AMBIENT MONITORING SYSTEM (AMS)

QUALITY ASSURANCE PROJECT PLAN

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

Approved by EPA
July 2012
Version 1.1

Abbreviations

AMS: Ambient Monitoring System
APHA: American Public Health Association
ARO: Asheville Regional Office
ATU: Aquatic Toxicity Unit
BAR: Basin Assessment Report
BAU: Biological Assessment Unit
BMP: Best Management Practices
CWA: Clean Water Act
DMF: Division of Marine Fisheries
DO: Dissolved Oxygen
DWQ: Division of Water Quality
EMT: Estuarine Monitoring Team
EPA: Environmental Protection Agency
ESS: Environmental Sciences Section
EU: Ecosystems Unit
FRO: Fayetteville Regional Office
HUC: Hydrologic Unit Code
ISU: Intensive Survey Unit
MDL: Method Detection Limit
MRO: Mooresville Regional Office
NC: North Carolina
NCDENR: North Carolina Department of the Environment and Natural Resources
NFQA: National Field Quality Assurance
NH_3: Ammonia
NO_2: Nitrite
NO_3: Nitrate
NPDES: National Pollutant Discharge Elimination System
P: Phosphorus
PQL: Practical Quantitation Limit
QA: Quality Assurance
QAM: Quality Assurance Manual
QAPP: Quality Assurance Project Plan
QC: Quality Control
RAMS: Random Ambient Monitoring System
RRO: Raleigh Regional Office
SOP: Standard Operating Procedures
STORET: STOrage and RETrieval data warehouse
TKN: Total Kjeldahl Nitrogen
TMDL: Total Maximum Daily Load
TSS: Total Suspended Solids
USGS: United States Geological Survey
WaRO: Washington Regional Office
WiRO: Wilmington Regional Office
WSRO: Winston-Salem Regional Office

REVISION LOG
AMBIENT MONITORING SYSTEM (AMS)
QUALITY ASSURANCE PROJECT PLAN

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

Date	Version	Section	Changes/Updates	Editor
12/1/2011	Ver. 1.0	Cover Page & Footers	Updated Document Date & version number to December 2011 and version 1.1	Andrea Thomas
12/1/2011	Ver. 1.0	Abbreviations	Updated Abbreviations	Andrea Thomas
12/1/2011	Ver. 1.0	Revision Log	Added Revision Log	Andrea Thomas
12/1/2011	Ver. 1.0	Table of Contents	Updated page numbers and Appendices	Andrea Thomas
12/1/2011	Ver. 1.0	Entire	Updated names and titles, removed WARO lab and NRRT and replaced PRRT with EMT	Andrea Thomas
12/1/2011	Ver. 1.0	URL links	All internet hyperlinks were checked and updated as necessary	Andrea Thomas
12/1/2011	Ver. 1.0	Figure A4.1	Removed NRRT and WARO Lab, Replaced PRRT with EMT	Andrea Thomas
12/1/2011	Ver. 1.0	A6, B1	Revised active station numbers	Andrea Thomas
12/1/2011	Ver. 1.0	Figures A6.1, B1.1	Updated map with active stations	Andrea Thomas
12/1/2011	Ver. 1.0	Table A6.1	Updated core and site-specific indicators	Andrea Thomas
12/1/2011	Ver. 1.0	Table A6.2	Replace table with Figure A6.2	Andrea Thomas
12/1/2011	Ver. 1.0	Appendix 3	Removed Appendix 3 and replaced with reference to BPU's website	Andrea Thomas
12/1/2011	Ver. 1.0	A9	Added Environmental Indicators Report	Andrea Thomas
12/1/2011	Ver. 1.0	Tables B1.1, B1.2	Updated Indicator lists and replaced action levels with standard	Andrea Thomas
12/1/2011	Ver. 1.0	Tables B2.1, B2.2	Updated tables and removed ISU column	Andrea Thomas
12/1/2011	Ver. 1.0	Table B4.1	Updated ISU SOP sections and removed reference point row	Andrea Thomas
12/1/2011	Ver. 1.0	Table B4.2	Updated methods and PQLs	Andrea Thomas
12/1/2011	Ver. 1.0	B7	Updated field meter section	Andrea Thomas
12/1/2011	Ver. 1.0	Table B8.1	Updated pH and conductivity standards	Andrea Thomas
12/1/2011	Ver. 1.0	B9	Removed USGS flow data bullet	Andrea Thomas

Date	Version	Section	Changes/Updates	Editor
12/1/2011	Ver. 1.0	B10	Revised Access database and STORET information	Andrea Thomas
12/1/2011	Ver. 1.0	Figure B10.1	Updated figure; removed WARO lab and added STORET	Andrea Thomas
12/1/2011	Ver. 1.0	Table D2.1	Updated data qualifiers	Andrea Thomas
12/1/2011	Ver. 1.0	References	Updated references	Andrea Thomas
12/1/2011	Ver. 1.0	Appendix 1,2,4-8	Updated each Appendix to current version of each document	Andrea Thomas
12/14/2011	Ver. 1.0	A6, Appendix 9	Added RAMS information	Andrea Thomas
12/14/2011	Ver. 1.0	Figure A4.1	Added BAU	Andrea Thomas

SECTION A:

PROJECT MANAGEMENT

A1. Signature and Approval Sheet

Approved by:

RECEIVED
JUL 17 2012
Environmental Sciences Section

Andrea Thomas 12/21/2011
Andrea Thomas
AMS Coordinator
Environmental Sciences Section, NC DWQ
Date

Steven Kroeger 12/21/2011
Steven Kroeger
Ecosystems Unit Supervisor
Environmental Sciences Section, NC DWQ
Date

Joanna Gmyr 12/21/2011
Joanna Gmyr
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

Abbreviations ……..2
Ambient Monitoring System QAPP Revision Log ……3

A. PROJECT MANAGEMENT
A1. Signature And Approval Sheet 7
A2. Table Of Contents 9
A3. Distribution List 11
A4. Project Organization 12
A5. Problem Definition And Background 16
A6. Project/Task Description And Schedule 18
A7. Quality Objectives And Criteria 25
A8. Special Training/Certifications 27
A9. Documentation And Records 28

B. DATA GENERATION AND ACQUISITION
B1. Sampling Process Design 32
B2. Sampling Methods..... 36
B3. Sample Handling And Custody..... 39
B4. Analytical Methods 41
B5. Quality Control..... 42
B6. Instrument/Equipment Testing, Inspection, And Maintenance..... 43
B7. Instrument Calibration & Frequency..... 45
B8. Inspection/Acceptance Requirements For Supplies And Consumables 45
B9. Non-Direct Measurements 46
B10. Data Management 47

C. ASSESSMENT AND OVERSIGHT
C1. Assessments & Response Actions..... 50
C2. Reports To Management 50

D. DATA VALIDATION AND USABILITY
D1. Data Review, Verification, And Validation..... 52
D2. Validation And Verification Methods..... 52
D3. Reconciliation With User Requirements..... 55

References……..57

Appendices
1. Organizational Information
2. NC Water Quality Standards Summary
3. Station Information
4. Sample Submission Documentation
5. Data Assessment Document
6. Data Review Checklists and Methods
7. Intensive Survey Unit SOP
8. Laboratory Section QA Information
9. Random Ambient Monitoring System Information

FIGURES

A4.1: AMS Organizational Chart 12
A5.1: NC Major River Basins 16
A6.1: AMS Station Locations (counties and basins) 19
A6.2: Rotating Basin Assessment Cycle 22
B1.1: AMS Station Locations (basins) 32
B2.1: Bridge Sampler 37
B2.2: Labline Sampler 37
B2.3: Labline Sampler Schematic.....37
B3.1: Sample Submission Form Generation.....39
B10.1: Data Flow.....48
D3.1: Sample size, number of exceedances, and statistical confidence.....56

TABLES

A5.1: NC Stream Classifications and Uses.....17
A6.1: Water Quality Indicators.....20
A9.1: Project Records and Retention Times.....29
B1.1: Core Indicators.....34
B1.2: Supplemental Indicators.....35
B2.1: Disposables and Sources.....38
B2.2: Equipment and Sources.....38
B4.1: Field Measurement Method References and Reporting Levels.....41
B4.2: Analytical Method References and Lower Reporting Levels (PQLs).....42
B6.1: Equipment Maintenance.....44
B8.1: Consumable Inspections and Acceptance Criteria.....46
D2.1: Common Data Qualifier Codes (flags).....53

A3. Distribution List

See Appendix 1 for contact information

Primary Distribution:

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

Marion Hopkins, NC Monitoring, Grant Technical Officer
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

Jay Sauber, Environmental Sciences Section Chief

Eric Fleek, Biological Assessment Unit Supervisor
Steven Kroeger, Ecosystems Unit Supervisor
Jason Green, Intensive Survey Unit Supervisor
Cindy Moore, Aquatic Toxicology Unit Supervisor
Jill Paxson, Estuarine Monitoring Team Leader

Jeff DeBerardinis, Fish Tissue Monitoring Program Coordinator
Joanna Gmyr, Quality Assurance Coordinator
Debra Owen, Lakes Monitoring Program Coordinator
Andrea Thomas, Ambient Monitoring System Coordinator
Bryn Tracy, Stream Fish Community Assessment Program Coordinator
Michael Walters, Benthic Macroinvertebrate Community Assessment Program Coordinator

Burt Simons, Estuarine Monitoring Team
Gary Davis, Estuarine Monitoring Team

Regional Office Surface Water Protection Supervisors:
Corey Basinger, Winston-Salem (WSRO)
Chuck Cranford, Asheville (ARO)
Jim Gregson, Wilmington (WiRO)
Belinda Henson, Fayetteville (FRO)
Al Hodge, Washington (WaRO)
Rob Krebs, Mooresville (MRO)
Danny Smith, Raleigh (RRO)

Regional Office Ambient Monitoring Technicians:
James Aaron, Asheville (ARO)
Stephanie Garrett, Wilmington (WiRO)
John Iverson, Winston-Salem (WSRO)
Kent Smith, Mooresville (MRO)
Danny Strickland, Fayetteville (FRO)
[vacant], Raleigh (RRO)

Planning Section

Alan Clark, Planning Section Chief

Courtesy distribution:

Coleen Sullins, NC Division of Water Quality Director
Chuck Wakild, NC Division of Water Quality Deputy Director
Matt Matthews, Surface Water Protection Section Chief
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

All activities involved with the AMS are performed by NC Division of Water Quality (DWQ) staff. Generally speaking, project management, QA, data management, analysis and reporting are performed by staff in the Environmental Sciences Section. Field work is performed by staff in seven Regional Offices under the regional Surface Water Protection Supervisor and by staff on the Estuarine Monitoring Team, who are supervised by the ESS Chief. Chemical, physical, and coliform analyses are performed by the two laboratories in the Laboratory Section. Results from the AMS are provided to Planning Section staff who use this information to support EPA reporting requirements such as the 303(d) and 305(b) integrated report, as well as general water quality basin planning activities.

An abbreviated organizational chart for the DWQ indicating the Units involved in the AMS is provided in Figure A4.1. Information on specific individuals' roles and responsibilities follows. Phone numbers and addresses for the offices listed below can be found in Appendix 1, along with more detailed organizational charts.

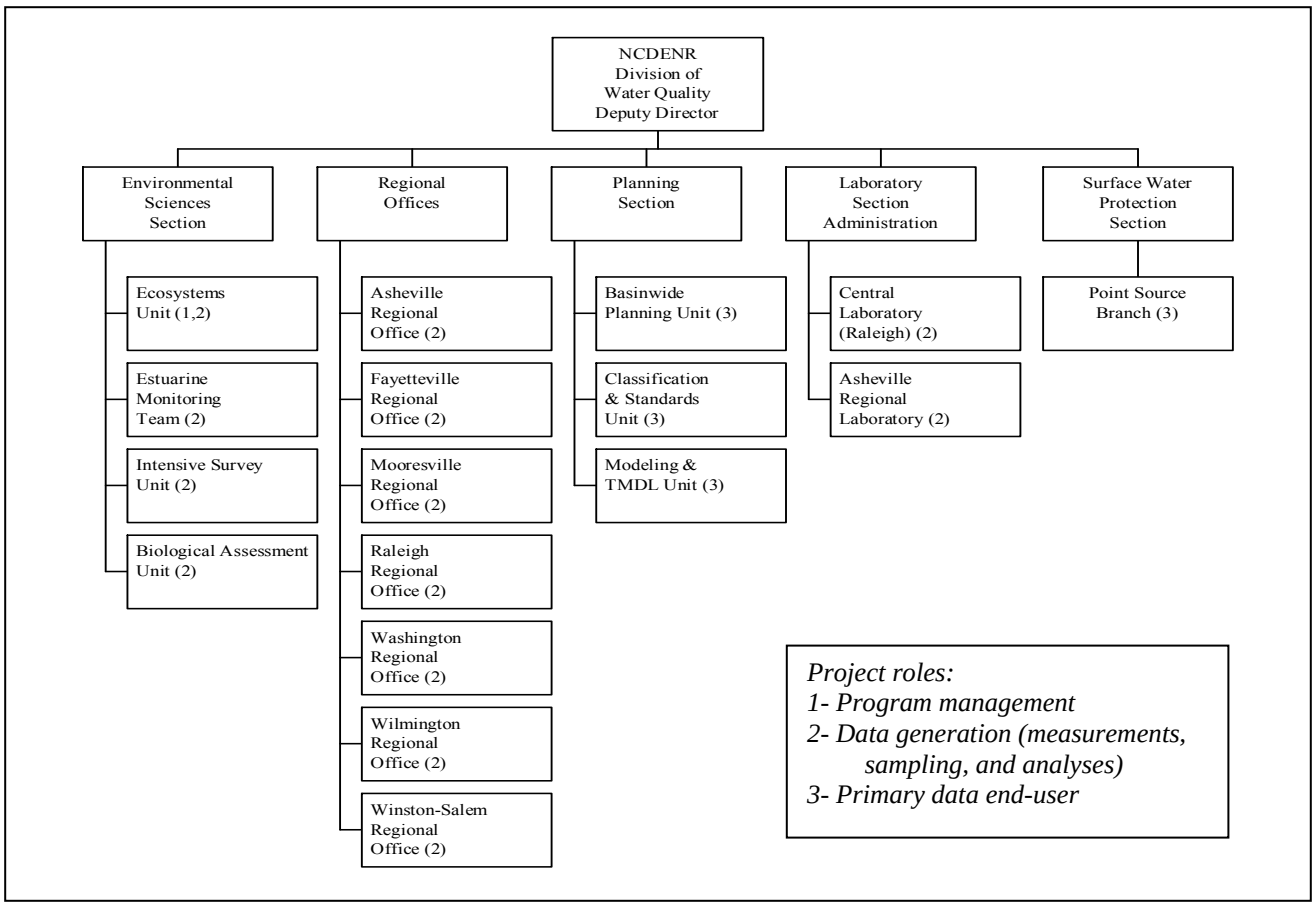


Figure A4.1: AMS Organizational Chart

Project Management and Oversight

Project Manager
Steven Kroeger
Supervisor, Ecosystems Unit

- Supervises AMS Coordinator/Data Manager, Water Quality Analyst, and QA Coordinator.
- Ultimately responsible for ensuring that program is conducted in accordance with this QAPP.
- 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
Andrea Thomas
AMS Coordinator, Ecosystems Unit

- 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 AMS to Project Manager for approval.
- Performs all aspects of data management, including tracking, compilation, review, coordinating data entry by ESS support staff, identifying and correcting errors, and upload of data to databases. Maintains in-house Microsoft Access data warehouses. Responsible for STORET metadata maintenance and data upload.
- Fulfills requests for raw data.
- Assists in training field staff.
- Performs field staff reviews, audits, and station visits to ensure compliance with QAPP and SOPs and communicates needed corrective actions to Project Manager and field staff supervisors when needed.
- Performs annual fecal coliform data screening and analysis.

Data Analyst and Reporting
Tammy Hill
Water Quality Analyst, Ecosystems Unit

- Performs data analysis and prepares AMS section of the ESS Basin Assessment Reports.
- Summarizes RAMS data in reports.
- Performs other statistical analyses as required.

Computer Support
Donald Kean
Computer Consultant, Environmental Sciences Section

- Provides technical support to ESS staff for in-house and STORET databases.
- Database administrator for Microsoft Access based STORET database.

Project QA Coordinator
Joanna Gmyr
ESS QA Coordinator, Ecosystems Unit

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

Field activities

Regional Office and Team Supervisors
Rob Krebs, MRO Surface Water Protection Supervisor
Jay Sauber, ESS Chief and EMT Supervisor
Belinda Henson, FRO Surface Water Protection Supervisor
Danny Smith, RRO Surface Water Protection Supervisor
Jim Gregson, WiRO Surface Water Protection Supervisor
Corey Basinger, WSRO Surface Water Protection Supervisor
Chuck Cranford, ARO Surface Water Protection Supervisor
Al Hodge, WaRO Surface Water Protection Supervisor

- Responsible for enforcing response or corrective actions of supervised field staff as necessary.

Field staff
Regional Office Ambient Monitoring Technicians:
[vacant], RRO
John Iverson, WSRO
Stephanie Garrett, WiRO
Kent Smith, MRO
Danny Strickland, FRO
James Aaron, ARO
Estuarine Monitoring Team
Intensive Survey Unit Staff (backup field staff)

- Perform all field activities including field measurements, observations, and sampling in accordance with QAPP and SOPs.
- Notify immediate Supervisor and AMS Coordinator of any issues encountered.

Laboratory analyses

Laboratory Administration
Kent Wiggins
Chief, Laboratory Section

- Manages both DWQ laboratories (Central/Raleigh and Asheville), which perform all analyses on samples taken as part of the AMS.
- Responsible for oversight of all analytical activities and for ensuring that all activities are performed in accordance with the Laboratory Section Quality Assurance Manual (Appendix 8).

Laboratory Quality Assurance
Dana Satterwhite
QA/QC Officer, Laboratory Section

- Responsible for establishing, implementing and coordinating a comprehensive QA/QC program for environmental sampling and analyses performed by the North Carolina Division of Water Quality Laboratory Section, and ensuring that environmental data operations are of a quality that meet or exceed requirements for informed decision making.

Primary data end-users

Planning Section
Alan Clark
Section Chief, Planning Section

- Supervises Basinwide Planning Unit and Modeling & TMDL Unit. These units include numerous staff acting as primary end users of data produced by AMS.
- Staff from Basinwide Planning and Modeling & TMDL Units should:
  - Provide input to AMS Coordinator and Project Manager on changes needed to AMS program as part of a continuous program assessment process.
  - Report any data anomalies to AMS Coordinator and Project Manager.

U.S. EPA
EPA Region IV, Water Protection Division
Water Quality Planning Branch

- Review, provide comments, and approve QAPP and subsequent revisions on behalf of EPA Region 4.
- Perform mid-year and end of year assessments of all DWQ monitoring programs, including the AMS, to determine progress on tasks listed in the annual §106 grant workplan.

A5. Problem Definition and Background

Introduction

As part of funding agreements between the State and the Environmental Protection Agency (EPA), North Carolina agrees to monitor the waters of the state and report findings to the EPA, in order to support the goals of the Clean Water Act (CWA). The CWA defines as its 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".*

Major provisions of the CWA led to the development of state-based water pollution management controls, primarily based on development and enforcement of numerical and narrative water quality standards. The current numerical standards are described in the NC Administrative Code, Chapter 2, Subchapter 2B, commonly called the "Redbook" by DWQ staff. Summary tables of these standards are included in Appendix 2. The full text of the code is available online at http://portal.ncdenr.org/web/wq/ps/csu/rules.

Stream classifications and water quality standards

North Carolina consists of seventeen major river basins, as shown in Figure A5.1. Within each of these, all segments of every named waterbody have been given a stream classification based on its intended use, which determines the level of protection required. Major stream classifications and their corresponding uses are shown in Table A5.1.

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, swamp waters, future water supplies, and nutrient sensitive waters. More detailed descriptions of the State's stream classification system can be found on the DWQ Classification and Standards Unit's website at http://portal.ncdenr.org/web/wq/ps/csu/classifications. Stream classifications for individual stream reaches can be obtained through NCDENR's Basinwide Information Management System (BIMS) website at http://portal.ncdenr.org/web/wq/admin/bog/netsupport/bimsreports.

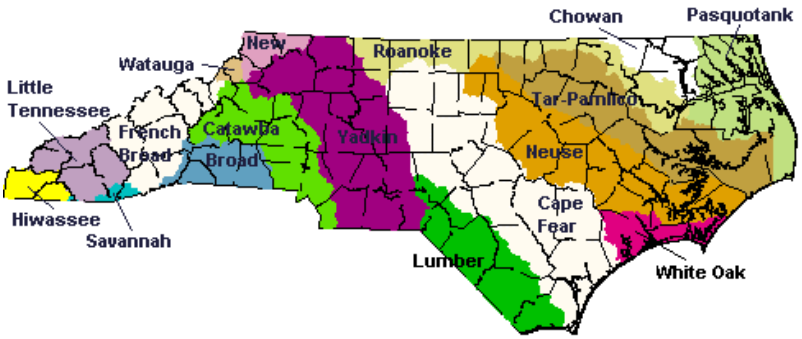


Figure A5.1: NC Major River Basins

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

- number and type of allowable discharges and permitted concentrations of pollutants
- 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

Table A5.1: NC Stream Classifications and Uses

Stream classification	Protected uses				
	Aquatic life	**Secondary recreation**	**Primary recreation**	**Water supply**	**Shellfish**
Freshwater					
C	x	x			
B	x	x	x		
WS (I-V)	x	x		x	
Saltwater					
SC	x	x			
SB	x	x	x		
SA	x	x			x

These managerial controls are meant as protective measures to allow attainment of the corresponding numerical instream water quality standards specifying the chemical, physical, and microbial pathogen levels required to ensure that the water is of sufficient quality for the stated use. These are tied to the stream classification, and consequently the uses those classifications represent.

AMS Objectives

The Ambient Monitoring System (AMS) is primarily designed to address three main objectives, but other projects within the DWQ have found that the data are suitable for their uses as well, so these programs' uses are listed as secondary objectives. These programs are asked to give input on design and modifications to the AMS program and these requests are accommodated whenever possible.

The AMS' Primary Objectives are:

- To monitor waterbodies of interest for determination of levels of chemical, physical, and bacterial pathogen indicators for comparison to a selection of the state's water quality standards.
- To identify locations where exceedances of water quality standards for physical and chemical indicators occur in more than 10% of samples/measurement (20% for coliforms).
- To identify long-term temporal or spatial patterns.

Data produced by the AMS are provided to several different Sections within the DWQ to help support their programs. Each one of these water quality management activities has fairly complex data needs and AMS data are generally not the only source of information used to support these programs. Individual Sections, Offices, or Units should be contacted for details on how AMS data are integrated into their projects. Contact information for these is included in Appendix 1.

The AMS' Secondary Objective is:

- To provide data suitable for supporting the following DWQ activities:

  Environmental Sciences Section
  - Background information for Intensive Survey Unit special studies, Biological Assessment Unit monitoring, and Aquatic Toxicity Unit investigations

  Planning Section
  - Biennial 303(d) and 305(b) reporting to EPA, including identification of areas of impairment or degradation
  - Basinwide Water Quality Plan development
  - TMDL development
  - Prioritization of restoration activities
  - Background information for reclassification studies
  - Triennial review of water quality standards

  Surface Water Protection Section, Point Source Branch
  - Identification of background levels of constituents for determination of NPDES permit limits
  - Identification of dischargers causing unacceptable impacts

  Regional Offices
  - Background information to assist with water quality management activities in each region

A6. Project/Task Description and Schedule

Overview

The AMS has been active in North Carolina for almost forty years. In the 1970's and 1980's, monitoring stations were generally located at fixed points above and below known point source dischargers to monitor their possible effects on surface water quality. With the institution of the NPDES permitting program in the late 1970's and its self-monitoring requirements, much of this oversight became redundant. Though some of these historic stations are still active and are useful for monitoring discharges that continue to have compliance issues, in more recent years attention has been shifted towards monitoring the effects of non-point sources of pollutants and representing the overall condition of watersheds.

The AMS consists of a relatively static network of stations located throughout the state to provide site specific, long-term water quality information on significant rivers, streams, and estuaries. The network is based on a judgmental design. Currently there are 323 active AMS stations established in all seventeen major basins and in 94 of the 100 counties across the state (Figure A6.1). All stations are georeferenced, with each station number assigned to a specific latitude and longitude. Though there are a few stations located on reservoirs, the main focus of the AMS is higher Strahler order rivers, streams, and estuaries. Most of the stations in the non-coastal regions are located at bridge crossings or other public accesses and are accessible by land. Estuaries and other large waterbodies are monitored by boat.

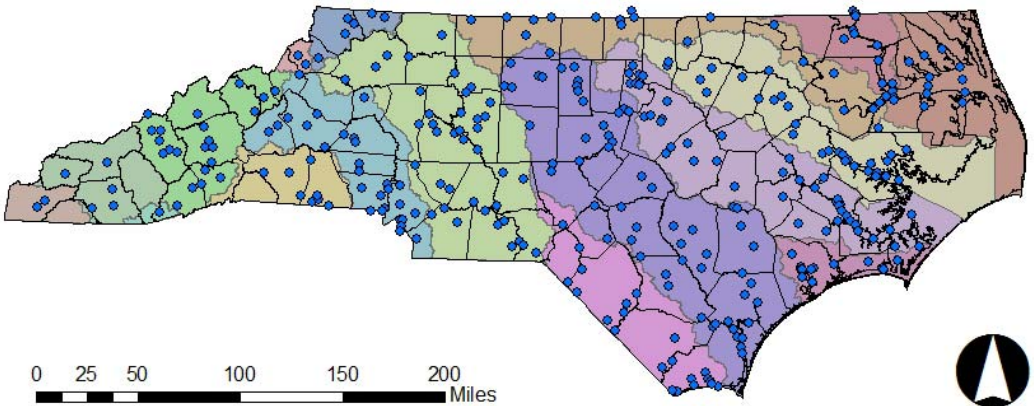


Figure A6.1: AMS Station Locations
Black lines indicate counties; colored regions indicate major basins; blue dots indicate AMS station locations

In January 2007, DWQ implemented the Random Ambient Monitoring System (RAMS) as a probabilistic component of the AMS. RAMS consists of station locations that are randomly located on freshwater streams (non-tidal, non-lake/reservoir, non-saltwater) throughout the state. Since RAMS is a component of AMS, they are very similar programs with a few differences. More information about RAMS is available in Appendix 9.

Water quality indicators

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

A basic core suite of indicators is measured at all stations (Table A6.1). Additional indicators may be included depending on site-specific concerns such as stream classification, discharge types, and historical or suspected issues. Additional field observations of weather conditions are also recorded at all site visits.

Occasionally, additional sampling requirements for other programs, such as ESS's Algal and Aquatic Plant Assessment program, can be accommodated if they are to be performed concurrently with regular AMS station visits. However, the methods and results for these other programs are not managed as part of the AMS and are not covered by this QAPP.

More information on indicators measured as part of the AMS is included in Section B1: *Sampling Process Design*.

Table A6.1: Water Quality Indicators

Indicator type	Core indicators	Site-specific indicators
Physical	Temperature Specific conductance Turbidity Total suspended solids (TSS) Stream flow severity	Salinity Secchi depth (transparency) Flow
Chemical	Dissolved oxygen (DO)	Nutrients (NH_3, NO_2 + NO_3, TKN, Total P) Total Hardness Chloride, Fluoride, Sulfate Color Oil and grease Dissolved Metals (arsenic, beryllium, cadmium, chromium, copper, manganese, lead, nickel, zinc)
Biological	Fecal coliform	Chlorophyll *a*
Other	Air temperature Cloud cover Wind velocity and direction 24 hour precipitation	

Sampling schedule

The AMS is geared towards collection of long-term data and is therefore a continuous project of indeterminate duration; there is no planned end date to data collection. Stations are visited at least monthly year-round for collection of field measurements and analytical samples. Sampling is performed by a designated Ambient Monitoring Technician in each Regional Office or by staff from the Estuarine Monitoring Team. In the case of staff shortages and/or position vacancies, trained substitute field staff, such as the AMS Coordinator or staff from the Intensive Survey Unit, may perform sampling as their primary duties and workloads allow.

Individual field staff determine their specific daily sampling schedule. This flexibility in scheduling site visits is needed to allow field staff to balance the AMS responsibilities with their other job duties (such as facility inspections and incident responses), inclement weather, and equipment availability. Each month's sampling must to be completed within five days after the end of the calendar month (i.e., January sampling must be completed by February 5).

Measurement methods overview

Field measurements

Measurements made in the field include water temperature, specific conductance, stream flow severity, salinity, Secchi depth, DO, air temperature, cloud cover, wind velocity and wind direction. Field measurements are to be made *in situ* by field staff at the time of the station visit.

The only acceptable exception to this is pH, since most pH probe cords are not long enough to reach a waterbody from a bridge crossing. In these cases, pH may be measured from a water sample as long as the analysis is performed within 15 minutes of sample collection. All field activities are to be performed in accordance with the ISU SOP (Appendix 7).

Analytical samples

Samples are submitted to the laboratories for analysis for turbidity, TSS, total hardness, dissolved metals, nutrients, chloride, fluoride, sulfate, color, oil and grease, fecal coliform, and chlorophyll *a*. All sampling, preservation and handling, and analytical methods are to be performed in accordance with the ISU SOP (Appendix 7) and the Laboratory Section's Quality Assurance Manual (QAM) (Appendix 8). Sample volumes, preservation, and other handling requirements are included in section *B3: Sample Handling and Custody* of this document.

Fecal coliform analyses are the only allowable variance from holding time requirements. Due to the distance of most Regional Offices from the laboratories, the majority of samples are shipped via courier to the Central Laboratory and consequently fecal coliform samples are already out of the required six-hour holding time when received at the laboratory. The laboratories have agreed to analyze fecal coliform samples received within 24 hours of collection but these are reported with a data qualifier code indicating that the analysis was performed outside of the required holding time. These results cannot, therefore, be used for regulatory or impairment determinations. The coliform data are used as a screening tool to identify waterbodies that may require more intensive sampling including analysis within the six-hour holding time to determine if they are meeting the NC water quality standard for fecal coliform.

In rare cases it may be necessary for samples to be analyzed by other state government laboratories or by a private facility. These labs must 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 have current certification from the DWQ Laboratory Certification program to perform the analysis requested.

For specifics of field measurement and sampling methods refer to section *B2: Sampling Methods* of this document. Analytical methods are listed in section *B4: Analytical Methods* of this document. Precision and accuracy information is detailed in section *A7: Quality Objectives and Criteria*.

Data management

All results are to be sent to the AMS Coordinator, who is responsible for the compilation, review, verification,validation, and warehousing of all data produced by the program. Field staff provide electronic versions of field measurements and observations to the AMS Coordinator by the tenth day of the month following collection (e.g., January field data are to be submitted by February 10). The laboratories will provide finalized analytical results as hard copy reports to the AMS Coordinator within approximately 30 days after sample collection. Details can be found in section *B10: Data Management* of this document.

On approximately a quarterly basis, data from all sources will be compiled, quality assured, and added to the in-house data warehouse. Data will also be uploaded to the national STORET warehouse on at least an annual basis.

Reporting

Two major forms of reporting are produced from the AMS program: Basin Assessment Reports and Annual Fecal Coliform Screening memoranda. These reports are provided to DWQ management and Planning Section staff and the information may be incorporated into Basinwide Water Quality Plans and required biennial EPA reporting for inventory and impairment (combined 303(d)/305(b) reporting). Reports are also made publicly available on the internet at http://portal.ncdenr.org/web/wq/ess/reports.

Basin Assessment Reports

All monitoring programs managed by the Environmental Sciences Section are reported in the Basin Assessment Reports (BARs). These are made publicly available on the internet at http://portal.ncdenr.org/web/wq/ess/reports. This is the major reporting method for the AMS program. Results 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. The collection of data continues monthly for all AMS stations, so a BAR assessment period has been defined for each basin that coincides with the rotating basin cycle (Figure A6.2). All historic data are reviewed when preparing the BAR. However, only data from the assessment period will be analyzed for violation of water quality standards. Each assessment period covers five years from January 1st of the first year to December 31th of the fifth year (e.g. 1/1/2006 to 12/31/2010).

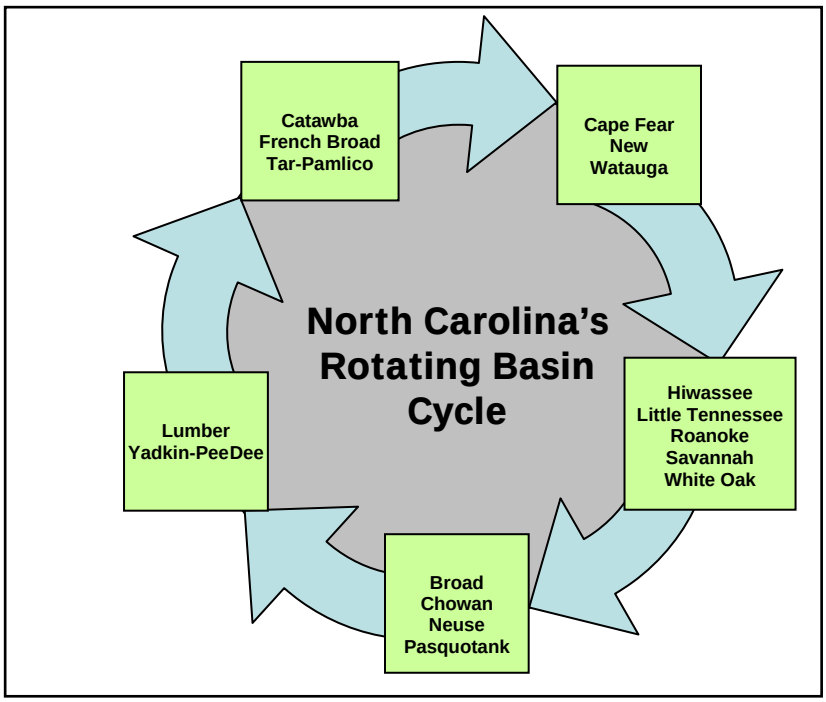


Figure A6.2: Rotating Basin Assessment Cycle

Once the assessment period has ended, it usually requires three to four months to finalize the data set due to analytical reporting lag time and the time required for compilation, review, validation, and verification of all data by the AMS Coordinator. After the last quarter of data is added to the main warehouse, the AMS Coordinator will perform a data retrieval of all available data for the basin(s) to be analyzed and provide it to the Water Quality Analyst. The Water Quality Analyst will summarize the data on two major scales: using all available data for the entire period of record (including the assessment period), and using all available data generated only during the applicable assessment period.

Period of record

The purpose of this analysis is to provide an historical perspective on relative levels of each indicator and to help identify areas, either spatial or temporal, that may require closer examination. The primary method of analysis employed is graphic explorations of each major individual indicator. Results for each indicator may be grouped for analysis by the entire basin, hydrologic unit code (HUC), waterbody, and/or individual stations. This approach can identify temporal patterns, such as gradual increases, decreases, or step-type changes in pollutant levels. To some extent, spatial patterns within the basin, individual HUCs, or along a specific waterbody may be discernable as well.

Assessment period

Once the review of the period of record is complete, analysis is focused on only those data generated during the five-year assessment period. Once again, analysis begins with graphical exploration of the data set for each indicator, generally by HUC or waterbody. 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 or NPDES permits, should be consulted to determine a possible cause. Other data sources, such as the USGS National Water Quality Assessment program, may also be consulted.

Summaries are prepared for each individual station for major indicators. The summaries include:

- Station information, including location, stream classification, stream index
- Date range of results collected during the assessment period
- Number of results for each indicator
- Applicable water quality standard for each indicator based on stream classification
- Number and percentage of observations exceeding the applicable standard for each indicator
- Descriptive statistics by indicator: minimum, maximum, median, 10th percentile, 90th percentile

After reviewing analyses, previous BARs and Basinwide Water Quality Plans, and discussions with appropriate field and Regional Office staff, results are presented by HUC as narrative summaries and graphical representations. Description 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.

The main audience for the information reported in the BAR is staff from the DWQ Planning Section. For each station, if >10% of results for any particular indicator exceed the applicable water quality standard, that particular stream reach (index number) may be subject to official impairment and consequent 303(d) listing. Enough information should be provided in the BAR to allow Planning Section staff to make informed decisions when determining if impairment is warranted for each monitored waterbody. Impairment can lead to further actions by other DWQ programs, such as intensive studies, development of TMDLs or other strategies, and implementation of additional pollutant controls, all of which can have costly impacts for NCDENR as well as NPDES dischargers, municipalities, industries, animal operations, etc. To prevent inaccurate judgments of impairment being made, the Planning Section has developed basic data quality and quantity criteria (available http://portal.ncdenr.org/web/wq/ps/mtu/assessment), to determine data sources appropriate for their uses. Information contained in the BAR for each station allows Planning Section staff to easily identify whether the data set for a particular station meets these criteria.

Annual fecal coliform screening memoranda

The current bacterial pathogen water quality standard for NC is based on five fecal coliform samples taken during a thirty-day period ("5-in-30"). The current AMS sampling regime for fecal coliform consists of one to two samples taken monthly, and is therefore not appropriate for determining exceedance of the standard. The current results are, however, useful as a screening tool to identify stream reaches where the intensive 5-in-30 sampling may be warranted.

In approximately March of each year, after the previous calendar year's data set is finalized, the AMS Coordinator analyzes fecal coliform data. Stations exceeding the following criteria are identified as candidates for 5-in-30 sampling:

For all stream classifications:

- Geometric mean >200 colonies/100mL
- >20% of results >400 colonies/100mL

For SA waters:

- Median >14
- >10% of results >43 colonies/100mL

Memoranda listing the stations that are 5-in-30 candidates and the results of analysis will be drafted by the AMS Coordinator and sent to the Basinwide Planning Unit Supervisor, Modeling and TMDL Unit Supervisor, and appropriate Regional Office Supervisor(s) and Ambient Monitoring Technician(s), requesting that the waterbodies undergo 5-in-30 sampling that year.

Given the significant resources required for staff and the analytical costs of such studies, it is not feasible that all waterbodies identified through this process can be sampled. Each Regional Office should assess their resources and then prioritize stations to be sampled. Suggested criteria for prioritization are as follows:

- High priority should be given to waters protected for primary recreation use, i.e., stream classifications B, SB, and SA.

- For coastal areas with primary recreational use, consult with the Recreational Water Quality Monitoring program (NCDENR, Division of Marine Fisheries, Shellfish Sanitation and Recreational Water Quality Section). If the location is already monitored by DMF, obtain available data, provide to AMS Coordinator and Planning Section staff, and assign station a low priority for 5-in-30 sampling by the Regional Office.
- For SA waters, request monitoring results from the Shellfish Sanitation program (NCDENR, Division of Marine Fisheries, Shellfish Sanitation and Recreational Water QualitySection). If the location is already monitored by DMF, obtain available results, provide to AMS Coordinator and Planning Branch staff, and assign station a low priority for 5-in-30 sampling by the Regional Office.
- If the stream segment has already been listed as impaired (303(d) listing) for fecal coliform, sampling is not required; impairment is already known.

The appropriate Regional Supervisor and Ambient Monitoring Technician should prepare a study plan in accordance with the latest Use Assessment Methodology prepared by the Planning Section that is available on the web at http://portal.ncdenr.org/web/wq/ps/mtu/assessment. Ideally, sampling will occur in June, July, and/or August, with more than one set of 5-in-30 samples being collected. Since the fecal coliform standard is based on human health criteria and is meant to protect for primary and secondary recreation uses, it follows that sampling during the months of highest recreational use will give a better indication of actual risks to human health. In addition to sampling at the AMS station location, the Regional Office staff may also include as part of their study plan sanitary surveys and sampling at several points along the waterbody and its tributaries, if resources allow. Not only would this process definitively determine exceedance of the numerical standard, but possible contaminant sources may also be identified.

Results of all 5-in-30 sampling should be prepared by the Regional Office and reported within 45 days of the completion of sampling via written memoranda. Copies should be sent to the AMS Coordinator, AMS Project Manager, Basinwide Planning Unit Supervisor, Modeling and TMDL Unit Supervisor, and appropriate county or other local public health agency. Planning Section will use the data to determine areas of impairment, in accordance with their current Use Assessment Methodologies at http://portal.ncdenr.org/web/wq/ps/mtu/assessment.

A7. Quality Objectives and Criteria

***Precision, Accuracy, and Sensitivity*:**

This information is included in Table 5.1 of the Laboratory Section's Quality Assurance Manual (Appendix 8). Results from the AMS program will be compared to NC water quality standards (Appendix 2), so reporting limits for these indicators should be at or below these critical values. All of the reporting limits used by the Laboratory Section (PQLs) meet these criteria.

Bias

The AMS is based in judgmental sampling design, so by definition bias will exist due to station locations. However, this is acceptable given that stations are generally established for targeted long-term monitoring of known or suspected areas of concern; identification of temporal patterns at these static locations are a major objective of the program.
Other sources of bias include:

- Sampling is performed during the daylight only. Stations may also be sampled at different times of day from month to month, which may affect indicators such as DO, pH, and nutrients.
- Extreme or acute unusual conditions, including storm events, may not be sufficiently sampled due to field staff safety concerns or station inaccessibility during these events.
- Almost all inland stations are located at bridge crossings for ease of access and to avoid trespassing on private property. Field staff are instructed to sample on the upstream side of the bridge whenever possible to minimize impacts, but the actual local impact of bridges on ambient water quality is unknown.

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

Representativeness

Environmental monitoring data generally show high variation due to natural conditions such as precipitation, seasonal and diurnal patterns, and biological activity. It is important to ensure that the variations over time and/or space that are seen in the results are truly representative of the system under study. Monitored waterbodies must have sufficient flow year-round at the specified sampling point to allow for the sampling of well-mixed areas (as required by ISU SOP) of the waterbody. This allows the samples to represent an "average" condition of the waterbody at that point in time. Careful selection of station locations on larger perennial waterbodies (higher-order streams and rivers, estuaries, and reservoirs) allows representative samples to be obtained year-round.

Comparability

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

Completeness

It is expected that some site visits or samples will be missed due to problems such as inclement weather, temporary station inaccessibility due to bridge construction, equipment problems, and staff issues such as illness or vacant positions. Many of these impediments are unavoidable. However, under anything but extraordinary circumstances it is expected that at least 90% of scheduled station visits and samples be completed annually in each Region. For each five-year period, it is expected that at each station a minimum of 54 observations for indicators sampled monthly and 18 observations for indicators sampled quarterly be collected.

A8. Special Training/Certifications

Field staff

Since new employees can vary greatly in their background, experience, and knowledge, field staff's direct supervisor should determine training needs on a case-by-case basis and ensure that these needs are met. At a minimum, all field staff are to be trained in the methods described in the Intensive Survey Unit SOP (Appendix 7), this QAPP, and the sample submission guidance included in Section 6.0 of the Laboratory Section's QAM (Appendix 8). This initial training in meter calibration, safety, required documentation, sampling methods, sample handling, safety and other field activities is generally performed by current Regional Office or Team staff as assigned by the Regional Supervisor or Team Leader. This is augmented by the AMS Coordinator, particularly concerning data management. Experienced field staff will continue to accompany all new field staff during sampling activities until the new staff member exhibits proficiency in the field, as determined by the trainer's observations.

It is strongly recommended that newly hired Ambient Monitoring Technicians attend the Laboratory Section's Sample Submission course or equivalent within six months of hire. This course gives a detailed presentation of requirements for sample volumes, containers, preservation, shipping, chain of custody documentation, and an overview of laboratory operations. The Sample Submission course is offered by the Central Laboratory on an irregular basis, based on need and number of requests for the training. Laboratory staff will also travel to Regional Offices to provide the training if requested by the Regional Supervisor and current workloads allow. Contact the Central Laboratory for further information (919-733-3908).

Field staff are encouraged to be certified in First Aid and CPR. Staff performing boat work should be thoroughly trained in the safe and proper handling of boats and trailers.

After initial training is completed, the following refresher training is recommended:

- Annual in-field observation and review by AMS Coordinator.
- First Aid and CPR re-certification as required by agency issuing the certification.
- Laboratory Section's Sample Submission Guidance training attendance or equivalent every three years.
- Participation in AMS Regional Monitoring Technician workshops held by the AMS Coordinator. These are held on an irregular basis, as changes to the program dictate and resources allow.
- Participation in Regional Office training sessions in meter use, calibration, and maintenance as offered. These are offered by ESS staff on an irregular basis, upon request from the Regional Office Supervisor.

Currently there is no formal documentation of training, but field staff are assessed on an ongoing basis by their direct supervisor and the AMS Coordinator to ensure field staff are performing activities in accordance with SOPs, the QAPP, and Laboratory QAM.

Laboratory (analytical) staff

Information on training of DWQ Laboratory Section staff is detailed in Section 4.2: *Personnel Orientation and Training* of the Laboratory Section Quality Assurance Manual. If a private laboratory is used for any analyses, it is required that it be Certified by the appropriate NC Laboratory Certification program, and staff training will be performed in accordance with the requirements inherent in this Certification. If another state agency's laboratory is used, its training requirements should be at least equivalent to those of a Certified laboratory.

A9. Documentation and Records

Quality assurance information, SOPs, and other support documentation

Once all approval signatures have been obtained, the QA Coordinator will electronically distribute copies of the approved QAPP 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, or any other documentation referenced by this QAPP. The QA Coordinator will then be responsible for distributing the information, as described above. The QA Coordinator will also be responsible for keeping current copies of all these documents on file at ESS.

Since the AMS is an ongoing project, this QAPP will be reviewed on at least an annual basis and, if appropriate, any changes or updates 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.

Project Records

The records produced during the project, their location, retention time, format, and disposition at the end of the required retention time are summarized in Table A9.1.

Electronic data storage

All field measurements and observations, site visit comments, and analytical results (including data qualifiers) are ultimately warehoused in a Microsoft Access database. Copies of this warehouse reside on the AMS Coordinator's drive of the ESS server and the ESS server. Tape backups are run daily on the ESS servers. The warehouse is updated approximately quarterly and updated copies are distributed to the aforementioned staff. Details of electronic data management and warehousing methods are further described in section *B10: Data Management* of this document.

Table A9.1:Project records

	Minimum retention time	Format	Disposition
Field staff- location: staff office			
Meter calibration sheets	5 years	hard copy	Destroy
Field data-- hard copy	5 years	hard copy	Destroy
Field data-- electronic	2 years	Excel spreadsheets	Destroy
Courier logs (where applicable)	5 years	hard copy	Destroy
Analytical reports-- hard copy	2 years	hard copy	Destroy
AMS Coordinator: location: AMS Coordinator office, ESS			
Field data-- electronic submissions from field staff	5 years	Excel spreadsheets	Archive electronically, storage onsite at ESS
Analytical reports-- hard copy	5 years	hard copy	Archive at State Records Center
Data review notes and checklists	5 years	hard copy	Destroy
Analytical laboratories- location: Central or Regional laboratory performing analyses			
Refer to section 12.4: Data Storage of the Laboratory QAM (Appendix 8)			

Data assessment reports

The AMS Coordinator, Water Quality Analyst, and QA Coordinator maintain a data assessment report, currently titled *Important Information for Users of North Carolina Ambient Water Quality Monitoring Data*, version 2.4. This document describes data format, method codes, station codes, data qualifier codes, and describes known quality assurance or other issues. It is provided to all data requestors electronically or is available on the web at http://portal.ncdenr.org/web/wq/ess/eco/ams. It was developed to address commonly asked questions and to provide enough information for most data users to make informed use of the raw data. It is updated as data quality issues arise.

Data report package: Basin Assessment Reports

Data are analyzed and summarized for each of the seventeen major basins in the state on a rotating five-year schedule. All available historic and current raw data, data qualifiers, station visit comments/observations, and station information, including stream classification and index numbers, are provided by the AMS Coordinator to the Water Quality Analyst as electronic files, generally delimited text files. These data are used to produce the AMS portion of the Basin Assessment Report (BAR), which summarizes all ESS monitoring activities during the appropriate assessment period. In addition to basinwide text and graphical summaries of the AMS data, the BAR also contains descriptive statistics by indicator for each station, including number and percentage of standard exceedances. The final BARs are made publicly available via the ESS web site at http://portal.ncdenr.org/web/wq/ess/reports. Copies of all BARs are retained electronically and in hard copy at ESS and are kept indefinitely.

The AMS Coordinator also provides raw data upon request to staff from other state and federal agencies, private consultants, academia, municipalities, private citizens, and others. This is generally provided in an electronic form (delimited text file or Microsoft Excel spreadsheet) and should contain the same information listed above for internal analysis, unless otherwise instructed by the requestor. All data requests are to be accompanied by a copy of the data assessment document described above.

Data report package: Annual Fecal Coliform Screening

The data report package for the annual Fecal Coliform Screening is very similar to that described for the BARs, except that results of interest are limited to fecal coliform from the preceding calendar year. The results are reported to Regional Office Supervisors, Ambient Monitoring Technicians, and Planning Section staff in internal memoranda.

Data report package: Annual Environmental Indicators Report

The data report package for the annual Environmental Indicators Report summarizes regional treands across North Carolina for DO, turbidity, and fecal coliform bacteria for a portion of AMS stations that have been identified as long term indicator sites. Long term indicator sites are those with on-going collection of data dating back to before 1980. Data are summarized and presented graphically to determine if the percentage of measurements that exceed water quality evaluation levels change over (decadally or annually).

SECTION B:

DATA GENERATION AND ACQUISITION

B1. Sampling Process Design

The AMS was designed as a long-term monitoring project and has been in existence for almost 40 years. It is a judgmentally designed network of stations located to monitor specific watersheds of concern as determined by DWQ staff. There are currently 323 stations across the state.

Stations are visited at least monthly for measurement of field parameters, fecal coliform, turbidity, and any site-specific samples. Total suspended solids are sampled quarterly at all stations and total hardness is measured quarterly at all freshwater stations. Dissolved metals are sampled quarterly at ten stations where additional information has been requested. Stations are sampled by designated Ambient Monitoring staff in each of the seven Regional Offices and the Estuarine Monitoring Team.

Station locations

Stations are established at publicly accessible, fixed locations (i.e., specific lat/long), generally at bridge crossings or areas accessible by boat. Locations and their latitude and longitude were originally identified using USGS topo maps or Maptech Terrain Navigator software. Some latitudes and longitudes have been updated using GPS technology. Stations are strategically located to monitor a specific area of concern:

- overall water quality in a larger watershed
- effect of point source discharges
- effect of non-point sources of pollution (e.g., urban areas, animal operations, agriculture)
- effect of land use changes
- waters of significant ecological, recreational, political, or municipal use
- waters which show an impairment due to unknown causes (e.g., biological data shows possible impairment)
- significant waterbodies as they leave the state

Statewide coverage is shown in Figure B1.1, and a station list is available in Appendix 3.

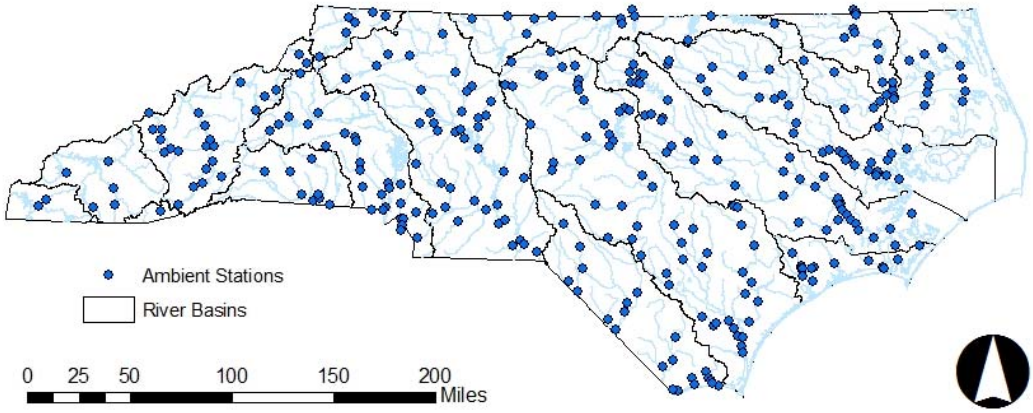


Figure B1.1: AMS Station Locations

Many of the current stations have been active for over thirty years and this focus on long-term data is integral to identifying temporal patterns within a watershed and to gaining an understanding of the variability within each system. Consequently, requests from DWQ staff for station establishment and/or discontinuation will be assessed on the value gained from a long-term perspective. Special study or short term monitoring (less than 2 years) is handled through other DWQ programs, such as the Intensive Survey Unit. Adjustments to station locations and sampling regimens may be made with sufficient reason, such as:

- safety concerns of field staff
- other changes to location accessibility
- the reason for sampling is no longer valid (e.g. a discontinued discharge)
- emergence of new water quality concerns
- resource constraints, particularly field and laboratory staff vacancies
- redundancy with a cooperating program (e.g. DWQ Monitoring Coalition program)

If any of these concerns arise, the AMS Coordinator, Regional Office Supervisor, Regional AMS Monitor, Ecosystems Unit Supervisor, and any other involved parties (e.g., Coalition Coordinator, Planning Section staff, USGS, etc.) will collectively decide if it is appropriate for the station to be discontinued.

Actual sampling points are generally mid-channel, or as determined by field staff as representative of the waterbody:

- flow should be significant enough to ensure a relatively well-mixed, homogenous sample
- outside of effluent mixing zones
- upstream side of bridge whenever possible
- not directly below large amounts of debris or other temporary impoundments

Indicators measured and sampling frequency

The selection of indicators is primarily focused on those with NC water quality standards 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, such as specific conductance are of themselves useful for identifying long-term trends. A summary of standards by stream classification is included in Appendix 2.

Field staff are encouraged to use their discretion to sample for any additional indicators they feel may be of concern due to unusual circumstances encountered on a station 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.

All measurements and samples are taken on whole water samples except dissolved metals. The following two tables list indicators measured and the minimum frequency of measurement. Table B1.1 lists core indicators, or those generally sampled at all stations. Table B1.2 lists supplemental indicators, which are only sampled at certain stations to monitor site-specific concerns. For a list of indicators measured at each station, refer to Appendix 3.

Table B1.1: Core indicators
Sampled at all stations

Indicator (unit)	STORET Parameter code	Minimum Frequency	Numerical Instream Standard (S)?
Field Measurements			
Water temperature (°C)	10	monthly	S
Specific conductance (µS/cm at 25°C)	94	monthly	none
Dissolved oxygen (DO) (mg/L)	300	monthly	S
pH (SU)	400	monthly	S
Air temperature (°C)	20	monthly	none
Field Observations			
Cloud cover (%)[1]	32	monthly	none
Wind velocity (mi./hr.)[1]	35	monthly	none
Wind direction (degrees from North)	36	monthly	none
Stream flow severity[2]	1351	monthly	none
Secondary Data Sources			
24 hr. precipitation (in.)[3]	45	monthly	none
Samples			
Fecal coliform (colonies/100mL)	31616	monthly	S
Turbidity (NTU)	82079	monthly	S
Total suspended solids (TSS) (mg/L)	530	quarterly	S

[1] Estimated value
[2] Subjective scale of 1-4
[3] Obtained from NC Climate Office or local news weather networks

Table B1.2: Supplemental Indicators
Sampled only at select stations, as determined by discharger types, access method, waterbody type, historic or future concerns, issues, or any other site-specific considerations

Indicator (unit)	STORET Parameter code	Minimum Frequency	Numerical Instream Standard (S) or?
Field measurements			
Salinity (ppt)[4]	480	monthly	none
Secchi depth (m)[5]	78	monthly	none
Samples			
Total coliforms (colonies/100mL)[6]	31504	monthly	S
NH_3 as N (mg/L)	610	monthly	none
TKN as N (mg/L)	625	monthly	none
$NO_2 + NO_3$ as N (mg/L)	630	monthly	S
Total Phosphorus (mg/L)	665	monthly	none
Total Hardness (mg/L)[7]	900	quarterly	S
Chloride (mg/L)	940	monthly	S
Sulfate (mg/L)	945	monthly	S
Fluoride (mg/L)	951	monthly	S
Chlorophyll *a* (µg/L)	70953	monthly	S
Color (Pt-Co & ADMI units)	80, 82, 83	monthly	none
Oil & Grease (mg/L)	556	monthly	none
Arsenic, dissolved (As) (µg/L)	1002	quarterly	S
Beryllium, dissolved (Be) (µg/L)	1010	quarterly	S
Cadmium, dissolved (Cd) (µg/L)	1025	quarterly	S
Chromium, dissolved (Cr) (µg/L)	1030	quarterly	S
Copper, dissolved (Cu) (µg/L)	1040	quarterly	S
Lead, dissolved (Pb) (µg/L)	1049	quarterly	S
Manganese, dissolved (Mn) (µg/L)	1056	quarterly	S
Nickel, dissolved (Ni) (µg/L)	1065	quarterly	S
Zinc, dissolved (Zn) (µg/L)	1090	quarterly	S

[4] Estuarine stations only
[5] Boat access stations only
[6] WS-I classifications only
[7] Freshwater classifications (C, B, WSI-V) only

Sampling and measurements

Field measurements and samples are taken in accordance with Sections III and IV of the ISU SOP (Appendix 7). Required sample volumes, containers, preservation, and sample handling requirements are detailed in Section 6: *Sampling Procedures* of the Laboratory Section QAM (Appendix 8). After collection and chemical preservation, samples are stored immediately on ice in coolers. The coolers are either hand-carried by field staff or sent via NC Department of Administration's overnight courier to the appropriate DWQ Laboratory.

If samples arrive at the laboratory in unacceptable condition (e.g., temperature out of range, inadequate chemical preservation) they can be rejected by laboratory staff. Resampling for these discarded samples is not necessary for those indicators sampled monthly. However, resampling should be performed as soon as practicable in the case of indicators sampled quarterly, either within the same month or during the following month's sampling.

Every reasonable attempt is to be made by field staff to complete all site visits each month, though some missed visits are to be expected due to situations such as bad weather, station inaccessibility, extreme flow (either extremely low flow making sampling impossible or inappropriate due to pooling/backwaters, or flooding preventing access of normal sampling point), meter problems, staff shortages/vacancies, etc. In these cases, missed sampling is acceptable as long as the reasons are documented in the monthly field data submissions. If a station location is inaccessible at a station visit, field staff should not sample at another location, such as the next bridge crossing. Longer-term inaccessibility, most notably bridge construction, should be assessed by the AMS Coordinator for consideration of temporary suspension or permanent discontinuation of the station. It is important that stations not be moved without sufficient reason, as an uninterrupted long-term record is a primary objective of this program.

B2. Sampling Methods

Samples and measurements are to be taken in accordance with ISU SOP (Appendix 7) and the Laboratory Section QAM (Appendix 8). Any irregularities or problems encountered by field staff should be communicated to the AMS Coordinator, either verbally or via email, who will assess the situation, consult with other project personnel if needed, and recommend a course of action for resolution.

The station list in Appendix 3 identifies sampling methods to be used for each indicator at each station. An overview of the different methods employed is described below.

Field measurements

- Surface (Sur): Measurements are only taken just below the water surface (depth = 0.1m). This method is employed when sampling at bridge crossings or other land accessed stations.
- Profile 1 (Pr1): Measurements are taken just below the water surface and at every meter of depth to the bottom. Method employed at estuarine (Chowan, Pasquotank, Pamlico, Roanoke, and Neuse basins) and reservoir stations accessed by boat that exhibit significant stratification.
- Profile 2 (Pr2): Measurements are taken just below the water surface, mid-depth (i.e., half the depth to bottom), and at the bottom. Method employed at estuarine stations accessed by boat that exhibit less severe stratification (White Oak, Cape Fear, and Lumber basins).

Samples

Refer to Section 4.2 of the ISU SOP (Appendix 7) for general information on sampling methods. Two basic methods are employed in the AMS program:

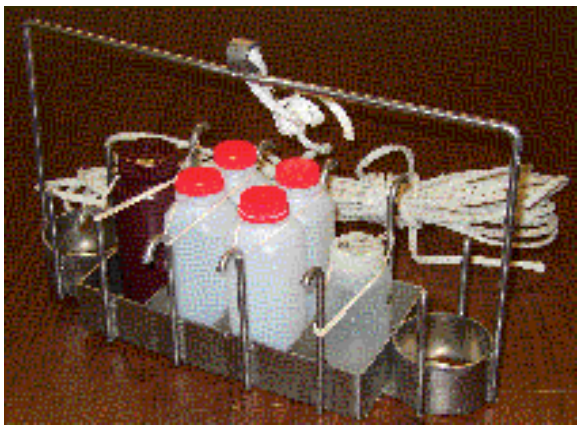


Figure B2.1: Bridge Sampler

- Grab (G): Samples are taken just below (depth = 0.1m) surface. Sample bottles are filled directly by plunging them in to the waterbody, either by submersing by hand or by using a bridge sampler (Figure B2.1). If it is necessary that grab samples be taken with an intermediary collection device, the intermediary device should have Teflon coating or be made of other non-reactive material and must be rinsed three times with site water before sampling to avoid contamination. The grab method of sampling is always used for fecal coliform, turbidity, TSS, total hardness, dissolved metals, chloride, color, fluoride, oil and grease, and sulfate samples. Also used for nutrient and chlorophyll *a* samples at most stations.

- Photic (Ph): 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 (Figures B2.2 and B2.3). Plugs are removed from the Labline sampler and it is slowly lowered to a depth of twice the Secchi reading then drawn back up out of the water. Lowering and raising the sampler is to be done at a slow, continuous pace in order to get a representative sample of the entire water column to the designated depth. This method is used only for chlorophyll *a* and nutrient sampling at designated estuarine and reservoir stations.

Figure B2.2: Labline sampler

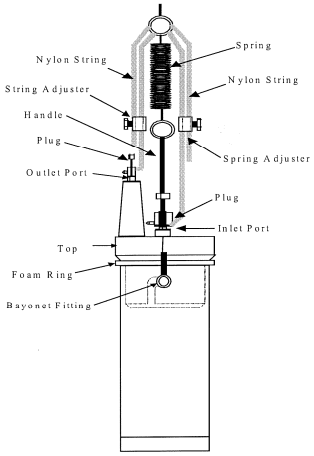


Figure B2.3: Labline schematic

Equipment and disposables

Table B2.1 and B2.2 show the equipment and disposable items needed by Regional Ambient Monitoring Technicians to perform field sampling and measurements.

Table B2.1: Disposables and sources

	AMS Coordinator	Laboratory	Field office
Sample bottles		X	
Sample tags	X		
Sample submission sheets	X		
pH standards (4.0, 7.0, 10.0 SU)			X
Conductivity standards (100, 1,000, 50,000 µS/cm)			X
25% sulfuric acid ampules		X	
1:1 nitric acid ampules		X	
Distilled or deionized water			X
Ice			X

Table B2.2: Equipment and sources

	Responsible for purchase	
	AMS Coordinator	Field office
Sample bottle rack and rope	X	
Field meters:		
YSI 85 combined DO/Cond/temp meter and membranes **AND** Accumet pH meter and probes		X
OR		
YSI Professional Plus w/ display, and probes		X
OR		
Hydrolab Quanta or MiniSonde 4a or MiniSonde 5a w/display, and probes		X
Labline composite sampler with marked rope	X	
Long-handled dipper (optional)		X
Safety equipment • Orange safety vest (bridge sampling) • Flashing beacon (bridge sampling) • Disposable gloves (nitrile or vinyl) • Acid handling equipment (apron, safety glasses, spill kit, portable eye wash, ampule disposal container) • First Aid kit • Personal floatation device (PFD) (boat work only)	X	 X X X X X
Compass	X	
Air thermometer	X	
Secchi disk (select stations)	X	
Coolers/ice chests		X
Truck/van		X
Boat/trailer (select stations)		X

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 (Appendix 8).

Sample preservation

Chemical preservation of samples should occur within 15 minutes of collection. Samples should then immediately be placed in coolers with ice. The chemical preservatives required for each sample are listed in Figure 6.1 of the Laboratory's QAM (Appendix 8).

Sample submission forms

Sample submission forms are printed by the AMS Coordinator each month. Each sheet corresponds to one or more samples that are taken using the same sampling method (i.e., grab or photic) at the same station, date, and time, so more than one sheet must be completed for a particular station visit if more than one sampling method is employed. If samples are to be analyzed by multiple laboratories (e.g., fecal coliform sample is analyzed by the regional laboratory and metals sample is sent to the Central Laboratory), a separate sample submission form must be also completed for samples sent to each laboratory. This means that for certain station visits, up to three sample submission forms must be completed:

- Monthly: grab samples submitted to the Central Laboratory
- Photic: photic zone composite samples submitted to the Central Laboratory
- Regional: grab samples submitted to a Regional Laboratory

There is one additional type of sampling event, "Weekly", for five stations that are visited once per week.

All these separate sheets for any particular station visit are tied together using a unique identifier called the "Visit ID", which is discussed further in *Section B10: Data Management*.

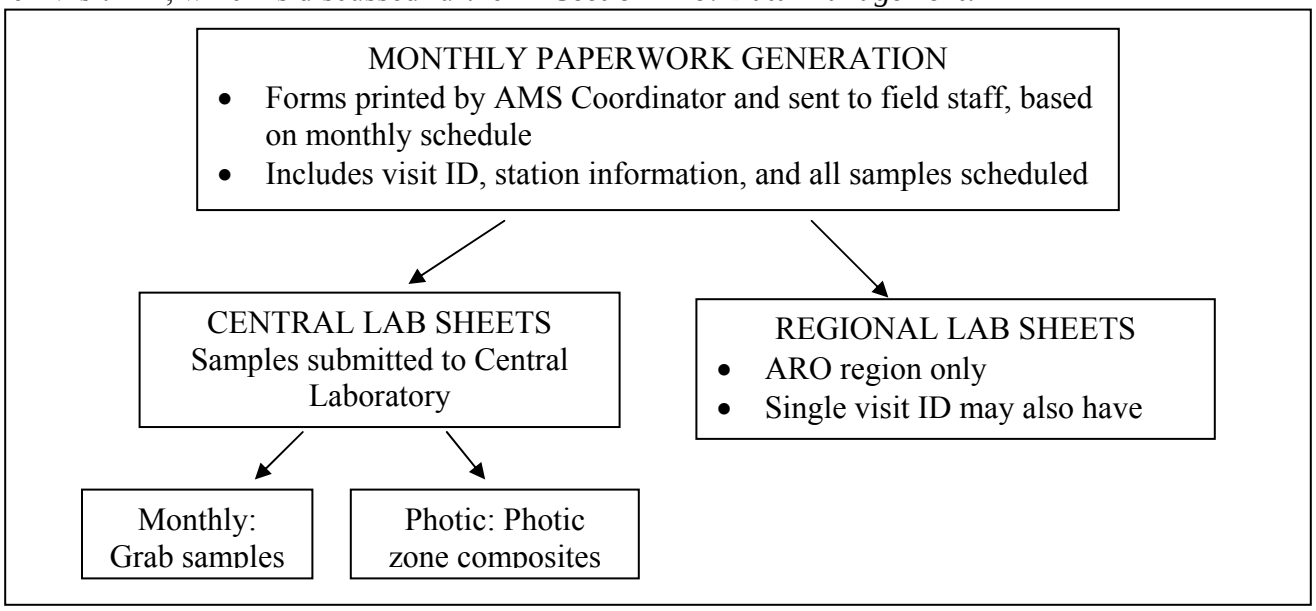


Figure B3.1: Sample submission form generation

An example of a completed sample submission form is shown in Appendix 4. Most information is pre-printed but field staff need to complete the following fields using waterproof ink:

- Collector(s): collector's first initial and last name (e.g., J. Smith)
- Shipped by: Circle appropriate method of transportation to the laboratory
- Date Begin: Date sampled in the format yyyy-mm-dd
- Time Begin: Time sampled in 24 hour format (hhmm)
- Depth: For photic samples, depth of photic zone sample; this field already completed for grab samples
- Sample set ID: Box located to the right of Visit ID; shorthand identifier, generally a single letter or number, allowing sample to be matched to appropriate sample identification tag

Recording field data, particularly precipitation and salinity, on the bottom of the form is very helpful to laboratory analysts. Field staff are strongly encouraged to include this information.

Sample identification tags

An example of a completed tag used for sample identification is shown in Appendix 4. Tags should be filled out using waterproof ink or pre-printed labels with the equivalent information may be placed on the tags. Tags are attached with rubber bands to the neck of the appropriate sample bottle immediately after sampling. Guidance for proper completion of tags is listed below:

- Water Body: Station location description
- Station #: 8-character station number
- Date: Date and time sampled in the format yyyy-mm-dd hhmm (24 hour time)
- Collector: Name of collector in the format first initial, last name
- Analysis: Name of analysis requested
- Preservative: Identification of preservation methods
- Sample set ID: Box in upper left hand corner; unique shorthand identifier allowing sample to be matched to appropriate sample submission sheet

Sample transport

Immediately after sampling, labeling, and chemical preservation, samples are placed in coolers on ice, along with a temperature blank. Sample submission forms are placed in a sealable waterproof bag and taped to the inside lid of the cooler. Coolers are then either hand carried by field staff or sealed and shipped via the NC Department of Administration's Courier Service to the lab.

Laboratory

Once samples arrive at the laboratory, support staff check the temperature blank (included in each cooler) to ensure that they are in appropriate temperature range (4 +/- 2ºC), assign lab tracking numbers, and distribute them to the appropriate analytical units. Any samples not meeting temperature, holding time, or preservation requirements or are otherwise not submitted in accordance with the SOP are

subject to rejection as per Section 13: *Corrective Actions* of the Laboratory Section QAM. Laboratory staff will attempt to contact collector by phone or email before rejecting. If conditionally accepted, the laboratory will document the anomaly with 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 be reported using the appropriate qualification code(s).

For details of laboratory protocols for sample receipt and handling, refer to Section 7: Sample Custody of their Quality Assurance Manual.

B4. Analytical Methods

Field measurements

In addition to the SOP sections cited in Table B4.1 below, the instruction manual for the appropriate meter should also be consulted.

Table B4.1: Field measurement method references and reporting levels

Parameter	ISU SOP section	EPA method (if applicable)	Reported to nearest…
DO	III.3.1; Appendices 1-4	360.1	0.1 mg/L
pH	III.4; Appendices 1-4	150.1	0.1 SU
Water temp	III.1; Appendices 1-4	170.1	0.1 ºC
Specific conductance	III.5; Appendices 1-4	120.1	1 µS/cm
Salinity	III.5; Appendices 1-4		0.01 ppt
Secchi Depth	III.6		0.1 m
Air temperature	III.2		1°C
24 hr. precipitation	Not directly measured- refer to QAPP Section B9		

Lab analyses

Samples are submitted for analysis to one or more of the two DWQ laboratories: Central Laboratory in Raleigh or Asheville Regional Laboratory. Time sensitive samples (coliform, turbidity, TSS) collected by Asheville Regional staff should be submitted to the Asheville Regional Laboratory. All other samples should be submitted to the Central Laboratory. Results should be reported to the AMS Coordinator and Regional Ambient Monitoring Technicians within 30 days of sample submission.

A summary of methods and PQLs (the Laboratory Section's minimum reporting limit) 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 (Appendix 8), Table 5.1: *QA Targets for Accuracy, Precision, and MDLs/PQLs* and Section 8: *Analytical Procedures*.

Table B4.2: Analytical method references and lower reporting levels (PQLs)

Parameter	***EPA method[1]***	***APHA method[1]***	***Other***	***PQL***
Fecal coliform		9222D (18th ed.)		1 colony/ 100mL
Turbidity	180.1	2130B (20th ed.)		1.0 NTU
Total suspended solids (TSS)		2540D (18th ed.)		6.2 mg/L
Chloride	300.0		QUIK CHEM 10-510-00-1-A$	1 mg/L
Color, ADMI		2120E		25 ADMI CU
Color, True		2120C		5 Pt-Co Units (PCU)
Chlorophyll a	445.0			1 µg/L
Fluoride	300.0		QUIK CHEM 10-510-00-1-A	0.4 mg/L
Grease and Oils	1664A			10 mg/L
Sulfate	300.0		QUIK CHEM 10-510-00-1-A	2 mg/L
NH_3 as N	350.1		QUIK CHEM 10-107-06-1-J	0.02 mg/L
TKN as N	351.2		QUIK CHEM 10-107-06-2-H	0.20 mg/L
$NO_3 + NO_4$ as N	353.2		QUIK CHEM 10-107-04-1-C	0.02 mg/L
Total P as P	365.1		QUIK CHEM 10-115-01-1-E,F	0.02 mg/L
Total Hardness		2340C		1 mg/L
As	200.8/200.9			2 µg/L
Be	200.7			5 µg/L
Cd	200.8/200.9			1.0 µg/L
Cr	200.8/200.7			10 µg/L
Cu	200.8/200.9			2.0 µg/L
Mn	200.8/200.7			10 µg/L
Ni	200.8/200.9			2 µg/L
Pb	200.8/200.9			2 µg/L
Zn	200.8/200.7			10 µg/L

[1] *Standard Methods for the Examination of Wastes and Wastewater*. Edition in parentheses.

B5. Quality Control

Field activities

Current QC practices in place for field measurements or other field activities include meter calibrations and standard checks, which are covered in Section B7: *Instrument Calibration & Frequency* of this QAPP. Field equipment blank samples are collected before each stream sample is filtered for dissolved metals. Duplicate samples, field blanks, and equipment blanks are done on an irregular basis when problems with contamination were suspected, or to access changes in methods, preservatives, or equipment that were being considered.

Laboratory activities

Information on required quality control checks for analytical samples and frequency is available in Section 11.2.1: *Laboratory QC Checks* of the Laboratory Section's QAM (Appendix 8). Criteria for acceptance for each analysis are presented in Table 5.1: *QA Targets for Accuracy, Precision, and MDLs/PQLs* of the Laboratory Section QAM. Generally speaking, for inorganic analyses accuracy should be within the range 80-120% and precision should be <20% relative percent difference (RPD) unless laboratory-generated data indicate that tighter control limits can be routinely maintained.

B6. Instrument/Equipment Testing, Inspection, and Maintenance

Field equipment

All field staff are responsible for regular cleaning, inspection, and maintenance of their assigned equipment. All equipment should be visually inspected daily for damage or dirt, and repaired or cleaned if needed before use. If meters are stored for long periods (> 1 week) without being used, it is recommended that they be calibrated and inspected at least weekly to keep them in good working order. Other required maintenance is shown in Table B6.1. Information on equipment maintenance is supplied in Chapters III andVI of the ISU SOP (Appendix 7) for field meters, equipment, vehicles, boats and trailers. Also refer to instruction manuals for manufacturer's recommendations for inspection, maintenance, and repair.

Laboratory analytical equipment

For laboratory equipment and instrument inspection and maintenance, refer to the Laboratory Section's QAM, Table 10.1 (Appendix 8).

Table B6.1: Equipment maintenance

Equipment	Task	Frequency
YSI 85 DO/Cond/temp meter	Check battery level	Daily
	Inspect membrane for holes, tears, bubbles, fouling or other damage	Daily
	Replace membrane and KCl solution	As needed if damaged, DO not calibrating or calibrations do not hold, responding slowly, showing excessive drift, or providing erratic readings
	Inspect gold cathode	As needed, when replacing membrane
	Clean cathode	As needed, if tarnished or plated
Accumet pH meter	Inspect probe for bubbles and electrolyte level	Daily
	Top off probe KCl electrolyte level	As needed
	Replace probe	As needed if damaged, not calibrating or calibrations do not hold, responding slowly, showing excessive drift, or providing erratic readings
YSI Professional Plus meter	Check battery level	Daily
	Inspect membrane for holes, tears, bubbles, fouling or other damage	Daily
	Replace membrane and KCl solution	As needed if damaged, DO not calibrating or calibrations do not hold, responding slowly, showing excessive drift, or providing erratic readings
	Inspect gold cathode	As needed, when replacing membrane
	Clean cathode	As needed, if tarnished or plated
	Inspect glass bulb for stratches, fouling or other damage	Daily
	Replace pH probe	As needed if damaged, pH not calibrating or calibrations do not hold, responding slowly, showing excessive drift, or providing erratic readings
Hydrolab meters	Check battery level	Daily
	Inspect membrane for holes, tears, bubbles, fouling or other damage	Daily
	Replace pH reference junction	As needed if clogged, no calibrating or calibrations do not hold, responding slowly, showing excessive drift, or providing erratic readings
	Replace pH reference electrode electrolyte solution	As needed and when replacing pH reference junction

B7. Instrument Calibration & Frequency

Field meters

All field meters are to be inspected and calibrated at a minimum at the beginning and end of each day used. Field staff should record calibration information on the Water Quality Monitoring Field Meter Calibration Sheet form (ISU SOP, Figure 10) including staff name, date/time of initial calibration and post-sampling check, and meter number. The specific calibration procedures are documented in the Intensive Survey Unit's SOP, Appendices 1-4 and in the manufacturers' instruction manuals. For specific conductance and pH, two-point calibrations should be performed. DO meters should be calibrated using the air calibration method.

Standards should be selected so that they bracket the range of measurements expected that day. Each Regional Office is required to purchase traceable conductivity standards and pH buffers (standards). Conductivity standard concentrations of 100 and 1,000 µS/cm are commonly used for freshwater stations and concentrations of 10,000 and 50,000 µS/cm for estuary stations. Meters currently in use require pH standards of 4.0, 7.0, and 10.0 S.U.

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.

A post-sampling check is completed at the end of each sampling day to confirm significant drift has not occurred and that readings are accurate and representative. If post-sampling check readings are not within the acceptable QC ranges (DO= ±0.5, Specific conductance= 10%, pH=±0.2) or a post-sampling check is not completed, data are determined questionable and are removed from the dataset.

Laboratory instrumentation calibration

For details of laboratory requirements and methods of calibration of analytical laboratory instrumentation, refer to Section 9: *Calibration Procedures and Frequency* of the Laboratory Section's QAM (Appendix 8).

B8. Inspection/Acceptance Requirements for Supplies and Consumables

The Central Laboratory performs quality assurance of sample bottles, reagents, and chemical preservatives that are provided to field staff. Containers that are purchased as pre-cleaned should be certified by the manufacturer or checked to ensure that the parameters tested are below the published reporting limits. Containers should be stored in a manner that does not leave them susceptible to contamination by dust or other particulates and should remain capped until use. Any containers that

show evidence of contamination should be discarded. Certificates for glass containers certified by the manufacturer should be kept on file by Laboratory Support Unit staff.

Additionally, field staff should inspect all bottles before use. Any bottles that are visibly dirty or whose lids have come off during storage should be 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.

The majority of chemical preservatives used by the AMS are provided by the Central Laboratory as pre-measured, sealed glass ampules. Certificates of purity from the manufacturer should be provided when purchased, and these certificates kept on file by the Laboratory Section Support Unit. If other sources of chemical preservatives are used by field staff, the preservatives are to be of American Chemical Society (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 not be used and should be discarded.

A summary of inspections to be performed by field staff is presented in Table B8.1.

Table B8.1: Consumable inspections and acceptance criteria

Item	***Acceptance criteria***
Sample bottles	• Bottle blanks less than laboratory reporting limits • No visible dirt, debris, or other contaminants
pH standards (4.0, 7.0, 10.0 SU)	• No visible discoloration, debris, or other contaminants
Conductivity standards (100, 1,000, 50,000 µS/cm)	• No visible discoloration, debris, or other contaminants
Acid ampules (sulfuric, nitric)	• Ampules intact • No visible discoloration, debris, or other contaminants
Distilled or deionized water	• No visible discoloration, debris, or other contaminants

B9. Non-direct Measurements

All data will be generated through AMS field activities and consequent lab analyses, with one exception:

- 24 hr. precipitation (in./day): Data are ideally to be obtained from the NC State Climate Office via the Chronos database available through their website at http://www.nc-climate.ncsu.edu/cronos/. Currently there are data available from approximately 90 stations across NC. If an appropriate station cannot be located, field staff can obtain approximate values from local news' weather services. 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.

B10. Data Management

There are approximately 100,000 individual results produced annually by the AMS, and results are submitted to the AMS Coordinator by staff from seven different Regional Offices, Estuarine Monitoring Team, and two Laboratories. For a single station visit, results may be received from as few as two or as many as four separate sources. Some data are reported electronically and some only as hard copies. Due to the quantity and complexity of information being produced, organized data management is critical to this project.

An overview of the data flow is given in Figure B10.1. A key tool for relating all results from a single station visit is the assignment of a unique identifier, called a Visit ID, to each scheduled station visit. The Visit ID is then associated with the appropriate station visit on spreadsheets for field data entry that are sent monthly to field staff and it is also included on each sample submission sheet. The laboratory carries over the Visit ID for each set of samples to their final analytical reports. Though not as important to those collecting the data (field and analytical staff), the Visit ID is a critical tool for data tracking, review and verification, so it is important to understand that the assigned Visit ID should be accurately transmitted at all stages of the data flow process.

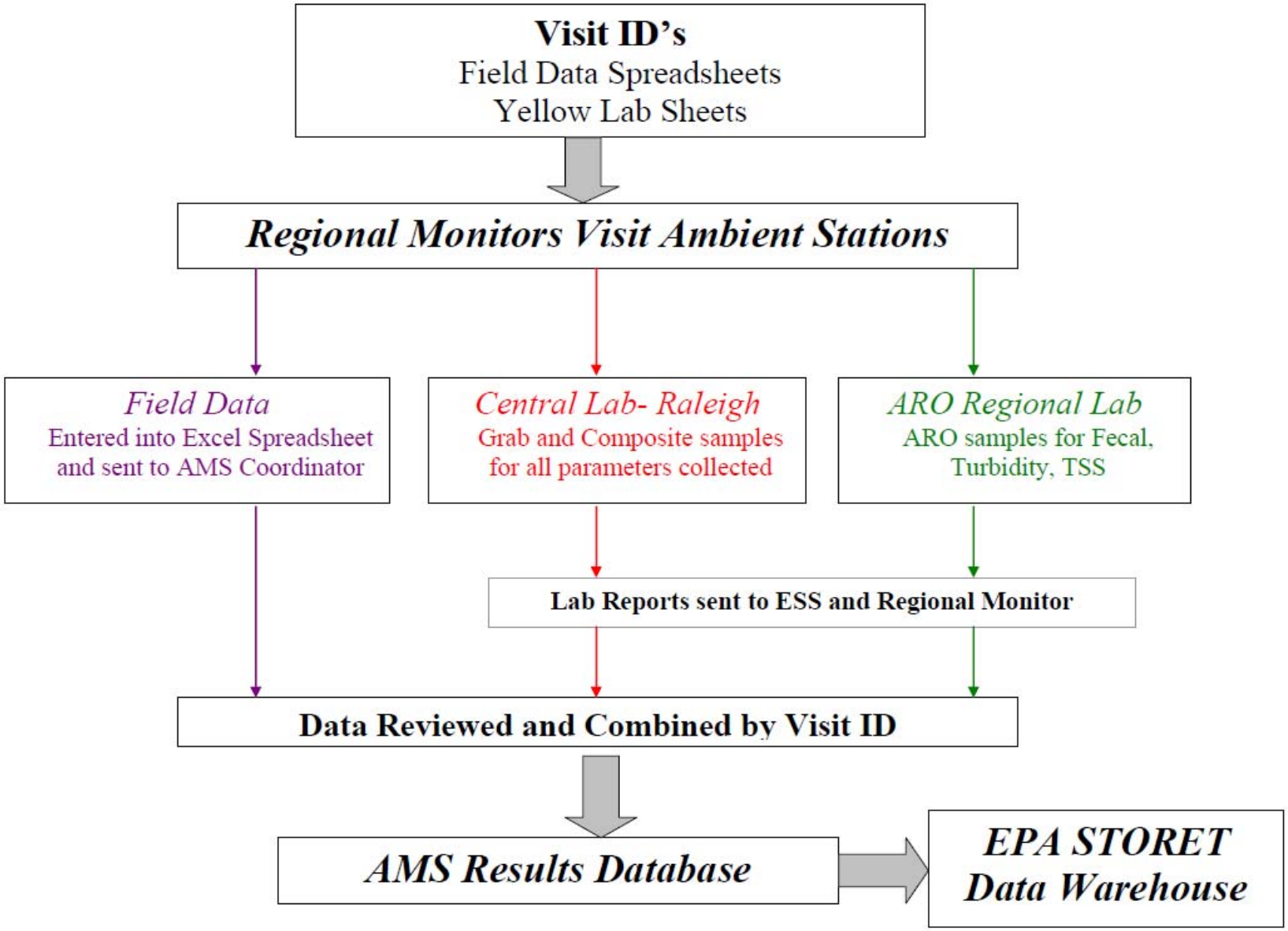
Field measurements and observations are documented at time of measurement by field staff according to their preference. They may either use the data logging capabilities of their meters or record on hard copy field data sheets. Ultimately they are required to submit these results using the standardized Excel spreadsheet supplied by the AMS Coordinator each month. Field staff must also document sampling anomalies and other comments/observations on this spreadsheet.

Samples are submitted with appropriate documentation as described in Section B3 of this document. Analytical results (including data qualifier codes) are provided as hard copies to both the AMS Coordinator and the appropriate Regional Office. The AMS coordinator reviews all results as they are received for obvious errors or omissions.

Lab results, which include numerical results as well as any data qualifiers, are keyed from hard copies by ESS support staff into a Microsoft Access database. The AMS Coordinator reviews the data for completeness, data entry errors, unlikely or impossible values, etc. as detailed in Section D: *Data Validation and Usability*. Lab results are then compiled with field data and appended to the in-house warehouse, a Microsoft Access database containing all AMS data from January 1, 1997 to present. Only raw data (i.e., no calculated fields) are warehoused. Historic data collected before 1997 are stored in a second Microsoft Access database that is identical in structure to the database containing current data.

Data are also being uploaded to EPA's STOrage and RETrieval database (STORET). All data produced by the AMS over the last 40+ years through current have been migrated to the national warehouse. The AMS Coordinator is responsible for uploading new results on at least an annual basis. Locally, the Ecosystems Unit's Computer Consultant provides network and general Access support and maintenance. EPA headquarters User Support Staff (phone 1-800-424-9067; STORET@epa.gov) provide support for technical issues with the STORET warehouse.

Figure B10.1: Data flow



SECTION C:

ASSESSMENT AND OVERSIGHT

C1. Assessments & Response Actions

The AMS Coordinator acts as the liaison between field staff, the Laboratory Section, program management, QA Coordinator, the EU Water Quality Analyst, and other data users. Issues with any aspect of the program noted by any of these should report them as soon as possible to the AMS Coordinator, who will assess the issue, consult with other parties as needed, and determine the course of action to be taken.

Within three months of hire, Regional Ambient Monitoring Technicians and Team members will be observed on a sampling run by the AMS Coordinator. The AMS Coordinator observes experienced Ambient Monitoring Technicians on sampling runs at least once every two years. The main purpose of these assessments is to ensure that field staff are performing activities in accordance with current SOPs and to determine if there are any other issues that need to be addressed. Concerns or irregularities noticed by the AMS Coordinator will be discussed with the Ambient Monitoring Technician or Team member. If significant issues arise, the AMS Coordinator will notify the Project Manager, Ambient Monitoring Technician, and the appropriate Regional Supervisor by written memorandum, describing the issue and providing recommendations for correcting the issue. As the Ambient Monitoring Technician's direct supervisor, the Regional Supervisor is responsible for ensuring that these significant issues are resolved. In the case of Team members, the ESS Chief acts as direct supervisor and is responsible for ensuring issue resolution for these field staff.

Annually, the Ambient Monitoring Technicians, Team members and AMS Coordinator participate in USGS's National Field Quality Assurance (NFQA) program. The NFQA is a yearly proficiency test for pH and specific conductance in order to provide precision data for field measurements and identify water quality analysts who need additional training. Staff who do not receive satisfactory readings are provided with additional training and retested. The QA Coordinator oversees the NFQA for ESS.

The Laboratory Section has a robust assessment program in place. Refer to Section 14: *Performance and System Audits*, Section 15: *Quality Assurance Reports* of their QAM (Appendix 8) for information.

C2. Reports to Management

The AMS Coordinator reports significant issues to the Project Manager verbally and/or via written emails. Issues of interest to the DWQ as a whole should be included in the annual ESS Update submitted by the Project Manager to the Section Head.

The AMS Coordinator,Water Quality Analyst, and QA Coordinator maintain a data assessment report, currently titled *Important Information for Users of North Carolina Ambient Water Quality Monitoring Data*, version 2.4 (Appendix 5). This is the main method for documenting significant quality concerns, changes in methodology, or other information vital to appropriate data interpretation. The document also accompanies all raw data requests and is incorporated into the text of the BARs. It is updated as data quality issues arise.

SECTION D:

DATA VALIDATION AND USABILITY

D1. Data Review, Verification, and Validation

Data verification and validation occurs at every step of data generation and handling. Field staff, laboratory support staff, laboratory bench chemists, and data entry staff are each responsible for verifying that all records and results they produce or handle are completely and correctly recorded, transcribed, and transmitted. Each staff member and analytical Unit Supervisor is also responsible for ensuring that all activities performed (sampling, measurements, and analyses) comply with all requirements outlined in the following project documents:

- AMS QAPP
- ISU SOP
- Laboratory Section QAM
- Laboratory Section SOPs

The AMS Coordinator is responsible for final verification and validation of all results.

D2. Validation and Verification Methods

Field staff

Field staff will visually check the following items as produced to ensure that they are complete and correct:

- Sample tags
- Sample submission documentation
- Field data worksheet (hard copy)
- Electronic field data spreadsheet submission (transcription of hard copy field worksheet)

Field staff will also review hard copy analytical results as received for completeness, accuracy, and unusual values. Any issues should be brought to the attention of the AMS Coordinator for resolution.

Laboratories

Data verification and validation activities performed by the Laboratory Section and applicable criteria are described in their QAM (Appendix 8). Activities involved in sample receipt are detailed in Section 7: *Sample Custody and Handling*. Verification of analytical results is detailed in Section 12.2: *Data Verification*.

If circumstances arise where samples do not meet criteria outlined in the QAM, the Laboratory Section will report this using their standard Sample Condition Upon Receipt (SCUR) form, Sample Anomaly Report (SAR), and flag the result using a standardized list of data qualifier codes. The most common qualifier codes used for AMS data are shown in Table D2.1. A full list is available in section 12.3: *Reporting* of the QAM. Copies of SCURs and SARs and data qualifiers will be provided along with the analytical report sent to the AMS Coordinator and Ambient Monitoring Technician.

Table D2.1: Common data qualifier codes (flags)

B	Results based upon colony counts outside of the acceptable range and should be used with caution. This code applies to microbiological tests and specifically to membrane filter (MF) counts. It is to be used if less than 100% sample was analyzed and the colony count is generated from a plate in which the number of coliform colonies exceeds the ideal ranges indicated by the method. These ideal ranges are defined in the method as 20-60 colonies (fecal coliform) and 20-80 colonies (total coliform). B1. Countable membranes with less than 20 colonies. Reported value is estimated or is a total of the counts on all filters reported per 100mL. B2. Counts from all filters were zero. The value reported is based on the number of colonies per 100mL that would have been reported if there had been one colony on the filter representing the largest filtration volume (reported as a "<" value). B3. Countable membranes with more than 60 (or 80) colonies. The value reported is calculated using the count from the smallest volume filtered (reported as a ">" value). B4. Filters have counts of both >60 (or 80) and <20. Reported value is a total of the counts from all countable filters reported per 100mL. B5. Too may colonies were present/too numerous to count (TNTC). The numeric value represents the maximum number of counts typically accepted on a filter membrane (60 or 80), multiplied by 100 and then divided by the smallest filtration volume analyzed (reported as a ">" value). B6. Estimated value. Blank contamination evident.
J	Estimated value; value may not be accurate. J1. Surrogate recovery limits have been exceeded. J2. The reported value failed to meet the established QC criteria for either precision or accuracy. J3. The sample matrix interfered with the ability to make any accurate determination. J4. The data is questionable because of improper laboratory or field protocols. J5. Temperature limits exceeded (samples frozen or >6°C) during transport. Non-reportable for NPDES compliance monitoring. J6. The laboratory analysis was from an unpreserved or improperly chemically preserved sample. The data may not be accurate.
P	Elevated PQL due to matrix interference and/or sample dilution.
Q	Holding time exceeded. These codes shall be used if the value is derived from a sample that was received, prepared, and/or analyzed after the approved holding time restrictions for sample preparation and analysis. Q1. Holding time exceeded prior to receipt by lab. Q2. Holding time exceeded following receipt by lab.
U	Indicates that the analyte was analyzed for but not detected above the reported PQL. The number value reported with "U" qualifier is equal to the PQL.
X	Sample not analyzed for this constituent. X1. Sample not screened for this compound. X2. Sampled, but analysis lost or not performed- field error. X3. Sampled, but analysis lost or not performed- lab error.
Y	Elevated PQL due to insufficient sample size.
Z	The sample analysis/results are not reported due to: Z1. Inability to analyze the sample. Z2. Questions concerning data reliability. The presence of absence of the analyte cannot be verified.

AMS Coordinator

Final review, validation, and verification duties of results reported by Regional Monitors and the Laboratory Section are performed by the AMS Coordinator on an ongoing basis.

- As received: Review hard copy lab reports. Consult Laboratory Section staff for clarification or corrections if needed. Review data entry of analytical results by ESS support staff.
- Monthly: Review electronic field data submissions from Regional Monitors. Consult individual Monitors for clarification or corrections if needed.
- Quarterly: All results, field and analytical, compiled, reviewed, validated, and verified.

The methods, criteria, and checklists used by the AMS Coordinator for the quarterly data verification and validation are included in Appendix 6. Most methods rely on using Microsoft Access queries and SAS JMP analysis.

When errors or omissions are found or suspected, focused verification will be conducted. The available electronic field data submissions or hard copy lab reports will be consulted to rule out transcription or data entry errors. If no errors are found in these records, the field staff that conducted the sampling/measurement or the appropriate Laboratory Chemist will be contacted so they can consult original hard copy records. If the result in question is found to be in error as compared to the original documentation, it will be corrected by the AMS Coordinator. In the case of "impossible" values (e.g., pH of 19) if a corrected value cannot be determined from original documentation, the result will be deleted. "Unusual" values (i.e., above or below the latest five year period's minimum or maximum for that station) that are confirmed by original documentation are left intact and unqualified.

Once these steps are completed, data and any accompanying information (comments from field staff, data qualifiers/flags) are considered finalized and are added to the data warehouse. In fulfillment of data requests, the AMS Coordinator will provide all comments, data qualifiers, and a current copy of the data assessment document (*Important Information for Users of North Carolina Ambient Water Quality Monitoring Data*, v. 2.4) to assist the data user with interpretation of the raw data and facilitate the data user's assessment of the usability of the data for their project or program.

Data end-users

The EU Water Quality analyst and others that request data retrievals from ESS may note odd or possibly incorrect values. These questionable data should be brought to the attention of the AMS Coordinator for focused verification. For data collected within the past five years, original lab reports and field data submissions are on file in the AMS Coordinator's office. Lab reports between six and ten years old are stored at the State Records Center and can be accessed if necessary. These will be consulted to determine if correction or deletion of any records in the main warehouse is required, using the same criteria as described above for quarterly data reviews. Original documentation for data collected before 1998 is not available and so confirmation and/or correction is not possible. This historic data will remain unchanged in the main warehouse and it is up to each data user to determine the proper handling of these results.

D3. Reconciliation With User Requirements

When preparing the BARs, the Water Quality Analyst will perform an additional tier of data review on results from the assessment period. This is a similar process to that performed by the AMS Coordinator. The Water Quality Analyst may use more stringent statistical validation methods in determining possible outliers or other anomalies. These may be omitted from the BAR data set for purposes of statistical analysis and reporting. The Water Quality Analyst will also review the current data assessment document and other available documentation of known issues or concerns.

One of the main objectives of the AMS is to use the data generated to determine the percentage of water quality standard violations. This information is combined with other available data by Planning Section staff to support their water quality management programs and reporting requirements, particularly 303(d)/305(b) reporting. For all indicators except fecal coliform, if data from a sampling station shows exceedance of the applicable water quality standard in more than 10% of samples, the reach may be subject to impairment for that indicator by the Planning Section. This threshold level of 10% is based on EPA guidance. However, this "raw-score" approach does not consider uncertainty, and the smaller the sample size, the greater the uncertainty.

In order to assist Planning Section with making sound decisions of impairment, the AMS uses a nonparametric procedure to identify when a sufficient number of exceedances have occurred that indicate the probability of a true exceedance of 10%. This method is described in detail in *A Nonparametric Procedure for Listing and Delisting Impaired Waters Based on Criterion Exceedances* (Lin, et al., 2000). It is partly based on the BINOMDIST function in MS Excel. For details, refer to http://www.dep.state.fl.us/water/tmdl/docs/Supdocument.PDF.

A graphical representation of the relationships between sample size, number of exceedances, and percent confidence is shown in Figure D3.1. The triangles denote where the number of exceedances correspond with a sample size that provides about a 95% confidence that the population has greater than 10% of results violating a water quality standard.

When preparing the BAR, the Water QualityAnalyst will present a summary of all indicators at all stations with a sample size of at least 10 and with more than 10% of samples exceeding the applicable standard. Instances where the 10% threshold was exceeded with about a 95% confidence or better will be highlighted.

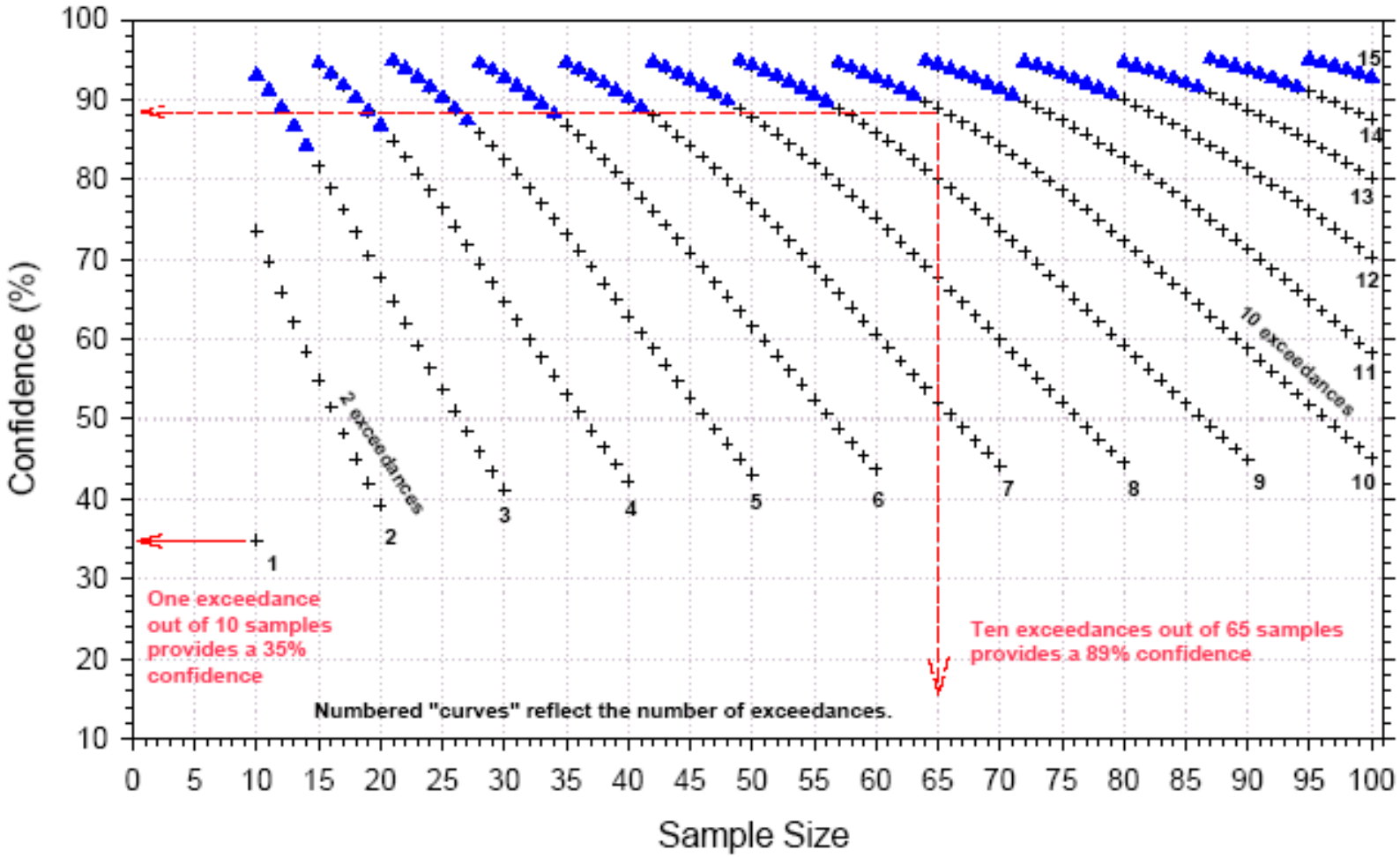


Figure D3.1: Sample size, number of exceedances, and statistical confidence of 10% exceedance

References

American Public Health Association.1992. *Standard Methods for the Examination of Water and Wastewater*, 18th ed. Washington, D.C.: APHA.

American Public Health Association.1998. *Standard Methods for the Examination of Water and Wastewater*, 20th ed. Washington, D.C.: APHA.

Fisher Scientific. 1998. *Accumet AP Series Handheld pH/mV/Ion Meter Instruction Manual*. Fisher Scientific International.

HACH Environmental. 2006. *Hydrolab DataSonde 5 and MiniSonde Water Quality Multiprobes User's Manual, Edition 3*. Loveland, CO: HACH Environmental.

Hydrolab Corporation. 1996. *Surveyor 4 Water Quality Data Display User's Manual Revision A*. Austin, TX: Hydrolab Corporation.

Hydrolab Corporation. 1999. *DataSonde 4 and MiniSonde Water Quality Multiprobes User's Manual, Revision G*. Austin, TX: Hydrolab Corporation.

Hydrolab Corporation. 2001. *Quanta Water Quality Monitoring System Operating Manual, Revision B*. Austin, TX: Hydrolab Corporation.

Lin, Pi-Erh, Duane Meeter, and Xu-Feng Niu. 2000. *A Nonparametric Procedure for Listing and Delisting Impaired Waters Based on Criterion Exceedances*. Tallahassee, FL: Florida State University, Department of Statistics.

NCDENR. 2010. *North Carolina Water Quality Assessment and Impaired Waters List (2010 Integrated 305(b) and 303(d) Report)*. Raleigh, NC: NCDENR, Division of Water Quality, Planning Section.

NC Environmental Management Commission. 2007. *Procedures for Assignment of Water Quality Standards.*15A NC Administrative Code Section 2B .0100.

NC Environmental Management Commission. 2007. *Classifications and Water Quality Standards Applicable to Surface Waters and Wetlands of NC.* 15A NC Administrative Code Section 2B .0200.

U.S. EPA. 2002. *Guidance for Quality Assurance Project Plans (QA/G-5)*. (EPA/240/R-02/009). Washington, D.C.: Government Printing Office.

U.S. EPA. 2002. *Guidance on Choosing a Sampling Design for Environmental Data Collection (QA/G-5S)*. (EPA/240/R-02/005). Washington, D.C.: Government Printing Office.

U.S. EPA. 2002. *Guidance on Environmental Data Verification and Data Validation (QA/G-8)*. (EPA/240/R-02/004). Washington, D.C.: Government Printing Office.

U.S. EPA. 2001. *EPA Requirements for Quality Assurance Project Plans (QA/R-5)* (EPA/240/B-01/003). Washington, D.C.: Government Printing Office.

U.S. EPA. 1995. *Method 1669: Sampling Ambient Water for Trace Metals at EPA Water Quality Criteria Levels*. Cincinatti, OH: U.S. EPA NCEPI.

U.S. EPA. 2002. *Method 1631, Revision E Mercury in Water by Oxidation, Purge and Trap, and Cold Vapor Atomic Fluorescence Spectrometry* (EPA 821-R-02-019). Washington, D.C.: U.S. EPA Office of Water.

YSI, Inc. 1998. *YSI Model 85 Handheld Oxygen, Conductivity, Salinity, and Temperature System Operations Manual, Revision D*. Yellow Springs, OH: YSI, Inc.

YSI, Inc. 2009. *YSI Professional Plus User Manual, Revision D*. Yellow Springs, OH: YSI, Inc.