among various parameters, will be documented.

2004 Data

Laboratory Analysis

The Duke Power Analytical Laboratory[19] has NC Certification (# 248) and SC Certification (ID # 90005001) and therefore subject to the quality assurance and quality control commensurate with those certifications.

All protocols for sample handling, e.g. Chain of Custody (Appendix C), data review, and data transfer are followed according to the Duke Analytical Laboratory Procedures.

[19] Address = McGuire Environmental Center, 13339 Hagers Ferry Rd., Huntersville, NC 28078-7929

Field Data Collection

Field data and sample collection, at present, follows the procedures established by Duke Power. This includes, but not limited to general QA/QC practices, equipment maintenance and records, field procedures, and sample handling. However, since the primary individuals[20] conducting these field investigations work for Devine, Tarbell and Associates, Inc., detailed procedures are in progress for submittal to South Carolina and North Carolina Field Certification Programs. State and/or federal agency personnel are encouraged to attend any of the field work (see Appendix F for the sampling schedule).

In general, all instruments (primarily Hydrolabs) are subjected to daily pre and post use calibration and documentation. This calibration extends to precision and accuracy measures where multiple instruments are employed, (e.g. numerous deployments downstream of the hydros). Field graphics are used to compare lake profiles from the most recent past sampling event to current data. These graphics permit on-site evaluation of the current data; any discrepancies or questionable data points are immediately resampled. On board standardization equipment is available for recalibration, if necessary.

Computer Modeling

Rarely is the development of computer models subject to QA/QC protocols. However, the development of 8 reservoir and 5 riverine models requires consistency in the development and calibration phases.

QA/QC for the water quality models will be accomplished with a number of uniform steps and ground rules in the modeling process and with milestone reviews by a Modeling Team that will oversee the QA/QC program.

Essentials of the QA/QC program include:
1. Modeling team peer reviews[21]
2. Control files will be compared for consistency and robust settings for coefficients/rates/variables used in the control files for each model
3. Documentation of data sources and assumptions used for input files
4. Flows and bathymetry consistent with other relicensing studies
5. Complete sets of model input files required to run each model will not be released until after the relicensing process is complete—this is to avoid conflicting results in model runs using obsolete or mismatched files that have not been reviewed

[20] Jon Knight 27 yrs and Dave Davis 26 yrs employed with Duke Power Environmental Laboratories
[21] Modeling Team Members include the Modelers (responsible to team), Aquatic Scientists, Tom Cole (W2 model developer), and state agency representatives.