AMBIENT LAKES MONITORING PROGRAM (ALMP)

QUALITY ASSURANCE PROJECT PLAN

Program Administered and Plan Prepared by:
North Carolina Department of
Environment & Natural Resources
Division of Water Quality
Environmental Sciences Section
Intensive Survey Unit

Version 1.1
Approved by EPA
July 2012

Abbreviations

AGPT	Algal Growth Potential Tests
ALMP	Ambient Lakes Monitoring Program
APHA	American Public Health Association
AU	Assessment Unit
BAR	Basin Assessment Report
BMP	Best Management Practices
CHL	Chlorophyll *a*
CWA	Clean Water Act
DENR	Department of the Environment and Natural Resources
DO	Dissolved Oxygen
DWQ	Division of Water Quality
EPA	Environmental Protection Agency
ESS	Environmental Sciences Section
GIS	Geographic Information System
ISU	Intensive Survey Unit
MDL	Method Detection Limit
NCTSI	North Carolina Trophic State Index
NFQA	National Field Quality Assurance
NH_3	Ammonia
NO_x	Nitrite + Nitrate
NPDES	National Pollutant Discharge Elimination System
NTU	Nephelometric Turbidity Units
PQL	Practical Quantitation Limit
QA	Quality Assurance
QAM	Quality Assurance Manual
QC	Quality Control
SAR	Sample Anomaly Report
SCUR	Sample Condition Upon Receipt
SD	Secchi Depth
SOP	Standard Operating Procedures
TKN	Total Kjeldahl Nitrogen
TMDL	Total Maximum Daily Load
TON	Total Organic Nitrogen
TP	Total Phosphorus
TSS	Total Suspended Solids
USGS	United States Geological Survey

REVISION LOG
AMBIENT LAKES MONITORING PROGRAM
QUALITY ASSURANCE PROJECT PLAN

*Actions older than five years may be removed from this log.

Date Edited	Editor	Version Edited	Section Edited	Changes/updates
11/14/2011	Debra Owen	Ver. 1.0	Cover page & Footers	Updated document date & version number to December 2011, Version 1.1
11/14/2011	Debra Owen	Ver. 1.0	Document hyperlinks	Updated links to web sites.
11/14/2011	Debra Owen	Ver. 1.0	Revision Log	Added a Revision Log.
11/14/2011	Debra Owen	Ver. 1.0	A3 Distribution List	Updated contact information.
11/14/2011	Debra Owen	Ver. 1.0	A4 Project Organization	Updated project contacts and field staff
11/14/2011	Debra Owen	Ver. 1.0	URL links	All Internet hyperlinks were checked and functioned correctly.
11/14/2011	Debra Owen	Ver. 1.0	Table A6.2 Basin Assessment Periods	Updated the river basin assessment schedule
11/14/2011	Debra Owen	Ver. 1.0	Table B2.1 Source of Equipment and Disposables	Updated conductivity standards
11/14/2011	Debra Owen	Ver. 1.0	B3. Sample Handling and Custody	Updated date format
11/14/2011	Debra Owen	Ver. 1.0	Table b6.1 Field Equipment Maintenance	Added inspection of probes for multiparameter meters
11/14/2011	Debra Owen	Ver. 1.0	References and Resources	Updated references.
11/14/2011	Debra Owen	Ver. 1.0	B7 Instrument Calibration & Frequency	Changed conductivity standard values to 500 and 1000 umhos/cm
11/14/2011	Debra Owen	Ver. 1.0	B9 Acquired Data (Non-Direct Measurements)	48-hour precipitation – added ACOE as source of rain data
11/14/2011	Debra Owen	Ver. 1.0	Figure B10.1 ALMP Data Flow	Changed ALMP Chemistry and Physical Database to ALMP Lakes Database
11/14/2011	Debra Owen	Ver. 1.0	Attachment 3	Updated NC Surface Water Quality Standards from 2003 to 2007 version

Revision Log Continued

Date Edited	Editor	Version Edited	Section Edited	Changes/updates
11/14/2011	Debra Owen	Ver. 1.0	Attachment 5	Updated Field meter calibration sheet
11/15/2011	Debra Owen	Ver. 1.0	Attachment 6	Updated the NCDENR/DWQ Chemistry Laboratory Data Qualifier Codes
11/15/2011	Debra Owen	Ver. 1.0	Attachment 4	Update the NC DWQ ALMP Station Information
11/16/2011	Debra Owen	Ver. 1.0	Table of Contents	Updated page numbers
11/16/2011	Debra Owen	Ver. 1.0	References to Laboratory QAP Document	Updated references to various sections of this document in the ALMP QAP
11/16/2011	Debra Owen	Ver. 1.0	References to ISU SOP – Nov.2011	Updated references to various sections of this document in the ALMP QAP
11/18/2011	Debra Owen	Ver. 1.0	B.6 Instrument/ Equipment Testing, Inspection and Maintenance	Updated the Field Equipment section to reflect items in the ISU SOP.
11/18/2011	Debra Owen	Ver.1.0	B10. Data Management	Updated figure numbers in first paragraphs.
11/23/2-11	Debra Owen	Ver.1.0	B.3. Sample Handling and Custody	Revised guidance for proper completion of sampling tags to indicate that chlorophyll a and fecal coliform bacteria sampling tags need sampling time per DWQ laboratory guidance.
12/2/2011	Jason Green	Ver.1.0	Entire Document	Update to new version number to encompass numerous revisions.
12/20/2011	Joanna Gmyr	Ver. 1.0	A1, A2, & A3	Updated signature list, distribution list, & project organization.

SECTION A: PROJECT MANAGEMENT

A1. Signature and Approval Sheet

Approved by:

Jason Green for Debra Owen — 12/21/11

Debra Owen
Ambient Lakes Monitoring Program Coordinator
Environmental Sciences Section, NC DWQ — Date

Jason Green — 12/21/11

Jason Green
Intensive Survey Unit Supervisor
Environmental Sciences Section, NC DWQ — Date

Joanna Gmyr — 12/21/11

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Quality Assurance Coordinator
Environmental Sciences Section, NC DWQ — Date

Jay H. Sauber — 12/21/2011

Jay Sauber
Section Chief
Environmental Sciences Section, NC DWQ — Date

Marion D. Hopkins — 7/10/2012

Designated Approving Official
Environmental Protection Agency Region IV — Date

A2. Table of Contents

TABLES

FIGURES

A3. Distribution List

Primary Distribution:

EPA, Region IV, Water Protection Division, Water Quality Planning Branch

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Andrea Zimmer, Monitoring and Information Analysis Section Chief
Joanne Benante, Water Quality Planning Branch Chief

NC Department of Environment and Natural Resources, Division of Water Quality

Environmental Sciences Section

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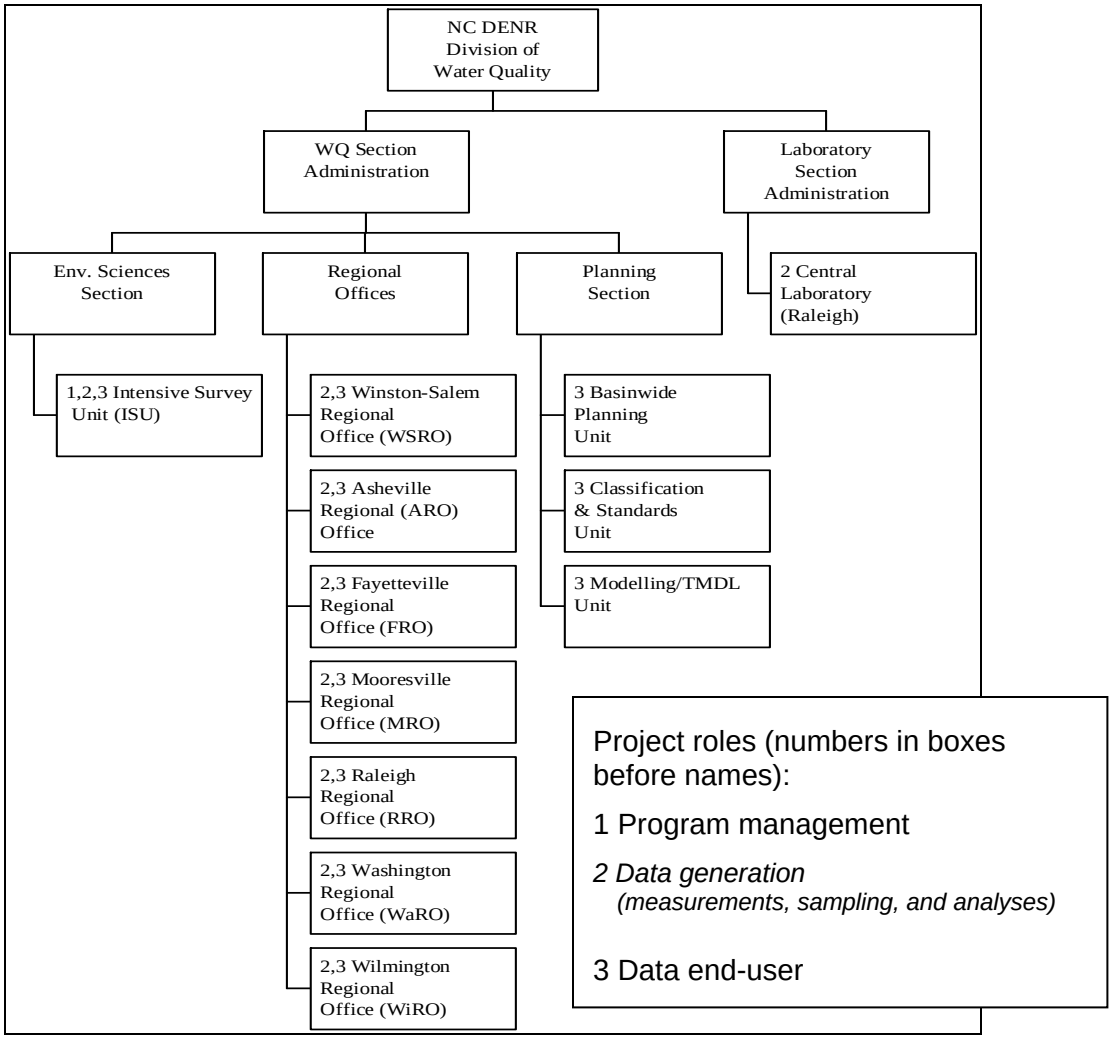
Jeff Manning, Basinwide Planning Unit Supervisor
Jeff Poupart, Point Source Branch Head
Dana Satterwhite, Laboratory QA/QC Officer
Kathy Stecker, Modeling & TMDL Unit Supervisor
Kent Wiggins, Laboratory Section Chief

A4. Project Organization

The Ambient Lakes Monitoring Program (ALMP) is implemented within the North Carolina Department of Environment and Natural Resources (NCDENR) Division of Water Quality (DWQ). An overview of DWQ units involved in the ALMP is provided in Figure A4.1. Detailed information on project contacts is provided below.

Figure A4.1: North Carolina Division of Water Quality Organizational Chart



(Only primary project participants within DWQ are shown. For a complete DWQ Organizational Chart, go to: *http://portal.ncdenr.org/c/document_library/get_file?p_l_id=1169848&folderId=485342&name=DLFE-15951.pdf*

Project Contacts

Project Manager

Jason Green

Supervisor, Intensive Survey Unit, ESS

- Supervises Ambient Lakes Monitoring Coordinator/Data Manager, QA Coordinator, and field staff.
- Responsible for ensuring that the ALMP is conducted in accordance with all relevant QAPPs and SOPs.
- Reviews and approves all reports, work plans, corrective actions, QAPP, and any other major work products and their revisions.
- Approves changes to program; ensures changes comply with DWQ regulations and policies as well as data users' needs.
- Program development.
- Reports to Environmental Sciences Section Chief.

Project Coordinator and Data Manager

Debra Owen

ALMP Program Coordinator, Intensive Survey Unit, ESS

- Acts as liaison between program management, field staff, analytical laboratory, and data users.
- Coordinates logistics of program, such as maintaining sampling schedule, producing and distributing sample submission forms to field staff, maintaining station information database, providing certain supplies.
- Responds to issues raised by any program participant or outside party, identifies root causes and recommends response actions to the Project Manager.
- Communicates needed or suggested changes to ALMP to Project Manager for approval.
- Performs all aspects of data management, including tracking, compilation, review, data entry, identifying and correcting errors, and upload of data to the Lakes Database. Fulfills requests for raw data.
- Assists in training field staff.

ISU Equipment Manager

Jim Fisher

Environmental Specialist, Intensive Survey Unit, ESS

- Responsible for the general maintenance and repair of sampling equipment and meters used by the ALMP.

Project QA Coordinator

Joanna W. Gmyr

ESS QA Coordinator, Ecosystems Unit, ESS

- Documents QA practices of ALMP.
- Maintains ALMP QAPP.
- Develops and recommends QA/QC improvements.

Data Generation (Measurements and Analyses)

Field staff: Perform all field activities including field measurements, observations, and sampling.

ISU Staff

- Debra Owen, (ALMP Coordinator)
- Kurt Trumbower
- Harold Quidley
- Jim Fisher
- Laura Spell
- Sam Whitaker
- Danielle Mir

Other/backup

- Staff of Winston-Salem Regional Office
- Staff of other Regional Offices

Laboratories: Perform all chemical, physical, and bacterial laboratory analyses.

DWQ Laboratory Section

Kent Wiggins, Section Chief

Data End Users

Primary: Used to support DWQ water pollution management programs

Ecosystems Unit staff

Biological Assessment Unit staff

Standards and Classifications Unit staff

Basinwide Planning Unit staff

Modeling/TMDL Unit staff

Intensive Survey Unit staff

Regional Office staff

U.S. EPA

A5. Problem Definition/Background

As part of funding agreements with the Environmental Protection Agency (EPA), North Carolina agrees to monitor the waters of the State and report findings to the EPA to support the goals of the Clean Water Act (CWA). The Federal Water Pollution Control Act Amendments of 1972, commonly referred to as the Clean Water Act (CWA), and subsequent amendments define the following as their objective:

> *"to restore and maintain the chemical, physical, and biological integrity of the Nation's waters, and, where attainable, to achieve a level of water quality that provides for the protection and propagation of fish, shellfish, and wildlife, and for recreation in and on the water".*

The Federal Clean Lakes Program, which was established as Section 314 of the Clean Water Act (CWA), enabled North Carolina in 1981 to receive federal funding to classify the trophic (or nutrient enrichment) status of the State's publicly owned freshwater lakes and to prioritize lakes for restoration. A sampling program was established in 1981 to survey the trophic condition of 65 lakes. Thirty-one of these lakes were sampled again in 1982. From this work, the North Carolina Trophic State Index (NCTSI) that the State has used for all subsequent trophic classifications was developed. The State has continued to monitor the significant lakes. The current Ambient Lake Monitoring Program (ALMP) consists of approximately 160 lakes statewide.

In addition to the development of North Carolina's lake monitoring program, major provisions of the CWA also led to the development of state-based water pollution management controls, which are based primarily on development and enforcement of numerical and narrative water quality standards. The current numerical standards and action levels are described in the NC Administrative Code (Chapter 2, Subchapter 2B), which is commonly referred to as the "Red Book". The full text of the Code is available online at:
http://portal.ncdenr.org/c/document_library/get_file?folderId=285750&name=DLFE-8513.pdf.

Since it is a project of indefinite duration, the ALMP is a valuable tool for identifying long-term spatial or temporal patterns in lakes across the state. Data produced by the ALMP support the activities of several different sections within the Division of Water Quality:

- Environmental Sciences Section
- Identification of long-term temporal or spatial patterns
- Determine current trophic status and identify potential changes in trophic state
- Identification of water quality standard violations present in lakes
- Provide background information for Intensive Survey Unit special studies, Biological Assessment Unit (BAU) monitoring and Ecosystems Unit special studies
- Analysis of lake data in support of §314 reporting requirements (305(b) report)
- Planning Section
- Biennial 303(d) and 305(b) reporting to EPA, including identification of lakes with impairment or degradation;
- Basinwide Water Quality Plan development;
- Identification of outstanding or unique lakes;
- Total Maximum Daily Load (TMDL) development;
- Background information for reclassification studies;
- Triennial review of water quality standards.

Lakes in North Carolina have been given a classification based on their intended use, which determines the level of protection required. Major classifications appropriate to lakes and their corresponding uses are shown in Table A5.1. Class C waters are protected to support the propagation and maintenance of aquatic life and incidental recreational uses. Class B waters are protected for full body contact

(organized swimming) and all Class C uses. The WS classifications II through IV are intended to protect source water and all Class C uses. The WS-I classification is to protect water supplies that are not filtered prior to use. There are no WS-I lakes in the ALMP.

Table A5.1: North Carolina Lake Classifications and Uses

	Protected Uses by Classification			
Lake Classification	**Aquatic Life**	**Secondary Recreation**	**Primary Recreation**	**Water Supply**
C	X	X		
B	X	X	X	
WS (I-V)	X	X		X

In addition to these major classifications, North Carolina also has supplemental classifications to protect for additional uses, such as trout survival and propagation, outstanding resource waters, future water supplies, and nutrient sensitive waters. Descriptions of the State's lakes classifications can be found on the Classification and Standards Unit's website: http://portal.ncdenr.org/web/wq/ps/csu/classifications. Classifications for individual lakes can be obtained through DENR's Basinwide Information Management System (BIMS) website at http://portal.ncdenr.org/web/wq/admin/bog/netsupport/bimsreports.

Different uses are protected by varying combinations of legislatively mandated requirements for activities within a watershed such as:

- Number and type of allowable discharges;
- Stream buffers;
- Erosion and sediment controls;
- Agricultural best management practices (BMPs);
- Forestry BMPs;
- Transportation BMPs;
- Number and type of landfills;
- Number and types of dams/water resources projects.

In addition to these managerial controls, there are also corresponding numerical water quality standards and action levels which specify the chemical, physical, and microbial pathogen characteristics required to ensure that the water is of sufficient quality for the intended use.

Information on DWQ's assessment protocol is available in the *NC Water Quality Assessment and Impaired Waters List* (NCDENR, 2004), also referred to as the "*Integrated Report*". This document is available on the Modeling and TMDL Unit's website at: http://portal.ncdenr.org/web/wq/ps/mtu/assessment.

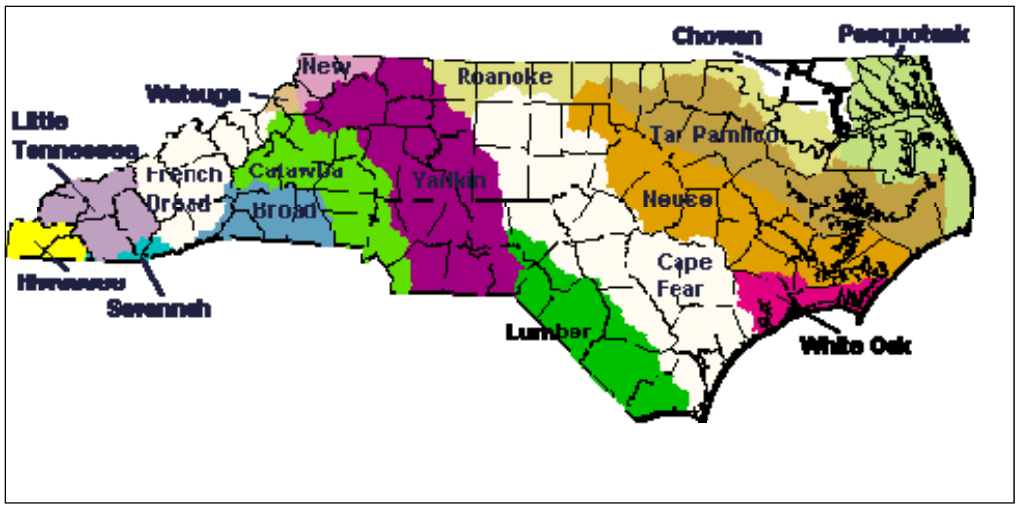
A6. Project/Task Description and Schedule

Overview

The ALMP consists of a relatively static network of stations located on lakes throughout the State, which provide site-specific, long-term water quality information. This network is based on sampling lakes that are publicly accessible, water supply lakes, or lakes that have been previously monitored by the Division of Water Quality (DWQ). There are currently 422 lake monitoring stations established throughout the State's seventeen major river basins (Figure A6.1). These stations are typically monitored by boat.

Other Intensive Survey Unit's studies differ from the ALMP in that they tend to be special studies targeted to many different types of waters. For the other studies, individual study plans are developed that include QAPP type information specific to the study.

Figure A6.1: North Carolina Major River Basins



Water Quality Indicators

The ALMP focuses primarily on chemical, physical, and biological characteristics of lakes. The indicators are primarily selected from those chemicals that have current NC water quality standards and that can be cost-effectively analyzed. Additional indicators are also included that may not have specific standards associated with them but are useful for interpretation of other measurements. Others are, of themselves, useful for identifying long-term trends.

A basic core suite of parameters is measured at all stations:

Temperature	Total Suspended Residue	pH
Specific Conductance	Secchi depth	Phytoplankton
Turbidity	Nutrients(nitrogen & phosphorus)	Chlorophyll *a*
Total Residue	Dissolved Oxygen	

Additional indicators may be included depending on lake-specific concerns such as classification and historical or suspected issues. Additional field observations, such as weather conditions, water color or appearance, presence of aquatic macrophyte, and/or visible indicators of algal blooms (i.e. floating mats, scums, or flecks) are also recorded at all site visits.

Measurement Methods Overview

Field measurements

Measurements made in the field include water temperature, specific conductance, stream flow severity, salinity, Secchi depth, DO, pH, air temperature, and wind velocity and direction. Field measurements are discrete and are made *in situ* by field staff at the time of the station visit. All field activities are performed in accordance with the ISU SOP (Attachment 1).

Analytical samples

Samples are submitted to the DWQ Laboratory for analysis for turbidity, TSS, metals, nutrients, TS, chlorides, fecal coliform, and chlorophyll *a*. All sampling, preservation and handling, and analytical methods are performed in accordance with the ISU SOP (Attachment 1). Analytical methods are performed in accordance with the Laboratory Section's Quality Assurance Manual (QAM) (Attachment 2). The Laboratory's analytical methodologies are not managed as part of the ALMP and are beyond the scope of this QAPP.

In rare cases, it may be necessary for samples to be analyzed by other laboratories. These alternative labs must meet the minimum criteria inherent in the NC Laboratory Certification regulations and are required to provide reporting levels, analytical methods, accuracy, and precision equivalent to or better than those of the DWQ laboratories. If a private laboratory is used, it must be certified by the NC Laboratory Certification Program to perform the analysis requested.

Sampling Schedule

The ALMP is geared towards the collection of long-term data and is therefore a continuous project. Stations are visited at least three times during May through September of a single year for each five-year river basin cycle for collection of field measurements and analytical samples. Lake sampling is conducted in each river basin the summer before the Basin Assessment Report (BAR) is due to Planning Section Staff.

The ALMP Coordinator prepares a draft-sampling schedule by March for the upcoming summer sampling trips. Each sampling trip consists of a lake or a group of lakes based on travel distance between lakes and number of sampling sites at each lake. All reasonable efforts are made to sample each lake per the sampling schedule; however, changes may be necessary due to weather conditions and/or staffing issues.

Data Management

The ALMP Coordinator is responsible for the compilation, review, verification and validation, and warehousing of all data produced by the ALMP. At the end of each sampling trip, water samples are submitted to the Central Laboratory for analyses. Hardcopies of the field data sheets are given to the ALMP Coordinator who manually enters the field data into the Lakes Database. Approximately 30 days after sample collection, the ALMP Coordinator receives hardcopy reports of the laboratory's finalized analytical results. The ALMP Coordinator reviews and manually enters the analytical results into the Lakes Database (see section A9 for specifics on data management). The finalized data are then used to determine the trophic status of each lake.

Reporting

The primary method of reporting for the ALMP is the Basin Assessment Reports (BAR). Results of lake monitoring efforts and lake classifications are reported for each of the seventeen major river basins in NC on a rotating five-year schedule based on the DWQ Basinwide Planning Schedule (Table A6.2).

After reviewing lab analyses, previous reports and plans, and discussions with appropriate staff, results are presented by subbasin as narrative summaries, tables and graphical representations. Descriptions of known issues or sources of bias (e.g., analytical, field, climatic, significant events such as droughts or hurricanes, etc.) should be sufficient to give the reader adequate context for appropriate interpretation of the results. Each lake's data is summarized in a table by basin to help facilitate assessment.

The main audience for the information reported in the BAR is staff from the DWQ Planning Section. Information from the BAR is used in developing the Integrated Report. The information also goes into the Planning Sections Basinwide Water Quality Plans (http://portal.ncdenr.org/web/wq/ps/bpu/basin).

Table A6.2: Basin Assessment Periods.

River Basin	Assessment Period	BAR Finalized
Broad Chowan Neuse Pasquotank	2006 – 2010	2011
Lumber Yadkin	2007 – 2011	2012
Catawba French Broad Tar-Pamlico	2008 – 2012	2013
Cape Fear New	2009 – 2013	2014
Hiwassee Little Tennessee Roanoke Savannah Watauga White Oak	2010 – 2014	2015

A7. Quality Objectives and Criteria

Precision, Accuracy, and Sensitivity

All field measurements, sample collection, preservation and handling are performed in accordance with the ISU SOP (Attachment 1). Analytical methods are performed according to the Laboratory Section's Quality Assurance Manual (Attachment 2). Quality assurance targets for accuracy and precision are listed in Table 5.1 of the Laboratory Section's Quality Assurance Manual (Attachment 2). Results from the ALMP are compared to NC Surface Water Standards (Attachment 3); reporting limits for these indicators should be at or below these critical values when possible.

Bias

The ALMP is based in judgmental sampling design, as a result, bias will exist due to station locations. However, this is acceptable given that stations are generally established at lake center or main-stem locations to capture whole-lake water quality and at the mouths of significant tributaries and/or tributaries suspected of contributing to water quality concerns in the lake.

Other sources of bias include:

- Samples are typically collected during the summer months, which often represent worst-case conditions in a lake.
- Sample size is limited by sampling summer months once every five years.
- Samples are collected during the day only. Stations may also be sampled at different times of the day from month to month, which may affect indicators such as DO, pH, and nutrients. Typically sampling is conducted after 10:00 A.M. to capture algal blooms that may be present and more active during the heat of the day.
- Extreme or unusual conditions, such as storm events, may not be sufficiently sampled due to field staff safety concerns during these events and scheduling.
- As noted above, most large reservoir sampling sites are located within the main-stem and near the mouths of large tributaries. Water quality conditions in coves, along the shoreline, and in small tributaries are not generally captured in the sampling effort.

Using consistent sampling methods, SOPs, and analytical methods minimizes bias from other sources.

Representativeness

Lake monitoring data generally show high variation due to natural conditions such as precipitation, diurnal patterns, and biological activity. Reservoirs also exhibit variation due to management of the water level for recreation, hydropower generation, and flood control.

In order to sample relatively stable conditions, the specified sampling point must have sufficient volume throughout the year. As a result, the collected samples represent an "average" condition of the waterbody at that point in time. In the event of volume loss due to drought or significant drawdown of a reservoir for dam repair, at least one year for stabilization of the system is required following the return to normal pool levels before sampling is resumed. However, under some circumstances these water bodies may be sampled within a year of volume loss to address specific needs.

Comparability

Fixed station locations and standardized operating procedures for sampling and analytical methods ensure that comparable samples are taken during each site visit.

Deviations from the SOP, due to unusual sampling conditions, are documented in the appropriate report or memorandum. Calibration procedures ensure accuracy and comparability of water quality measurements.

Measurements of water temperature, dissolved oxygen, specific conductance, and pH are made in the field with calibrated meters. The measurements are taken from just below the water surface (depth = 0.15 m) and at every meter to a depth of 10 meters. Readings are then taken every 5 meters until reaching a depth of 40 meters. After forty meters, readings are taken every 10 meters until reaching the bottom.

Completeness

It is expected that some site visits or samples will be missed due to problems such as inclement weather, equipment problems, vacant positions, and staff issues. Maximum possible effort is made to sample each monitored lake within a river basin three times within each five-year cycle period.

A8. Special Training/Certifications

Field Staff

Field personnel are trained in the methods described in the Intensive Survey Unit SOP (Attachment 1), this QAPP, and the Laboratory Section's Quality Assurance Manual (Attachment 2). Intensive Survey Unit staff generally performs initial training for new employees in meter calibration, required documentation, sampling methods, sample handling, safety, GPS operation, and other field activities. Employees are required to attend the Central Laboratory's sample submission training class when hired and take a refresher course every three years.

Staff performing boat work will be thoroughly trained in the safe and proper handling of boats and trailers. Hazardous material training is not required for Lakes Monitoring Program activities.

All staff involved in lake sampling participates in an annual field audit to evaluate knowledge of sampling procedures, safety, boat handling, and record keeping. Results of the field audits are tabulated and this information is used to evaluate the need for additional training and/or changes in protocols to improve overall quality assurance.

Laboratory (Analytical) Staff

Required training of DWQ Laboratory Section staff is detailed in Section 4.0: *Organization, Facilities, and Equipment* of the Laboratory Section Quality Assurance Manual (Attachment 2). If a private laboratory is used for any analyses, it must certified by the appropriate NC Laboratory Certification program, and staff training must be performed in accordance with the requirements inherent in their certification. If another state agency's laboratory is used, its training requirements should be at least equivalent to those of a certified private laboratory.

A9. Documentation and Records

Quality Assurance Information, SOPs, and Other Program Documentation

Once all approval signatures have been obtained, the QA Coordinator will distribute copies of the approved QAPP via email to persons on the distribution list in Section A3 of this document. Copies must be disseminated within 30 days of final approval. The original hard copy with approval signatures will be kept on file in the QA Coordinator's office at ESS.

The QA Coordinator is to be notified of changes made to SOPs, analytical methods, and/or any other documentation referenced by this QAPP. This should be done before the summer field sampling season begins. The QA Coordinator will be responsible for distributing the information, as described above.

Since the ALMP is an ongoing project, this QAPP will be reviewed annually. If appropriate, changes or updates will be made at that time. However, critical revisions can be made at any time.

The QA Coordinator is responsible for completing revisions, obtaining signatures of approval, and disseminating the revised document to those on the distribution list within 30 days of final approval. The version or revision number and date shall be easily identifiable by the document control information on each page. A complete list of all revisions/updates will be provided with each annual update.

Field staff (listed in Section A4) that assist in the sample collection aspects of the ALMP are responsible for reading and reviewing the ALMP QAPP on an annual basis. Documentation that each staff member has reviewed this QAPP will be maintained by the QA Coordinator.

Project Records

Original hardcopies of all ALMP meter calibration sheets are retained a minimum of five years in the ESS Calibration Laboratory.

Original hardcopies of the following records are retained a minimum of five years in the "Lakes Files" , which are located in the ESS building in Raleigh, NC:

- Field Data Sheets
- Stratified Field Data Sheets
- Field Observation Form
- Analytical Reports/Documents
- Sample Submission Sheets
- Analytical Laboratory Report

The following electronic records are retained indefinitely and are kept on the ALMP Coordinator's Lakes Database located on the ESS server:

- Physical Field Data
- Analytical Laboratory Results

Tape backups are run weekly on the ESS servers. The Lakes Database is updated weekly, at a minimum, during the summer sampling period. Details of electronic data management and warehousing methods are further described in section *B10: Data Management* of this document.

Analytical Laboratory Activities

Detailed descriptions for handling of original sample submission sheets, sample tags, and laboratory documentation and the required retention times and storage methods are listed in the Section 12 of the Laboratory Section Quality Assurance Manual (Attachment 2).

Data Reporting: Basin Assessment Reports

Data are analyzed and summarized for monitored lakes in each of the seventeen major basins on a rotating five-year schedule. The ALMP Coordinator provides all available historic and current raw data, data, station visit comments/observations, and station information (including lake classifications) as electronic files. These data are used to produce the ALMP portion of the Basin Assessment Report (BAR), which summarizes all monitoring activities during the appropriate assessment period. The final BAR is made publicly available via the ESS website at http://portal.ncdenr.org/web/wq/ess/reports.

The ALMP Coordinator also provides raw data upon request to staff from other state and federal agencies, private consultants, academia, municipalities, private citizens, and others. Raw data are generally provided in an electronic format (delimited text file or Microsoft Excel spreadsheet) and contain the same information listed above for internal analysis, unless otherwise instructed by the requestor.

SECTION B: DATA GENERATION AND ACQUISITION

B1. Sampling Process Design

The Federal Clean Lakes Program, which was established as Section 314 of the Clean Water Act (CWA) enabled North Carolina in 1981 to receive federal funding to classify the trophic (or nutrient enrichment) status of the State's publicly owned freshwater lakes and to prioritize lakes for restoration. A sampling program was established in 1981 to survey the trophic condition of 65 lakes. Thirty-one of these lakes were sampled again in 1982. From this work, the North Carolina Trophic State Index (NCTSI) that the State has used for all subsequent trophic classifications was developed.

The NCTSI is based on total phosphorus (TP in mg/L), total organic nitrogen (TON in mg/L), Secchi depth (SD in inches), and chlorophyll *a* (CHL in µg/L). Lake-wide means for TP, TON, SD, and CHL are used to calculate a NCTSI score for each lake, using the following equations:

$$NCTSI = TON_{Score} + TP_{Score} + SD_{Score} + CHL_{Score}$$

Where:

TON_{Score} = ((Log (TON) + 0.45)/0.24)*0.90

TP_{Score} = ((Log (TP) + 1.55)/0.35)*0.92

SD_{Score} = ((Log (SD) – 1.73)/0.35)*-0.82

CHL_{Score} = ((Log (CHL) – 1.00)/0.48)*0.83

In general, NCTSI scores relate to trophic classifications (Table B1.1). When scores border between classes, best professional judgment is used to assign an appropriate classification. NCTSI scores may be skewed by highly colored water typical of dystrophic lakes. Therefore, a trophic state is not assigned to dystrophic lakes.

Table B1.1: Trophic Classification Criteria for Lakes

NCTSI Score	Trophic Classification
< -2.0	Oligotrophic
-2.0 to 0.0	Mesotrophic
0.0 to 5.0	Eutrophic
> 5.0	Hypereutrophic

Data analysis is focused on those data generated during the five-year assessment period. Analysis begins with review of the data set for each indicator, generally lake-wide by sampling station. Graphical exploration of the data may be used if the lake has a number of sampling sites, generally greater than three, which makes such an analysis reasonable. Spatial patterns may be more evident at this point. Temporal patterns, with the exception of large step-type changes, are generally not easily discernable over such a short time period. Patterns or anomalies noted during this process are more closely

examined and appropriate sources, such as Regional Office staff, NPDES permits, lake managers and municipalities, are consulted to determine a possible cause.

Station Locations

Stations are established at GIS referenced fixed locations (i.e., specific lat/long). A full station list is available in Attachment 4. Stations are strategically located to obtain data which are representative of the main body of the lake and capture the following:

- Overall water quality in the lake or reservoir;
- Effects of point source discharges;
- Effects of non-point sources of pollution (e.g., urban areas, animal operations, agriculture);
- Effects of land use changes;
- Levels of constituents of concern for load calculations, TMDLs, and determination of water quality standard attainment;
- Lakes of significant ecological, recreational, political, or municipal use;
- Lakes which show an impairment due to unknown causes (e.g., biological data shows possible impairment); and
- Lakes that have had public complaints or concerns related to water quality.

Many of the current stations have been active for over thirty years. This focus on long-term data is integral in identifying temporal patterns within a lake and to gaining an understanding of the variability within each system. Consequently, requests for station establishment and/or discontinuation are assessed based on the value gained from a long-term perspective. Special studies may also be conducted; however, these activities are beyond the scope of this QAPP. Study plans that contain QAPP information are developed for all special studies.

Adjustments to station locations and sampling regimens may be made with sufficient reason, such as:

- Safety concerns of field staff;
- Changes regarding location accessibility (i.e., sediment deposition preventing boat access);
- Original intent of sampling is no longer valid (i.e., a discontinued discharge);
- Emergence of new water quality concerns;
- Resource constraints, particularly field and laboratory staff vacancies; and/or
- Redundancy with a cooperating agency (e.g. sampling performed by lake managers, etc.).

If any of these concerns arise, the ALMP Coordinator, Intensive Survey Unit Supervisor, and any other involved parties (e.g., Planning Section staff), will collectively decide if it is appropriate to make modifications.

Actual sampling points are generally located within the center or main-stem of the lake, or as determined by field staff as representative of the lake or specific areas of concern within the lake.

Indicators Measured

The selection of indicators is primarily focused on those with NC water quality standards that can be cost-effectively analyzed and trophic state indicators appropriate to lakes. Additional indicators, which may not have specific standards associated with them but are useful for interpretation of water quality in lakes, are also included.

Field staff may use their discretion to sample for any additional indicators believed to be of concern due to unusual circumstances encountered during a lake visit. Permanent changes to parametric coverage

at a station may be made in response to requests from DWQ staff. These changes undergo a review process similar to that for station location changes.

Currently, all measurements and samples are taken on whole water samples. Analyses for dissolved fractions may be performed as part of special studies. See Table B1.2 for a complete listing of the indicators sampled. Attachment 4 lists the current ALMP stations and provides information on where additional indicators are collected. Core and lake specific indicators are collected during every sampling trip. When additional lake sampling is required, a study plan is developed to address sampling locations, parameters, frequency, and duration.

Table B1.2: Water Quality Indicators Collected in the ALMP

Indicator Type	Core Indicators	Lake-Specific Indicators
Physical	Temperature (°C) Specific conductance (μmhos/cm @25°C) Turbidity Total residue (TS) Total suspended residue (TSS) Secchi depth (transparency)	
Chemical	Nutrients*: NH_3, NO_x, TKN, TON, TIN, TN, Total P Dissolved oxygen (DO) pH	Metals (water supplies only): Cd, Cr (total), Cu, Fe, Mn, Ni, Pb, Zn) Hardness (w*ater supplies only)* - Calculated using Calcium & Magnesium Chloride
Biological	Phytoplankton Chlorophyll *a* Aquatic macrophyte presences	Fecal coliform (Class B waters only) Aquatic macrophyte coverage Algal bloom (water color, mats, flecks, scums) Algal Growth Potential Tests (AGPT)
Other	Air temperature (°C) Cloud cover (%) Wind velocity (mi/hr) Wind direction (degrees from North) 48 hour precipitation (inches) Shoreline development and density Land uses observed in the watershed	

* Nitrogen species calculated using these equations: TON = TKN - NH_3 TN = TKN + NOx TIN = NH3 + NOx

Sampling and Measurements

Field measurements and samples are collected in accordance with Sections III, IV, and XI of the ISU SOP (Attachment 1). Required sample volumes, containers, preservation, and other handling information are detailed in Section 6 of the QA Manual for the Laboratory Section (Attachment 2).

After collection and chemical preservation, samples are immediately stored on ice in coolers. The sample coolers are either hand-delivered by field staff or sent via NC Department of Administration's courier to the appropriate DWQ Laboratory for analyses.

There is no re-sampling in the event that samples are lost after leaving a lake or if samples are rejected by laboratory staff due to improper handing (temperature out of range, inadequate preservation, etc).

Every reasonable attempt is made by field staff to complete all site visits each month (May through September); however, some missed visits are to be expected due to situations such as bad weather, station inaccessibility, extreme drop in lake water volume, meter problems, staff shortages/vacancies, etc. In these cases, the reasons are documented in a memorandum, which is copied to the ALMP Coordinator, Intensive Survey Unit Supervisor, and the applicable lake file. If a station location is inaccessible during a sampling trip, field staff should consult with the ALMP Coordinator for consideration of changing the station location or permanent discontinuation of the station. It is important that stations not be moved without sufficient reason, as an uninterrupted long-term record is critical to this program.

B2. Sampling Methods

Samples and measurements are to be taken in accordance with ISU SOP sections III, IV, and XI (Attachment 1). Any irregularities or problems encountered by field staff are communicated, either verbally or via email, to the ALMP Coordinator who will assess the situation, consult with other project personnel, and recommend a course of action for resolution. Irregularities are documented on the field sheets by the field staff and by the ALMP Coordinator either in the database or by memo to the lake files. An overview of the different sampling methods employed is described below.

Field Measurements

Field parameters (temperature, dissolved oxygen, pH, and conductivity) are measured just below the water surface (depth = 0.15 m) and at every meter to a depth of 10 meters. Readings are then taken every 5 meters until reaching a depth of 40 meters. After forty meters, readings are taken every 10 meters until reaching the bottom.

A Secchi disk is lowered into the water to the depth at which the disk is no longer visible, then raised to where it just becomes visible. The depth where it just becomes visible again is recorded as the Secchi depth. Additional information on this procedure is documented in Section III of the ISU SOP (Attachment 1).

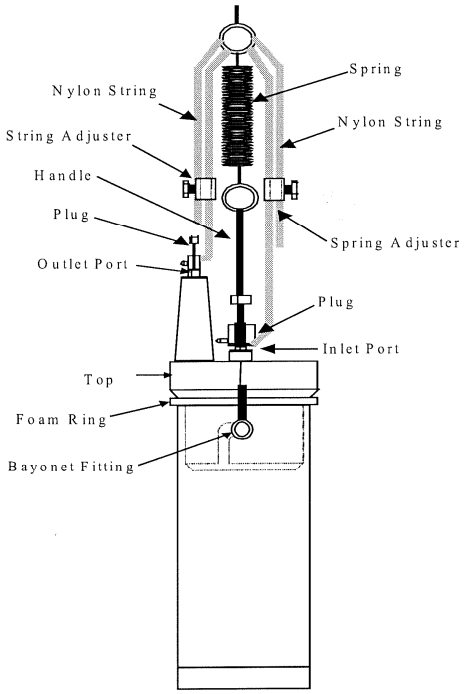
All readings and measurements are recorded in the field on a Stratified Field Data Sheet (Attachment 1, ISU SOP, Section II, Figure 5).

Samples

Refer to Section IV of the ISU SOP for general information on sampling methods (Attachment 1). Three basic methods are employed in the ALMP:

- Surface Grab: Samples are taken just below the surface (depth = 0.15m). Opened sample bottles are filled by plunging them into the water by hand. This method is used for fecal coliform bacteria, metals, and chloride.
- Photic Zone: A composite sample over the entire depth of the photic zone, defined as twice the Secchi depth, is taken using a Labline® Poly-Pro water sampler (see Figure B2.1). Corks are removed from the Labline® sampler, which is slowly lowered to a depth of twice the Secchi reading and then drawn back up to just below the surface. Lowering and raising the sampler is done at a slow, continuous pace in order fill the sampler with a representative sample of the entire water column to the designated depth. This method is used for chlorophyll *a*, nutrients, total solids, suspended solids, turbidity, and phytoplankton.
- Bottom (samples collected just above the bottom of the lake): These samples are collected by lowering a Labline® (with the cork holes plugged) to just above the bottom of the lake and then pulling the attached rope to release the corks, thereby filling the Labline®. Bottom grab samples are only conducted in certain instances (i.e., special lake studies involving sampling stations near dams with deep hypolimnetic water withdrawal).

Figure B2.1: Labline® Sampler



Detailed notes on any deviation from sampling protocol are documented on the field sheets and reported to the ALMP coordinator. The ALMP coordinator will review the affected data and determine if it is appropriate to use per Section D of this document.

Sources for equipment and disposables needed for lake sampling activities are listed in Table B2.1.

Table B2.1: Sources for Equipment and Disposables

	RESPONSIBLE SOURCE		
	ALMP Coordinator	ALMP Staff	Central Laboratory
Equipment			
Field Meters: Multiparameter Meter (ex, Hydrolab Quanta or MiniSonde 4a with display and probes).		X	
Labline® composite sampler with marked rope		X	
Safety equipment Disposable gloves (nitrile or vinyl) Acid handling equipment (apron, safety glasses, spill kit, portable eye wash, ampule disposal container) First Aid kit Personal floatation devices		X	
Secchi disk		X	
Coolers/ice chests/temperature blanks		X	
Truck/van		X	
Boat and trailer		X	
Disposables			
Sample bottles			X
Sample tags	X		
Sample submission sheets	X		
pH buffers (4.0, 7.0, 10.0 s.u.)		X	
Conductivity standards (500, 1000 *u*mhos/cm)		X	
25% sulfuric acid			X
1:1 nitric acid ampules			X
Lugol's solution		X	
Distilled or deionized water*		X	
Ice		X	

* From the Environmental Sciences Section Calibration Laboratory

B3. Sample Handling and Custody

All samples are to be handled by field staff in accordance with Sections 6-7 of the Laboratory Section QAM (Attachment 2) except for completion of Chain of Custody forms. Chain of Custody forms are not typically completed for ALMP sampling. They are only completed if sampling is conducted for enforcement purposes.

Sample Preservation

Chemical preservation of samples should occur within 15 minutes of collection. Samples should then immediately be placed in coolers with ice. Sample submissions requirements (i.e. container specifications, minimum sample volumes, preservation, and holding times) are listed in Figure 6.1 of the Laboratory's QAM (Attachment 2).

Sample Submission Forms

The ALMP Coordinator prepares sample submission forms (also called Field Lab Forms) (Figure B3.1) for each sampling month. Each sheet corresponds to one or more samples that were taken using the same sampling method (i.e., grab, photic, bottom) at the same station, date, and time. If more than one sampling method is employed at a single station visit, multiple sheets must be completed for that station. This means that for certain station visits, up to three sample submission forms may be required:

- Surface: grab samples submitted to the Central Laboratory
- Photic: photic zone composite samples submitted to the Central Laboratory
- Bottom: bottom grab samples submitted to the Central Laboratory

The flow of ALMP Sample Submission Forms is displayed in Figure B3.2.

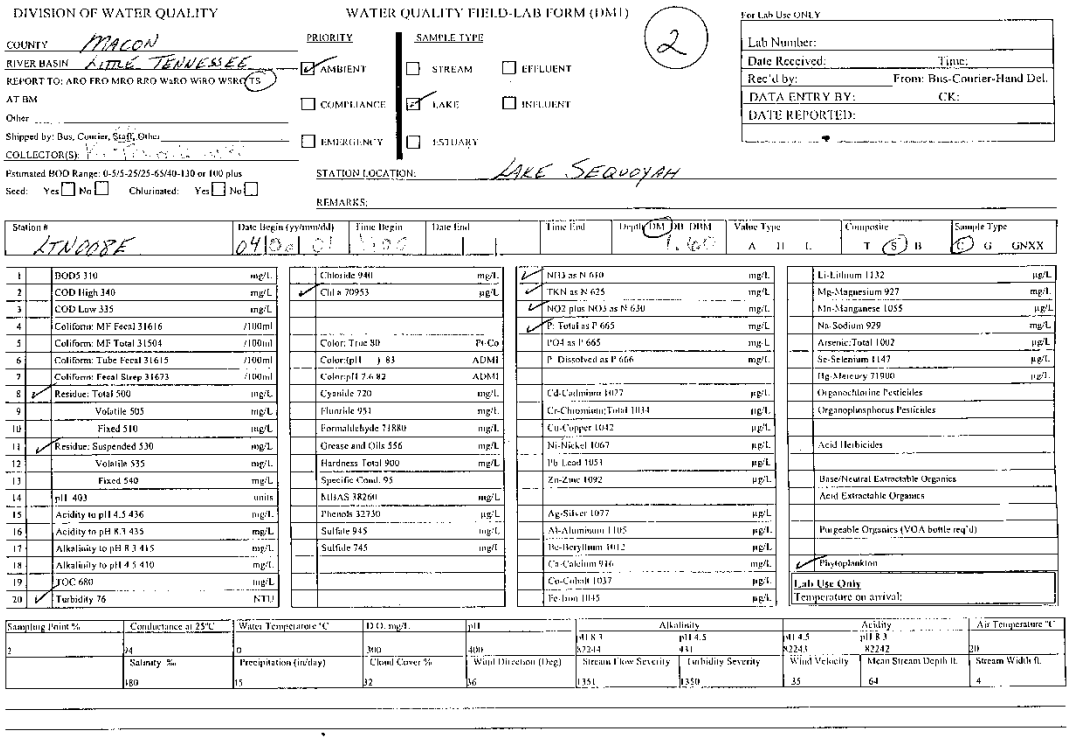
An example of a completed sample submission form is shown in Figure B3.1. Most information is pre-printed; however, the following fields must be completed by field staff using waterproof ink:

- Collector(s): Collector's first initial and last name (e.g., J. Smith)
- Date Begin: Date sampled (yymmdd)
- Time Begin: Time sampled (hhmm)
- Depth: For photic samples, depth of photic zone sample; depth of bottom for bottom grab samples; this field already completed for surface grab samples
- Sample set ID: Unique shorthand identifier allowing sample to be matched to appropriate sample tag

Sample Identification Tag

An example of a completed tag used for sample identification is shown in Figure B3.3. Tags should be filled out using waterproof ink and attached to the neck of the appropriate sample bottle with rubber bands immediately after sampling.

Figure B3.1: ALMP Sample Submission Form



DIVISION OF WATER QUALITY — WATER QUALITY FIELD-LAB FORM (DM1) — 2

COUNTY: MACON
RIVER BASIN: LITTLE TENNESSEE
REPORT TO: ARO FRO MRO RRO WaRO WRO WSRO TS
AT BM
Other
Shipped by: Bus, Courier, Staff, Other
COLLECTOR(S):
Estimated BOD Range: 0-5/5-25/25-65/40-130 or 100 plus
Seed: Yes ☐ No ☐ Chlorinated: Yes ☐ No ☐

PRIORITY: ☑ AMBIENT ☐ COMPLIANCE ☐ EMERGENCY
SAMPLE TYPE: ☐ STREAM ☐ EFFLUENT ☑ LAKE ☐ INFLUENT ☐ 1ST DARY
STATION LOCATION: LAKE SEQUOYAH
REMARKS:

For Lab Use ONLY
Lab Number:
Date Received: Time:
Rec'd by: From: Bus-Courier-Hand Del.
DATA ENTRY BY: CK:
DATE REPORTED:

Station #	Date Begin (yy/mm/dd)	Time Begin	Date End	Time End	Depth: DM DB DHM	Value Type A I L	Composite T S B	Sample Type C G GNXX
LTN008E	04 06 01	1105			1 60		S	C

1		BOD5 310	mg/L		Chloride 940	mg/L	✓	NH3 as N 610	mg/L		Li-Lithium 1132	µg/L
2		COD High 340	mg/L	✓	Chl a 70953	µg/L	✓	TKN as N 625	mg/L		Mg-Magnesium 927	mg/L
3		COD Low 335	mg/L				✓	NO2 plus NO3 as N 630	mg/L		Mn-Manganese 1055	µg/L
4		Coliform: MF Fecal 31616	/100ml		Color: True 80	Pt-Co	✓	P: Total as P 665	mg/L		Na-Sodium 929	mg/L
5		Coliform: MF Total 31504	/100ml		Color:(pH) 83	ADMI		PO4 as P 665	mg/L		Arsenic:Total 1002	µg/L
6		Coliform: Tube Fecal 31615	/100ml		Color:pH 7.6 82	ADMI		P: Dissolved as P 666	mg/L		Se-Selenium 1147	µg/L
7		Coliform: Fecal Strep 31673	/100ml		Cyanide 720	mg/L					Hg-Mercury 71900	µg/L
8	✓	Residue: Total 500	mg/L		Fluoride 951	mg/L		Cd-Cadmium 1027	µg/L		Organochlorine Pesticides	
9		Volatile 505	mg/L		Formaldehyde 71880	mg/L		Cr-Chromium;Total 1034	µg/L		Organophosphorus Pesticides	
10		Fixed 510	mg/L		Grease and Oils 556	mg/L		Cu-Copper 1042	µg/L			
11	✓	Residue: Suspended 530	mg/L		Hardness Total 900	mg/L		Ni-Nickel 1067	µg/L		Acid Herbicides	
12		Volatile 535	mg/L		Specific Cond. 95			Pb-Lead 1051	µg/L			
13		Fixed 540	mg/L		MBAS 38260	mg/L		Zn-Zinc 1092	µg/L		Base/Neutral Extractable Organics	
14		pH 403	units		Phenols 32730	µg/L					Acid Extractable Organics	
15		Acidity to pH 4.5 436	mg/L		Sulfate 945	mg/L		Ag-Silver 1077	µg/L			
16		Acidity to pH 8.3 435	mg/L		Sulfide 745	mg/L		Al-Aluminum 1105	µg/L		Purgeable Organics (VOA bottle req'd)	
17		Alkalinity to pH 8.3 415	mg/L					Be-Beryllium 1012	µg/L			
18		Alkalinity to pH 4.5 410	mg/L					Ca-Calcium 916	mg/L	✓	Phytoplankton	
19		TOC 680	mg/L					Co-Cobalt 1037	µg/L		Lab Use Only	
20	✓	Turbidity 76	NTU					Fe-Iron 1045	µg/L		Temperature on arrival:	

Sampling Point %	Conductance at 25°C	Water Temperature °C	D.O. mg/L	pH	Alkalinity pH 8.3	Alkalinity pH 4.5	Acidity pH 4.5	Acidity pH 8.3	Air Temperature °C
2	94	0	300	400	82244	441	82243	82242	20
	Salinity ‰	Precipitation (in/day)	Cloud Cover %	Wind Direction (Deg)	Stream Flow Severity	Turbidity Severity	Wind Velocity	Mean Stream Depth ft.	Stream Width ft.
	180	15	32	36	1351	1350	35	64	4

Figure B3.2: Flow of ALMP Sample Submission Forms

SAMPLE SUBMISSION FORMS CREATED

- Each month's forms printed by ALMP Coordinator and given to field staff.
- Includes sample set ID, station information, and all samples scheduled.
- Separate sheets for:
  - Surface grabs
  - Bottom grabs
  - Photic zone composites

Sample Submission Forms are completed in the field

SAMPLES SUBMITTED FOR ANALYSES

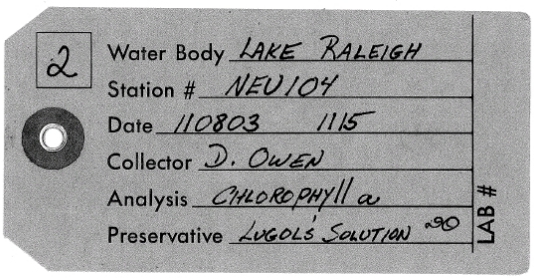
Samples and completed Sample Submission Forms are submitted to Laboratory

ANALYTICAL RESULTS

Within 30 days of submittal, Sample Submission Forms and Lab Results are returned to ALMP Coordinator for review and data entry.

Sample Submission Forms are

Figure B3.3: Completed ALMP Sample Tag



Guidance for proper completion of sample tags is listed below:

- Water Body: Station location description
- Station #: lake station number
- Date: Date sampled (yymmdd); for chlorophyll a and fecal coliform bacteria samples, the time that the sample was collected is added behind the date (hhmm)
- Collector: Name of collector (first initial, last name)
- Analysis: Name of analysis requested
- Preservative: Identification of preservation methods. This item is initialed by collector upon preservation of sample with chemical preservative.
- Sample set ID: Box in upper left hand corner; unique shorthand identifier allowing sample to be matched to appropriate sample submission sheet

Note that forms for surface (SUR) and bottom (BOT) samples have the station number followed SUR or BOT (examples: LTN008ESUR or LTN008EBOT).

Sample Transport

Immediately after sampling, labeling, and chemical preservation, samples are placed in coolers on ice. Sample submission forms are placed in a sealable waterproof bag and are taped to the inside of the cooler if samples are to be shipped. Otherwise, the forms are kept with the field staff until the coolers are delivered to the lab. Coolers are then either delivered to the lab by field staff or sealed and shipped via the NC Department of Administration's Courier Service to the appropriate lab.

Laboratory

Once samples arrive at the laboratory, support staff check the temperature blank (included in each cooler) to ensure that the samples are within the appropriate temperature range (4°C, ±2°), assign lab tracking numbers, and distribute the samples to the appropriate analytical units.

Any samples not meeting temperature, holding time, or preservation requirements, or otherwise not submitted in accordance with the SOP are subject to rejection as per Section 7.0 of the Laboratory's QAM (Attachment 2). Laboratory staff will attempt to contact the collector by phone or email before rejecting samples. If conditionally accepted, the laboratory will document the anomaly as a "Sample Condition Upon Receipt" (SCUR) and/or Sample Anomaly Report (SAR) form and include copies with the final analytical report. Results from anomalous samples will also be reported using the appropriate qualification code.

For details of laboratory protocols for sample receipt and handling, refer to Section 7: Sample Custody of the Laboratory's QAM (Attachment 2).

B4. Analytical Methods

Field Measurements

All field parameter measurements performed in the field are listed in Table B4.1. Methods for measurement of these parameters are included in Section III of the ISU SOP (Attachment 1). Instruction manuals for the appropriate meter should also be consulted for instruction on proper meter operation.

Table B4.1: Field Measurement Method References and Reporting Levels

Parameter	EPA Method (if applicable)	Reported to Nearest…
Dissolved Oxygen	360.1	0.1 mg/L
pH	150.1	0.1 SU
Water temp	170.1	0.1 ºC
Specific conductance	120.1	1 umhos/cm
Depth		0.1 m
Secchi depth		0.1 m

Lab Analyses

A summary of methods and reporting limits are listed below in Table B4.2. More detailed information on sample preparation methods, approved method modifications, method performance criteria, precision, accuracy, MDLs and PQLs can be found in the Laboratory Section's QAM (Attachment 2; Table 5.1: QA Targets for Accuracy, Precision, and MDLs/PQLs and Section 8: Analytical Procedures).

Table B4.2: Analytical Method References and Reporting Levels

Parameter	EPA Methods	APHA Methods	Other Methods	Practical Quantitation Limit (PQL)	PQL Revision Date
pH		SM 4500-H+ B		0.01 units from 4.01 - 9.18 s.u.	3/13/2001
Conductance @ 25°C		SM 2510 B		14.9 µmhos/cm	3/30/2001
BOD_5		SM 5210 B		2.0 mg/L	3/13/2001
$CBOD_5$		SM 5210 B		2.0 mg/L	6/5/2007
COD			HACH 8000	20 mg/L	9/5/2002
Coliform, MF Fecal		SM 9222 D		1 colony/100 mL	3/13/2001
Coliform, MF Total		SM 9222 B		1 colony/100 mL	3/13/2001
Coliform, Tube Fecal		SM 9221 B		MPN/100 mL	3/13/2001
Coliform, Fecal Strep		SM 9230 C		1 colony/100 mL	3/13/2001
Total Residue		SM 2540 B		12 mg/L	6/1/2007
Total Volatile Residue	EPA 160.4			12 mg/L	6/1/2007
Total Fixed Residue	EPA 160.4			12 mg/L	6/1/2007
Total Suspended Residue		SM 2540 D		6.2 mg/L	6/1/2007
Suspended Volatile Residue	EPA 160.4			6.2 mg/L	6/1/2007
Suspended Fixed Residue	EPA 160.4			6.2 mg/L	6/1/2007
Total Dissolved Residue		SM 2540 C		12 mg/L	6/1/2007
Alkalinity to pH 8.3		SM 2320 B		1 mg/L	3/13/2001
Alkalinity to pH 4.5		SM 2320 B		1 mg/L	3/13/2001
TOC		SM 5310 B		2 mg/L	
Turbidity	EPA 180.1 Rev. 2.0 (1993)	SM 2130 B		1 NTU	3/13/2001
Chloride	EPA 300.0 Rev. 2.1 (1993)		QUIK CHEM 10-510-00-1-A$	1 mg/L	4/1/2007
Chlorophyll *a* EPA 445.0 modified option	EPA 445.0			1 µg/L*	3/13/2001
Color: True		SM 2120 C		5 color units	3/13/2001
Color: ADMI		SM 2120 E		25 color units	3/13/2001
Cyanide, Total	EPA 335.4 Rev. 1.0 (1993)$		QUIK CHEM 10-204-00-1-A QUIK CHEM 10-204-00-1-X	0.02 mg/L	4/22/2002
Fluoride	EPA 300.0 Rev. 2.1 (1993)		QUIK CHEM 10-510-00-1-A$	0.4 mg/L	4/1/2007
Formaldehyde			APHA, 1972 Method 111	0.2 mg/L	2/21/2003
HEM (Oil and Grease)	EPA 1664 A			10 mg/L	11/1/2005
HEM (Oil and Grease) sludge, sediment and solid samples			SW-846 9071 B	1000 mg/Kg	11/1/2005

*

Parameter	EPA Methods	APHA Methods	Other Methods	Practical Quantitation Limit (PQL)	PQL Revision Date
MBAS		SM 5540 C		0.1 mg/L	3/13/2001
Phenols	EPA 420.4 Rev. 1.0 (1993)		QUIK CHEM 10-210-00-1-A$	10 µg/L	
Silica		SM 4500-SiO2 C	QUIK CHEM 10-114-27-1-A$	2 mg/L	4/16/2002
Sulfate	EPA 300.0 Rev. 2.1 (1993)		QUIK CHEM 10-510-00-1-A$	2 mg/L	4/1/2007
Sulfide		SM 4500-S2 D		0.1 mg/L	3/13/2001
Hexavalent Chromium		SM 3500-Cr B (20th Edition)		50 µg/L	4/22/2002
NH3 as N	EPA 350.1 Rev. 2.0 (1993)		QUIK CHEM 10-107-06-1-J$	0.02 mg/L	3/1/2009
TKN as N	EPA 351.2 Rev. 2.0 (1993)		QUIK CHEM 10-107-06-2-H$	0.20 mg/L	3/1/2009
NO2 + NO3 as N	EPA 353.2 Rev. 2.0 (1993)		QUIK CHEM 10-107-04-1-C$	0.02 mg/L	3/1/2009
P, Total as P	EPA 365.1 Rev. 2.0 (1993)		QUIK CHEM 10-115-01-1-EF$	0.02 mg/L	6/1/2008
PO4 as P	EPA 365.1 Rev. 2.0 (1993)		QUIK CHEM 10-115-01-1-A$	0.02 mg/L	3/1/2009
P, Dissolved as P	EPA 365.1 Rev. 2.0 (1993)		QUIK CHEM 10-115-01-1-EF$	0.02 mg/L	3/1/2009
NO2 as N	EPA 353.2 Rev. 2.0 (1993)		QUIK CHEM 10-107-04-1-C$	0.01 mg/L	3/1/2009
Boron	EPA 200.7 Rev. 4.4 (1994)			50 µg/L	1/12/2009
Cadmium	EPA 200.8 Rev. 5.4 (1994) EPA 200.9 Rev. 2.2 (1994)$			1.0 µg/L	1/2/2007
Chromium, Total	EPA 200.8 Rev. 5.4 (1994) EPA 200.7 Rev. 4.4 (1994)$			10 µg/L	1/2/2007
Copper	EPA 200.8 Rev. 5.4 (1994) EPA 200.9 Rev. 2.2 (1994)$			2.0 µg/L	3/13/2001
Nickel	EPA 200.8 Rev. 5.4 (1994) EPA 200.9 Rev. 2.2 (1994)$			2 µg/L	3/1/2011
Lead	EPA 200.8 Rev. 5.4 (1994) EPA 200.9 Rev. 2.2 (1994)$			2 µg/L	3/1/2011
Zinc	EPA 200.8 Rev. 5.4 (1994) EPA 200.7 Rev. 4.4 (1994)$			10 µg/L	3/13/2001
Silver	EPA 200.8 Rev. 5.4 (1994) EPA 200.9 Rev. 2.2 (1994)$			5 µg/L	3/13/2001
Aluminum	EPA 200.7 Rev. 4.4 (1994)			50 µg/L	3/13/2001

EPA refers to *Methods for Chemical Analysis of Water and Wastes* , USEPA Office of Research and Development, Rev. 3/83 (unless otherwise specified). Cincinnati, OH; EPA 600/4-79-02(

SM refers to *Standard Methods for the Examination of Water and Wastewater* , 18th Edition (unless otherwise specified), American Public Health Association, Washington, DC, 1992 (unles otherwise specified).

SW-846 refers to *Test Methods for Evaluating Solid Wastes, Physical/Chemical Methods* ; 3rd edition (9/86), USEPA Office of Solid Waste and emergency Response, Washington, D.C.

HACH refers to Hach Chemical Company, PO Box 389, Loveland, CO 80537.

QUIK CHEM refers to HACH Company/Lachat Instruments, Milwaukee, WI, 53219.

* - under evaluation

$ - secondary method reference

F

B5. Quality Control Requirements

Field Activities

Field water quality instruments are calibrated for each sampling trip prior to that day's work. Meter calibrations for dissolved oxygen (D.O.), pH, and specific conductance are checked after each sampling trip to confirm that significant drift has not occurred and that the data collected is accurate and representative. If post-sampling calibration readings are beyond acceptable limits (D.O. = ±0.5; pH = ±0.2; conductance = ±10%), the data are discounted and are not entered into the databases.

A temperature blank is included in each cooler containing samples to be analyzed by the Central Laboratory.

Laboratory Activities

Quality control for analytical samples is conducted per Section 11 of the Laboratory Section's QAM (Attachment 2).

B6. Instrument/Equipment Testing, Inspection, and Maintenance

A routine preventative maintenance program minimizes the occurrence of instrument and equipment failures. All equipment should be visually inspected for damage at the start of each sampling day and repaired or cleaned if needed before further use. Required maintenance is shown in Table B6.1.

Field Equipment

Information on equipment cleaning is supplied in Chapter VI of the ISU SOP for field meters, equipment, and vehicles (Attachment 1). Other required maintenance is shown in Table B6.1. Operator's manuals for all equipment should be consulted for manufacturer's recommendations for inspection, maintenance, and repair. Problems with meters and other equipment should be reported to the ISU Equipment Manager who is responsible for overseeing equipment maintenance and repairs.

Table B6.1: Field Equipment Maintenance

Equipment	Task	Frequency
Multiparameter Meters	Check battery level	Daily
	Inspect membrane for holes, tears, bubbles, fouling or other damage	Daily
	Inspect probes for damage,	
Labline®	Check distance measurements on rope	Annually
	Clean and inspect Labline®	Before each sampling trip
Secchi Disk	Check distance measurements on rope	Annually

Laboratory Analytical Equipment

For laboratory equipment and instrument inspection and maintenance, refer to the Laboratory Section's QAM, Table 10.1 (Attachment 2).

B7. Instrument Calibration & Frequency

Field Meters

Field meters are inspected and calibrated before each sampling trip and at the beginning and end of each day used. Pre- and post-sampling calibration information is recorded on the Water Quality Monitoring Field Meter Calibration Sheet (Attachment 5). Completed calibration forms are stored in the ISU calibration room and are retained for at least five years. The specific calibration procedures are documented in Section III of the Intensive Survey Unit's SOP (Attachment 1) and in each meter's instruction manual.

Calibration standards are selected so that they bracket the range of measurements expected that day. Meters should also be checked against standards periodically throughout the day and recalibrated if needed if any of the following occur:

- Physical shock to meter;
- DO membrane is touched, fouled, or dries out;
- Unusual (high or low for the particular site) or erratic readings, or excessive drift;
- Extreme readings (e.g., extremely acidic or basic pH; D.O. saturation >120%);
- Measurements are outside of the range for which the meter was calibrated.

Standards

Traceable conductivity standards and standards for pH (buffers) are purchased. Meters currently used to measure pH require standards of 4.0, 7.0, and 10.0 S.U. Conductivity standards used are 500 and 1000 μmhos/cm at 25 °C.

Laboratory Instrumentation Calibration

For details of laboratory requirements and methods of calibration of analytical laboratory instrumentation, refer to Section 9 of the Laboratory Section's QAM (Attachment 2).

B8. Inspection/Acceptance Requirements for Supplies and Consumables

Sample submissions requirements (i.e. container specifications, minimum sample volumes, preservation, and holding times) are listed in Figure 6.1 of the Laboratory's QAM (Attachment 2).

The Central Laboratory is responsible for purchasing and quality assuring sample bottles, reagents, and chemical preservatives used by the ALMP field staff.

ALMP field staff members are responsible for visibly inspecting all sample bottles before use. Any bottles that are visibly dirty or whose lids have come off during storage are discarded. It is recommended that field staff periodically check bottles for contamination attributed to storage conditions by filling representative containers with analyte-free water (available from the Laboratory Section), adding the appropriate preservative(s), and submitting them to the laboratory for metals and wet chemistry analyses. Any container lots showing analyte levels at or above the reporting limits should be discarded.

Manufacturer's certificates of purity for chemical preservatives are retained by the Laboratory Section Support Unit. If alternative suppliers of chemical preservative are used by the ALMP, the preservatives must be ACS-grade or equivalent, and the manufacturer should provide a certificate of purity or equivalent indicating that contaminants of interest are below the Laboratory's current reporting limits. Any preservatives that show signs of contamination, such as discoloration or the presence of debris or other solids, should be not be used and should be discarded.

A list of supplies and consumables is available in Table B2.1.

B9. Acquired Data (Non-Direct Measurements)

All data will be generated through ALMP field activities and laboratory analyses, with the following exceptions:

48-hour precipitation (inches/day): Data are obtained from the State Climate Office of North Carolina via the NC CRONOS database, which is available on the Internet at: http://www.nc-climate.ncsu.edu/cronos/. There are data available from approximately 657 weather monitoring stations across NC. If an appropriate station cannot be located, field staff may obtain approximate values from local news' weather services or the National Weather Service. In both cases, data are used for relative interpretations of other parameters such as fecal coliform or turbidity that may be affected by recent runoff. Data may also be obtained from rain records maintained for reservoirs managed by the US Army Corps of Engineers.

Anecdotal lake information: Information regarding lake management activities, public complaints of water taste and odor, general water quality, and fish health are collected from lake managers, lake owners associations, public environmental groups, and water treatment facility supervisors. Other information, such as estimated aquatic weed coverage and observed algal blooms, is also collected from these sources.

Records of public complaints: Documented water quality issues are collected from public health departments and the NC Division of Health and Human Services, water treatment facility supervisors, NC Water Resources staff, NC Division of Water Quality Regional Office staff, universities, and power generation companies. Examples include letters of complaint from the public, laboratory and field studies, notices of swimming area closures, and fish consumption advisories.

Maps: USGS Quads, county map books and ALMP lake files are sources of maps used in locating lakes and stations on the lakes. Other map sources may be used. Latitude and longitude of lake stations are determined on the first sampling trip, are verified once every five years and are maintained in the AMLP database.

B10. Data Management

Field measurements and observations are recorded on Stratified Field Data Sheets and Field Observations Forms (Attachment 1; Figures 5 and 19). Completed field sheets are submitted to the ALMP Coordinator who manually enters the data into the Lakes Database. Original hardcopies of all Lake Stratified Field Data Sheets, Laboratory Analytical Reports and Lake Field Observations Forms are retained a minimum of ten years (or the most recent two sampling trips) in the "Lakes Files", which are located in the ESS building in Raleigh, NC. Table B10.1 presents the retention time for paper and electronic data generated by the Intensive Survey Unit.

Table B10.1. Retention times for Lakes Data generated by ISU.

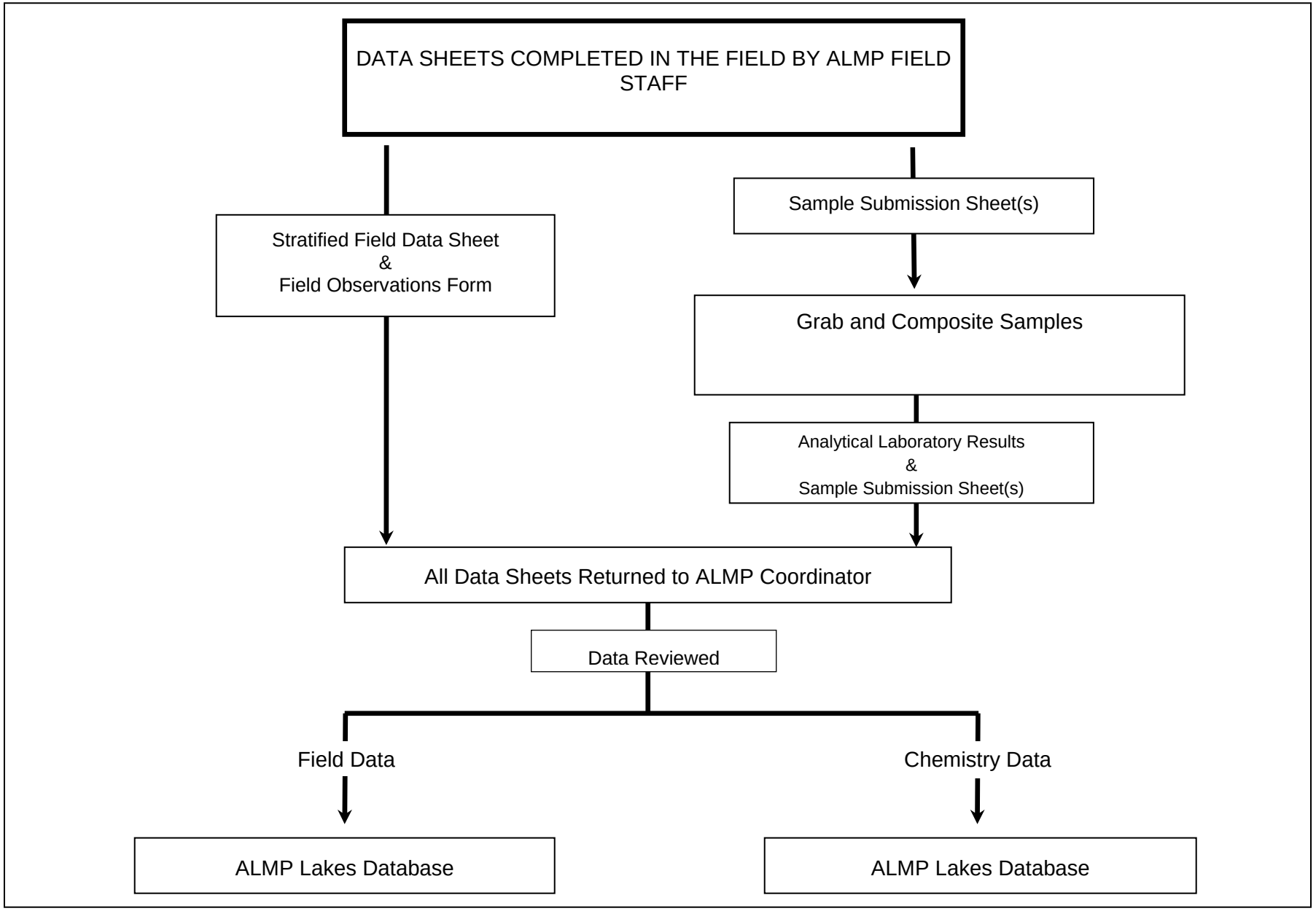
Record	Retention Time
Lake Stratified Field Data Sheet	The two (2) most recent sampling years for ambient monitoring
Laboratory Analytical Report	The two (2) most recent sampling years for ambient monitoring
Lake Field Observation Form	The two (2) most recent sampling years for ambient monitoring
Electronic Lake Monitorin Data	Indefinately

Immediately after collection, water samples and the corresponding Sample Submission Forms (Figure B3.1) are submitted to the Central Laboratory for analyses. Within 30 days of sample submission to the Central Laboratory, the ALMP Coordinator receives the Laboratory's analytical results (including data qualifier codes). Hardcopies of the Sample Submittal Forms and any Sample Anomaly Reports (SARs) or Sample Condition Upon Receipt (SCUR) forms are also provided to the ALMP Coordinator. The ALMP coordinator reviews all analytical results as they are received and manually enters these data into the Lakes Database.

The Lakes Database is "housed" on the ESS server, which is backed up every week. The ALMP Coordinator reviews the databases for completeness, data entry errors, unlikely/impossible values, etc. as detailed in Section D of this document. Data is provided to EPA and other parties upon request as electronic files or hard copy.

An overview of the data flow for the ALMP is displayed in Figure B10.1.

Figure B10.1: ALMP Data Flow



SECTION C: ASSESSMENT AND OVERSIGHT

C1. Data Quality Assessments & Response Actions

Data quality is a high priority for the ALMP and a comprehensive assessment and oversight program is currently under development. At present, a field audit to evaluate the QA/QC of sampling efforts is in place. Also, data entered into the Lakes Database is evaluated for completeness and accuracy following the receipt of the final laboratory sample report from the Central Laboratory for the summer lake sampling effort.

Field Monitoring

Each field crew is composed on at least one member that has participated in an annual lake monitoring audit. This individual is responsible for ensuring that proper meter calibration, sampling techniques and documentation are employed. Any modifications to sampling techniques are reviewed with all staff prior to start of the sampling season. The ALMP Coordinator is responsible for overseeing training of new crew members and training of staff in new lake monitoring methods.

Field staff participate every three years in the Laboratory's Sample Submission Training and annually in the USGS National Field Quality Assurance Program (NFQA). The NFQA was created in 1979 to provide quality-assurance reference samples to field personnel who make water quality field measurements. The program verifies the proficiency of pH, and specific conductance measurements collected by water quality field analysts. Staff failing a test are required to undergo additional training until proficiency is achieved. The ESS QA Coordinator coordinates this testing.

Further requirements are under developed.

Laboratory Activities

The Laboratory Section has a robust assessment program in place. Refer to Sections 13 and 14 of the Laboratory QAM for details (Attachment 2).

C2. Reports to Management

Reporting of issues related to data collected for the ALMP involve different approaches based on the nature of issues/deficiencies encountered in the course of the administration of this program. Methods of reporting include, but are not limited to the following:

- Oral and written notification to the ALMP Coordinator of issues related to sampling and data collection by field staff.
- Written reports regarding significant issues from the ALMP Coordinator to the Program Manager. Issues of interest to the Environmental Sciences Section as a whole are included in the Monthly Branch Update submitted by the Program Manager to the Section Chief.
- Oral and written notification to field staff and the ALMP Coordinator of significant issues related to sample submissions by the laboratories.
- Weekly oral reports on general status of ALMP to Program Manager.

A discussion of issues regarding QA assessments is included in the BAR, as needed. This discussion includes the parameter of concern, the nature of the QA issue and how the results for the parameter are affected. If the validity of the parameter results cannot be determined due to QA problems, the data are not included water quality assessments for the BAR or sent out as part of raw data requests.

SECTION D: DATA VALIDATION AND USABILITY

D1. Data Review, Verification, and Validation

Verification and validation occurs at each step of data generation and handling. It is the responsibility of field staff, laboratory bench chemists and support staff, and the ALMP Coordinator to verify that all records and results produced or handled are accurately transcribed, transmitted, and recorded. Each ALMP staff member is also responsible for ensuring that all activities (measurements, sampling, and analysis) comply with all requirements outlined in the following project documents:

- ALMP QAPP
- ISU SOP (Attachment 1)
- Laboratory Section QAM (Attachment 2)

The ALMP Coordinator performs primary review, validation, and verification duties of results reported by field staff and the Laboratory Section on an ongoing basis. This process involves comparison of new data with previously collected data and known historical water quality trends at the lake. If data are found to be unusual for a particular lake, actions may include a request to the lab to verify the data, an investigation of lake and watershed activities that could have influenced the data results, and a check of how the sample was collected to determine if sample collection and handling influenced the data results.

Field parameter data are considered invalid if post-sampling meter calibrations for DO, pH and specific conductance are beyond acceptable limits as indicated on the calibration sheet (Attachment 5). If meter calibrations are not within the acceptable limits, the data are discounted and are not entered in the Lakes Database.

D2. Validation and Verification of Methods

Field staff

Field staff will visually inspect the following items as they are produced to ensure accuracy and completeness:

Sample tags

Sample submission documentation

Field data worksheets

Lake descriptive data forms

Laboratory

The Laboratory Section's data verification and validation activities are described in their QAM (Attachment 2). *Section 7: Sample Custody* describes the activities involved in sample receipt and *Section 12.2: Data Verification* details the verification of analytical results.

In the event samples do not meet criteria outlined in the QAM, the Laboratory Section will indicate this using their standard Sample Condition Upon Receipt (SCUR) form, Sample Anomaly Report (SAR), and flag the subsequent result using a standardized list of qualifier codes. A full list of these codes is shown in Attachment 6.

ALMP Coordinator

The ALMP Coordinator, on an ongoing basis, performs the review, validation and verification of data results reported by field staff and the Laboratory Section. Data entry into the Lakes Database is also performed by the ALMP Coordinator.

When errors or omissions are found or suspected, corrections will be made using available hard copy laboratory reports and hand written field data forms. If these still do not contain the needed information, the field staff that conducted the sampling/measurement or the appropriate Laboratory Chemist will be contacted so they can consult their records. A determination of the source of the error is made (i.e., sample analysis error, data transcription error, etc.). If the source of the error cannot be determined or if an accurate reading cannot be obtained, the data is dropped from the Lakes Database and a comment is added to indicate why the data was not entered. Data that have been given an SAR code or a SCUR are entered into the Comments block of the database with the laboratory SAR code. These data are not used for regulatory purposes but may be used to determine if additional sampling or staff training is required depending on the nature of the code.

Data end-users

Data retrievals from the ALMP that are found to have odd or possibly incorrect values should be brought to the attention of the ALMP Coordinator. Consultation with field staff and laboratory personnel will be employed as deemed necessary to resolve data questions or issues.

D3. Reconciliation With User Requirements

A main objective of the ALMP is to provide data for use in determining lake water quality. This information is combined with other available data by the ISU and Planning Section staff to support reporting requirements such as 303(d)/305(b) reporting.

Though the major objectives of the ALMP are best served by a relatively stable monitoring schema, the system does allow for some flexibility in addressing the needs of its primary data users. Adjustments to the current ALMP can be accommodated, if deemed appropriate and sufficient resources exist, as concerns are raised. Appropriate reasons for adjustments are discussed in Section B1 of this document.

The ALMP also undergoes regular reviews; each basin's lake station locations and the indicators measured are assessed during the Basinwide Planning process. ALMP staff participates in basinwide monitoring pre-planning meetings with regional office staff prior to the beginning of each sampling season. Appropriate adjustments are made in response to needs, emerging water quality issues, and concerns identified by Regional Office staff observations and public comments received regarding lake water quality/lake watershed issues.

SECTION E: REFERENCES

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ATTACHMENTS