APPENDIX 12: APPROVED MONITORING QUALITY ASSURANCE PROGRAM PLAN

Quality Assurance Project Plan

Required for certain US EPA funded grants and contracts that are awarded by the Division of Water Quality, NCDENR

NCDENR- DWQ QUALITY ASSURANCE PROJECT PLAN CHECKLIST

To first assess whether a Quality Assurance Project Plan is necessary, please answer the following four questions:	
1. Is Federal money from the US EPA being spent on this activity? (*If the answer is "No" then a QAPP is not necessary; proceed to answer section A1 only. If "Yes" then proceed to # 2).*	❑ **Yes** ❑ **No**
2. Will work require acquisition of environmental data generated from direct measurements activities (i.e., water quality sampling), collected from other sources, or compiled from computerized databases? *(If the answer is "No", then a QAPP is not necessary; proceed to answer section A1 only. If "Yes" then proceed to # 3).*	❑ **Yes** ❑ **No**
3. *Will all instream water quality samples be analyzed by a Laboratory certified by the State of North Carolina? Proceed to # 4.*	❑ **Yes** ❑ **No**
4. Has a QAPP already been approved for your activity*? (If the answer is "No" then please complete Sections A-D on the following pages. If "Yes", then please answer section A1 and attach a copy of the approved QAPP, or provide a reference (including Agency, Telephone number, and Web Address, if available) for the complete approved QAPP, and return this form with attachments to your DWQ EPA Funds Manager*).	❑ **Yes** ❑ **No**
5. Do you intend for your data to be considered for Use Support decisions, e.g., 303(d)	❑ **Yes** ❑ **No**

Quality Assurance Project Plan Form

Adopted from the US EPA by the Division of Water Quality, NCDENR

A1. Project Title and Approval Sheet

Bolin Creek Watershed Restoration Initiative

(Project Name)

Town of Chapel Hill, Division of Stormwater Management

(Responsible Agency)

September 10, 2009

(Date)

1666

(NC DENR Contract #)

Project Manager Signature ______________________________

(Name/Date)

Project QA Officer Signature______________________________

(Name/Date)

DWQ EPA Funds Manager

Signature of Receipt (Name/Date)___________________________

Quality Assurance Project Plan Details and Explanation

All environmental projects that are funded, directly or indirectly, by the US Environmental Protection Agency (EPA) and which generate data from direct measurement activities, collect data from other sources or compile data from computerized data bases and information systems must have a Quality Assurance Project Plan (QAPP) approved prior to the collection of project data. QAPPs are required under Code of Federal Regulations 48CRF46, and 40CFR 30, 31 and 35. The QAPP documents the planning, implementation and assessment procedures of the project's data needs. Specifically, it describes and documents the collection methods, and type and quality of data to be gathered. These criteria will vary from project to project depending on the scope of the work, expectations for the end result and perhaps overall cost of the project. Some project QAPPs must follow the national consensus standard, (ANSI/ASQC E4-1994, Specifications and Guidelines for Environmental Data Collection and Environmental Technology Programs*) in order to be acceptable for their end use. Whereas other projects may use non-standardized or simplified data collection approaches because the end result, or use of the data, may not need to conform to existing data quality or may not be as critical for decision making .The overall purpose of the QAPP is to assure that appropriate methods of data collection are used and that documentation of the quality assurance approach is available for users of the data.*

EPA has established requirements for an acceptable QAPP. Details and explanations of these requirements can be found on EPA's web site at ***http://www.epa.gov/quality1/qapps.html.*** *Many of the required elements may already be found in your DWQ approved study proposals (e.g., Scope of Work). If so, please copy the appropriate information from your workplan to the attached DWQ/EPA QAPP form. The completed QAPP MUST be submitted to the DWQ BEFORE data collection activities begin.*

A2. Table of Contents

A3. Distribution List 5

A4. Project/Task Organization 6

A5. Problem Definition/Background..7
 Problem Statement 7
 Intended Usage of Data 7

A6. Project/Task Description 8
 General Overview of Project...8
 Project Timetable 9

A7. Quality Objectives and Criteria 10
 Data Precision, Accuracy, Measurement Range 10
 Data Representativeness 11
 Data Comparability..11
 Data Completeness...12

A8. Special Training/Certification 13
 Training Logistical Arrangements 13
 Description of Training and Trainer Qualifications.......................13

A9. Documents and Records 13

B1. Sampling Process Design..14
 Rationale or Criteria for Selection of Sampling Sites...................14
 Project Monitoring Locations and Watershed Boundaries 15
 Sample Design Logistics..16

B2. Sampling Methods 17
 Identify Sampling Equipment, Collection Methods and SOPs 17
 Field Sampling Methods 18
 Sources and References used as Guidance for Typical Data Collection........19

B3. Sampling Handling and Custody 12

B4. Analytical Methods..12

B5. Quality Control 13
 Field QC Checks...13
 Laboratory QC Checks 13
 Data Analysis QC Checks...13

B6. Instrument/Equipment Testing, Inspection, and Maintenance..............................14

B7. Instrument/Equipment Calibration and Frequency 14

A2. Table of Contents (continued)

B8. Inspection/Acceptance of Supplies and Consumables 15

B9. Non-Direct Measurements 15
Non-Direct Measurements 15
Data Recording Methods for Non-Direct Measurements 15

B10. Data Management 16
Data Type and Data Management/Storage 16
Data Management and Analysis 16

C1. Assessment and Response Actions 17

C2. Reports to Management 17

D1. Data Review, Verification, and Validation 17
Criteria for Accepting, Rejecting, or Qualifying Project Data 17
Decision Rule or "if/then" Statement 18

D2. Verification and Validation Methods 18

D3. Reconciliation with User Requirements and DQOs 18

Appendices

Appendix A: Location and Site Maps

Appendix B: Laboratory Documents and Forms

A3. Distribution List

Names and telephone numbers of those receiving copies of this QAPP. Attach additional page, if necessary. (Name, Organization, Telephone)

Name	Organization	Phone	Email	Mailing Address
Kim Nimmer	NC DWQ	919-807-6438	kimberly.nimmer@ncdenr.gov	NPS Planning Unit, NCDWQ, 1617 Mail Service Center, Raleigh, NC 27699-1617
Sue Burke	Town of Chapel Hill, Stormwater Management	919-969-7233	sburke@townofchapelhill.org	405 Martin Luther King Jr., Blvd., Chapel Hill, NC 27514
Randy Dodd	Town of Carrboro	919-918-7326	rdodd@townofcarrboro.org	301 W. Main Street, Carrboro, NC 27510
Paul Clark	NC DWQ	919-807-6443	paul.clark@ncdenr.gov, paul.clark@ncmail.net	NPS Planning Unit, NCDWQ, 1617 Mail Service Center, Raleigh, NC 27699-1617
Greg Jennings	NCSU, Biological and Agricultural Engineering	919-600-4790	jennings@ncsu.edu, Greg_Jennings@ncsu.edu	North Carolina State University Campus Box 7625 Raleigh, NC 27695-7625
Bill Hunt	NCSU, Biological and Agricultural Engineering		bill_hunt@ncsu.edu, wfhunt@ncsu.edu	North Carolina State University Campus Box 7625 Raleigh, NC 27695-7625
Michael Herrmann	NC Ecosystem Enhancement Program	919-715-5458	Michael.Herrmann@ncmail.net, michael.herrmann@ncdenr.gov	NC Ecosystem Enhancement Program, 1652 Mail Service Center, Raleigh, NC 27699-1652
Michael Shaffer	NCSU, Biological and Agricultural Engineering	336-312-8786	mike_shaffer@ncsu.edu, mbshaffe@ncsu.edu	North Carolina State University Campus Box 7625 Raleigh, NC 27695-7625
Patricia D’Arconte	Town of Chapel Hill, Stormwater Management	919-969-7202	pdarconte@townofchapelhill.org	405 Martin Luther King Jr., Blvd., Chapel Hill, NC 27514
Zan Price	NCSU, Biological and Agricultural Engineering	828-712-9194	gaprice@ncsu.edu	North Carolina State University Campus Box 7625 Raleigh, NC 27695-7625
Karen Hall	NCSU Water Quality Group	919-515-8242	karen_hall@ncsu.edu	NC Cooperative Extension, Campus Box 7637, Raleigh, NC 27695-7637
Rachel Huie	NCSU, Biological and Agricultural Engineering	919-515-6766	huie@eos.ncsu.edu	North Carolina State University Campus Box 7625 Raleigh, NC 27695-7625

A4. Project/Task Organization

Key project personnel and their corresponding responsibilities are listed below. Organization chart is Figure 1.

Name, Position	Project Title/Responsibility
Patricia D'Arconte	Project Manager
Dr. Greg Jennings	QA Officer
Michael Shaffer, Patricia D'Arconte	Field/Sampling Leaders
David Almond, Randy Dodd	Field Assistants
NCSU BAE Lab (Rachel Huie)	Laboratory Manager/Leader
Zan Price, Michael Shaffer	Project Engineer, Surveying
NCSU BAE Lab, Dave Lenat	Subcontractors (if applicable)
Town of Chapel Hill, Town of Carrboro, NC Division of Water Quality	Data users (list organizations/agencies that will use data)

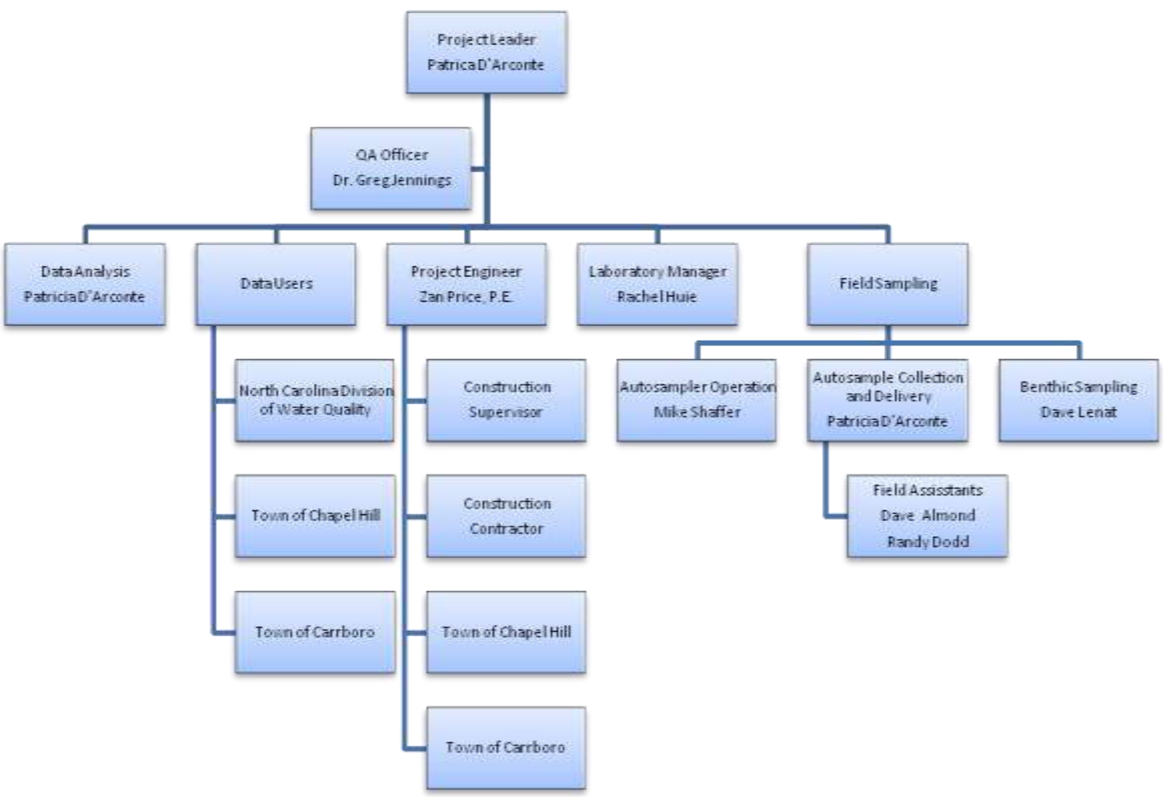


Figure 1. Organization Chart

A5. Problem Definition/Background

Problem Statement - Explain the background of the project and the reasons for initiating the project Also include uses and/or designated uses and impairment of the water resource, if applicable.)

The Bolin Creek Watershed Restoration Initiative is a joint project between the Towns of Carrboro and Chapel Hill, the Ecosystem Enhancement Program, US EPA and NC DWQ to improve the health and functioning of the Bolin Creek Watershed, with a goal of removing all listed segments of Bolin Creek from the State's 303(d) List of Impaired Waters. Watershed restoration is being approached on a subwatershed basis since sources of impairment are well-distributed throughout the watershed.

Two project subwatersheds within the larger Bolin Creek watershed have been chosen as pilot projects to restore a more natural hydrology and reduce nutrient export. These projects call for the installation of stormwater BMPs and stream enhancement, restoration, and riparian reforestation in order to decrease stormwater runoff velocities and volumes, increase infiltration and groundwater recharge, reduce erosion and export of sediment and nutrients, and improve stream habitats and biological conditions.

The monitoring described in this QAPP is specifically for evaluation of effectiveness of these two projects, comparing water chemistry, flow, and morphology before construction to conditions after construction.

Intended Usage of Data - State the usage and outcomes expected from the information to be collected (e.g., remove from impaired list, show that the BMP is effective, watershed characterization or background data, environmental education, etc.). Describe type of data to be collected (e.g., screening, definitive, characterization, baseline/background). If applicable, cite technical or regulatory standards or criteria to which data will be compared.

The purpose of this monitoring is to determine effectiveness of combined installed stormwater BMPs and stream channel enhancement, restoration, and reforestation for two project watersheds. In specific, we expect a decrease in suspended sediment, nitrogen, and phosphorus loads, moderation of a "flashy" urban hydrograph, reduction in bank/bed erosion rates, and increased channel stability.

Certain outcomes may take longer periods of time to detect changes, such as increased base flow, reduced temperatures (both base flow and stormwater), denser canopy cover/vegetative community, more diverse benthic habitats and stream geomorphology, and an improved Index of Biotic Integrity using benthic macroinvertebrates. These subsystems take longer to respond to changes in hydrology and chemical fluxes. Taking measurements of these subsystems right before and after construction gives us a baseline to compare to in five to ten years, should monitoring resources become available then.

A6. Project/Task Description

General Overview of Project - Summarize the work to be performed. Define geographic, spatial, and/or temporal boundaries. Briefly describe the monitoring/experimental design and how monitoring data will assist in achieving project monitoring objectives. Note, details on sample locations and monitoring design should be provided in Section B1 below. Discuss resource and time constraints, as appropriate.

Chemical, hydrological, biological, and morphological conditions before construction will be compared to conditions after construction. The primary aims of monitoring are to detect reductions in export of nitrogen, phosphorus, and suspended sediment and a reduced flood peak (i.e. reduced flashiness). While we would like to observe an improved biological community as a result of changes in morphology, hydrology, and chemistry, sampling of benthic macroinvertebrates for one or two years after construction is probably insufficient to detect changes in the community, as it can take well over 5 years for the community to respond to changes in chemistry, flow, or habitat. However, samples taken as part of this project can be compared to samples taken in 5 years or more to detect changes in the macroinvertebrate community.

Some conditions are being monitored for purposes of pre-construction analysis and engineering design (i.e. rainfall, flow). Some conditions are being monitored for changes that might require additional maintenance or care (i.e. stability of modified channel sections and longitudinal profile, erosion, survivorship of riparian plantings, resprouting of invasive species, photos). Other conditions are being monitored in support of benthic macroinvertebrate monitoring, where additional information may help us better understand factors that may help or hinder improvement in the macroinvertebrate community (stream habitat, bed sediment, temperature).

Primary monitoring locations will be below areas of construction and riparian plant management in the two project subwatersheds (Baldwin Park and a tributary to Mill Race). Monitoring will begin prior to construction in fall of 2009, continue through construction, and conclude in fall of 2011. Construction will be staggered, with work done in summer 2010 for Baldwin Park, and work done in winter 2010/2011 for the tributary to Mill Race.

Project Timetable - Work schedule indicating critical project points

Activity	Start Date	Known or Anticipated Date of Completion
Install automated samplers, rain gauge	June 2009	September 2009
Collect water samples, discharge, water level, temperature, precipitation	October 2009	September 2011
Longitudinal and cross-sectional surveys, bed and bank erosion, bed sediment	December 2008, February 2009 (pre-design); March 2010, March 2011 (post-design)	December 2008, February 2009 (pre-design); March 2010, March 2011 (post-design)
Photo documentation	Fall 2009, Spring 2010, Fall 2010, Spring 2011	Fall 2009, Spring 2010, Fall 2010, Spring 2011
Collect benthic macroinvertebrates and habitat	Summer 2009, Summer 2010, Summer 2011	Summer 2009, Summer 2010, Summer 2011
Vegetation survivorship	Fall 2010, Spring 2011, August 2011	Fall 2010, Spring 2011, August 2011
Quarterly Reports (to include a summary of data from each quarter)	End of each quarter, starting October 2009	October 2011
Data Analysis & synthesis	July 2011	October 2011
Complete Project Final Report	July 2011	October 2011

A7. Quality Objectives and Criteria Identify performance/measurement criteria for all information to be collected; and acceptance criteria, including project action limits and laboratory detection limits, and range of anticipated concentrations of each parameter of interest (includes field and lab, if applicable)

Data Precision, Accuracy, Measurement Range

Express the degree to which sample results are repeatable. State decision error limits, if applicable
Note: Projects which are based on authoritative rather than statistical sampling designs will not have quantitative decision error limits

Matrix	Parameter	Measurement Range	Accuracy	Precision
Water	Nitrate + nitrite	0.0-2.0 mg N/L, MDL 0.011 mg N/L	0.0024 mg N/L	0.0035 mg N/L
Water	Ammonia/ammonium	0.0-2.0 mg N/L, MDL 0.015 mg N/L	0.0003 mg N/L	0.0017 mg N/L
Water	Orthophosphate	0.00-0.80 mg P/L, MDL 0.008 mg P/L	0.0006 mg P/L	0.003 mg P/L
Water	Total Phosphorus	0.0- 4.0 mg P/L, MDL 0.014 mg P/L	0.0143 mg P/L	0.0045 mg P/L
Water	Total Kjeldahl Nitrogen	0.0-6.0 mg N/L, MDL 0.038 mg N/L	0.023 mg N/L	0.011 mg N/L
Water	Total suspended solids	1 mg/L	Not available at this time	Not available at this time
Water	Temperature	-20° to 50° C (HOBO) -5.00 to 55.00° C (Hanna)	0.2° C (HOBO) 0.15° C (Hanna)	0.02° C (HOBO) 0.01° C (Hanna)
Water	pH	0.00 to 14.00	600.0 mV	0.01
Water	Specific conductivity	0.001 to 9.999 mS/cm	0.001 mS/cm	0.001mS/cm
Water	Dissolved oxygen	0.00 to 30.00 mg/L	0.10mg/L	0.01mg/L
Water	Level	0 – 3 feet	0.001 feet	0.01 feet
Water	Velocity	0.001 m/s to 4.5 m/s	0.001 m/s	0.001 m/s
Benthic habitats	Benthic macroinvertebrates	N/A	ID to lowest possible taxonomic level	N/A
Precipitation	Volume/rate	0 – 50 inches	0.01 inches	0.01 inches
Stream channel	Bank erosion	± 2 feet	0.1 feet	0.25 feet
Stream channel	Bed erosion	± 2 feet	0.1 feet	0.25 feet
Stream channel	Bed substrate	N/A	N/A	N/A
Stream channel	Cross-section profiles	N/A	Depends on local benchmark data quality	0.01 foot vertical, 0.1 feet horizontal
Stream channel	Longitudinal profiles	N/A	Depends on local benchmark data quality	0.01 foot vertical, 0.1 feet horizontal
Riparian area	Vegetation survivorship plots	N/A	N/A	N/A
Riparian area	Photos	N/A	N/A	N/A

Data Representativeness

Express the degree to which the data accurately represents the population or the environmental condition at the sampling location (i.e. explain how well the monitoring characterizes the physical conditions)

Water sampling locations (chemistry, flow, temperature) are selected on a judgemental basis (not random/statistical) and located below construction and riparian management areas. Water sampling locations at the end of each watershed (instead of scattered throughout) are expected to be sufficiently representative of stream chemistry conditions at those points only, but may give an adequate understanding of nutrient and sediment export to lower reaches. They are not expected to represent conditions throughout each watershed. The specific locations for water sampling are somewhat biased due to the difficulty of siting autosamplers in high-density urban areas (i.e. there may be better locations to site them if it weren't for the surrounding land uses and constraints).

Locations for biological samples are taken as far down in the watershed as possible, but must also avoid being too close to culverts, construction areas, and water sampling areas to reduce effects on organisms. Biological sampling locations are thus limited by the high density of land use and may not well represent biological conditions through most of each watershed.

Locations for channel measurements (surveys, sediment, erosion) are necessarily biased towards areas undergoing purposeful channel adjustment (i.e. construction) or accidental channel adjustment (areas observed to appear to have high erosion).

It is assumed the area will maintain fairly normal climatic conditions through the length of the study. Any severe climatic deviations (such as the exceptional drought of 2007-08) will be carefully considered in data analysis should they occur.

Data Comparability

Express the degree of confidence that one data set can be compared to another at the sample location or to a sample taken at another location

To ensure within-project data comparability, established standard operating procedures will be used, and sampling locations will not change throughout the length of the study. We intend to maintain similar or comparable procedures for subsequent projects of a similar nature in the Bolin Creek watershed.

Channel surveys, bed sediment, and measurement of erosion use standard methods used for many other projects familiar to many of the project participants.

Biological samples are being collected using DWQ's Qual4 method, and being identified by a retired DWQ employee who conducted such sampling while employed by the agency. This ensures that our biological data are more readily comparable to other streams, collections made by other teams, as well as to collections at the two project areas made several years from now.

Data Completeness

Measure of the amount of valid data needed to develop conclusions (i.e., estimate how many measurements are needed to meet each monitoring objective(s))

Parameter	No. Valid Samples	Minimum No.	Monitoring

	Anticipated	Valid Samples needed	Objective
Base flow chemistry	24 per watershed	12	Detect differences between pre- and post-construction
Storm flow chemistry	24 per watershed	6	Detect differences between pre- and post-construction
Benthic macroinvertebrates	3	2	Get a community baseline

A8. Special Training/Certification - General description of training requirements and needs. Describes special personnel or equipment requirements, if applicable.

Training Logistical Arrangements

Training Topic(s)	Personnel Trained	Training/Certification Frequency
Macroinvertebrate collection methods	D'Arconte, Almond, Dodd	once
Plant ID	D'Arconte, Almond, Dodd	As needed (at least once)
Autosampler care and maintenance	D'Arconte, Almond, Dodd	At least once

Description of Training and Trainer Qualifications

Training Topic(s)	Training Description	Trainer Qualifications
Macroinvertebrate collection methods	DWQ methods	Dave Lenat, retired DWQ
Plant ID	Based on target invasive species for management, selected planted species	Karen Hall, NCSU Extension Biologist
Autosampler care and maintenance	Installation, programming, maintenance and data manipulation	Michael Shaffer, NCSU Extension Associate

A9. Documents and Records - Identify all data reporting information and list all project documents, reports, and electronic files that will be produced. Include QA records and reports, List information and records to be included in data reports (e.g., lab/field raw data, field logs, lab records, results of QC checks, problems encountered).

Information/Data Type	Recording Medium & Retention Duration	Responsible Party
Field notes	Field book using checklist (copy attached) and permanent storage of field books	Field Sampling Leader
Field data	See section B-10	Field Sampling Leader
Lab analysis reports	Excel, two separately stored permanent electronic copies of results	Lab supervisor and Project Leader

Photos	Two separately stored permanent electronic copies of each photograph	Field Sampling Leader and Project Leader
Survey data	Excel, two separately stored permanent electronic copies of results	Project Engineer and Project Leader

B1. Monitoring Experimental Design - Describe and justify the experimental monitoring design strategy, indicating size of the area, volume, or time period to be represented by the monitoring (detail the type and total number of sample types/matrix or test runs/trials expected and needed). Also include monitoring of covariates such as rainfall and discharge.

Rationale or Criteria for Selection of Sampling Sites- Describe and justify the experimental monitoring design strategy, indicating size of the watershed area, discharge volume, or time period to be represented by the monitoring. Describe appropriate validation study information for nonstandard sampling situations (if applicable).

Two small project watersheds: "Baldwin Park" (approximately 2776 acres) and "Trib to Mill Race" (approximately 2363 acres). Monitoring is taking a "before-after construction" approach for each project location rather than a paired watershed approach. This is due to the difficulty of finding well-matched watersheds of similar size and land use type and history for comparison in our urban areas.

Due to the restrictive timeline of EPA funding (3 years), and the need to stagger construction (i.e. construction in one watershed summer 2010) and the other winter 2010/2011), the two watersheds will have different amounts of pre-construction and post-construction monitoring. At a minimum, we will have 4 months of sampling before construction, and 6 months of sampling after planting.

See section A7 for a description of possible biases due to sampling location.

Project Monitoring Locations and Watershed Boundaries - Show map that delineates watershed boundaries or drainage area being monitored. Provide maps or tables that show/state geographic locations of sample locations (include GPS data coordinates). If other data sources are to be obtained and compiled, list these sources as well.

Each project includes a combination of multiple stormwater BMPs, riparian vegetation management, stream enhancement and stream restoration along the stream lengths. Water flow, chemistry, and temperature sites are located below all areas of disturbance. See Appendix A, Map 1 for the location of the Bolin Creek Watershed relative to other sections of the Upper Cape Fear Basin. See Appendix A, Map 2 for locations of project watersheds within Bolin Creek Watershed.

The "Baldwin Park" water flow/chemistry/temperature site is located just below the confluence of two tributaries (both with project activity on them), on Town of Chapel Hill-owned property. It is accessed via a cleared OWASA easement. See Appendix A, Map 3 for approximate locations of surveys and monitoring in the "Baldwin Park" watershed. A rain gauge is located in Baldwin Park in an open area.

The "Tributary to Mill Race" water flow/chemistry/temperature site is located just above a concrete-encased OWASA line crossing that is acting as grade control. It is on property owned by the local Homeowner's Association and accessed via a cleared OWASA easement. See Appendix A, Map 4 for approximate locations of surveys and monitoring in the "Trib to Mill Race" watershed.

Benthic macroinvertebrate collection areas are approximately 100 feet along the channel, upstream from the water flow/chemistry locations, not in areas to undergo channel modification.

Post-construction vegetation survivorship surveys will be multiple 1m x 5m plots representative of different treatments (i.e. kudzu control with riparian reforestation, privet/ivy control with riparian reforestation, bank stabilization with non-woody plants, riparian understory enhancement, and park/ornamental riparian plantings).

Longitudinal and cross-sectional profiles will be collected along the length of the channel for engineering design purposes prior to construction. A post-construction as-built survey will be conducted and permanent markers placed for locations of longitudinal and cross-sectional profiles. Cross-sections, photos, and bed sediment monitoring will be conducted where the stream channel has been modified or moved, to be determined during engineering design. Bank/bed erosion rate monitoring will be conducted at identified areas of probable high erosion observed prior to construction.

Sample Design Logistics - Sample numbers and frequency. Also include monitoring of covariates such as rainfall and discharge. State if parameter is for informational purposes only and not critical.

Type of Sample/ Parameter (i.e. storm/grab, water/sediment, etc.)	Number of Samples	Sampling Frequency and Period	Importance
Baseflow water chemistry – "grab" using autosampler	24 per watershed	Monthly	Critical
Stormflow water chemistry – flow-proportional storm composite	24 per watershed	Depending on precipitation events	Critical
Water level	Continuous - bubbler module 24 – staff gage	(bubbler measures every 5 minutes), staff gauge height noted at each maintenance visit	Critical
Water field parameters	48 per watershed	At each baseflow and stormflow sample time	Supporting
Discharge	Irregular	Sufficient measurements at different flow levels to develop rating curve	Critical
Precipitation	Continuous	measures every 0.01 inches of precipitation	Supporting
Benthic Macroinvertebrates and habitat	3 per watershed	One every summer	Critical
Water Temperature	Continuous	measures every 5 minutes	Supporting
Longitudinal Profiles	3 per watershed	One before construction, one as-built, at least one after	Supporting
Cross-section Profiles	3 per cross-section	One set before construction, one as-built, at least one set after	Supporting
Bed Sediment Survey	Once per year pebble count (2 total) at each permanent cross section	Annually (at least twice) before and after construction	Supporting
Bank/Bed Erosion	From annual cross sections and scour chains	Annually (at least twice) before and after construction	Supporting
Planted vegetation survivorship	3 per watershed	Once each spring after construction	Supporting
Photo documentation	3 sets per watershed	Before during and after construction at fixed photo points	Supporting

B2. Sampling Methods

Identify Sampling Equipment, Collection Methods and SOPs

Parameter	Sampling Equipment	Sampling Method	Sample Container, Size, Preservative, Max Holding Time
Water chemistry – nitrogen and phosphorus	Teledyne ISCO 6712 Portable Sampler	Baseflow – grab Stormflow – flow proportional	500 mL, Polyethylene bottle, acidified to pH<2 (w/ H_2SO_4), refrigerate at 4 degrees C, 48 hours
Water chemistry – total suspended solids	Teledyne ISCO 6712 Portable Sampler	Baseflow – grab Stormflow – flow proportional	500 mL, Polyethylene bottle, refrigerate at 4 degrees C, 7days
Water level	Teledyne ISCO 730 Bubbler Module, Staff gage	recorded	N/A
Water chemistry – field parameters (pH, DO, cond.)	Hanna multiparameter meter	recorded	N/A
Water temperature	Onset HOBO U22 Water Temperature Pro 2 logger (with Solar Radiation Shield)	recorded	N/A
	Hanna multiparameter meter		
Water discharge	Sontek FlowTracker	Equal width increment	N/A
Precipitation	Davis Rain Collector II	Tipping rain gauge – recorded	N/A
Benthic macroinvertebrates, habitat	Screens/nets with 0.5mm mesh	DWQ Qual 4	Glass vials, 95% ethanol
Bed sediment survey	Ruler (mm)	Wolman pebble count	N/A
Longitudinal and cross-section profiles	Topcon 320-D Total Station	3-D survey	N/A
Bank/Bed erosion	Bank pins (rebar) and scour chains	Annual measurement	N/A
Vegetation survivorship	N/A	N/A	N/A
Photo documentation	Digital camera, minimum 3.0 megapixel	Defined photo points, annually	N/A

Field Sampling Methods. Describe procedures for collection of monitoring samples. Describes sample preservation methods. Describe process for preparation and decontamination of sampling equipment. Describe or reference selection and preparation of sample containers and sample volumes. (Please do not simply reference another document, but summarize the procedures to be used here and include reference for details! Identify individuals responsible for corrective action

Cross-sections used for measuring discharge will set using painted rebar, and tape stretched between these for each manual discharge measurement. A series of discharge measurements through the duration of at least one storm for each site will be used to develop a stage-discharge rating curve. A new stage and discharge measurement will be made at each sample collection time.

Water level is recorded every 5 minutes by the autosampler using a bubbler module. The recorded level will be referenced back to a stage measurement on a stage gauge at each site visit. The elevation of a stage gauge will be referenced back to a known benchmark using standard survey methods. A measurement of pH, temperature, dissolved oxygen, and specific conductivity will be made using the multiparameter meter at the time of sample collection.

Precipitation will be recorded at Baldwin Park only using a tipping bucket rain gauge that records each 0.01 inch of rainfall. Data will be downloaded every 2 months by the field crew.

Water temperature is measured every 5 minutes by the logger, and downloaded every 2 months by the field crew. The logger should be covered by a temperature shield or cover of some kind to prevent heating of the logger by sunlight.

Lab bottle sets will be labeled with the site name (Mill Race or Baldwin Park) the date the sample bottle was filled and the date the autosampler collected the sample. They will be placed directly into a cooler with ice and transported to NCSU's lab within 48 hours of collection. Chain-of-custody forms are filled out at the time of collection. Stormflow samples will be retrieved from the autosampler no later than 40 hours after the beginning of the storm so that they may be delivered to the lab with in the holding time of 48 hours.

Bottle sets for each site will include one 500mL sample bottle for nitrogen and phosphorus analyses, and one 500mL bottle for total suspended solids analysis. Nutrient samples will be acidified to a pH below 2 using 0.5mL H2SO4 added after collection and before transport. Acidified bottles will be labeled with a "+".

3 sets of QA samples will be taken; one in fall 2009, one in fall 2010, and one in fall 2011. Each set will include a blank and a replicate for each site. Blanks will be supplied by the lab.

Baseflow samples will be collected monthly, at least 48 hours after rainfall or 72 after snow/ice using the autosampler's "grab" function to ensure comparability to the storm samples (rather than grabbing "by hand").

Autosamplers will be programmed to start sampling stormflow after 0.02" rise in water level, depending on results from the developed discharge rating curve. Each autosampler will be programmed for one rinse prior to collecting flow-proportional samples. The developed stage-discharge rating curve will be used to program the sampler for flow-proportional sampling, including the trigger water level rise, termination of the autosampler program, the flow increment for each sample, and the sample size taken at each flow increment.

Compositing the storm flow samples will utilize a dedicated incremented 4 liter polyethylene wide-mouth bottle using all the samples from the storm event. All stormflow samples will be agitated and an equal volume of each poured into the compositing bottle. The volume required from each sample will be determined by the volume of sample required and the volume available in sample bottles. The composited sample will be agitated again before filling each of the lab bottles.

Compositing bottles will be rinsed with deionized water, dried, and stored covered/capped between sample collections.

Macroinvertebrates are collected in sets of 4 types – one kick-net, one sweep-net, one leaf-pack, and one visual collection. Samples are rinsed through 0.6mm mesh and hand-picked in the field. All organisms are collected and stored in 95% ethanol for ID in the laboratory. Habitat characterization takes place at the time of organism collection using DWQ's habitat form.

Bed sediment is characterized using Wolman pebble counts unless the majority of the sediments are sand or finer, in which case sieves are to be used. Pebble counts include collection of 100 samples divided proportionally between riffles and pools.

Bank erosion is measured by the installation of rebar into banks, and the amount of rebar exposed recorded once per year. Bed erosion is measured by the installation of scour chains into the bed, and the amount of chain exposed (or buried) also measured once per year.

Longitudinal surveys – Starting at a permanently-marked point, and continuing downstream for a length of more than 2 times the meander wavelength. Elevation points of the thalweg, water surface, bankfull height, and top of bank height on both banks will be recorded at each station, to a precision of hundredths of an foot. Stations are located 10 feet apart, or at each change in bed form, whichever is the shorter distance. Standard survey procedures should be used to reference the elevation back to a known benchmark, and to make turning-points as necessary.

Cross-sectional surveys – a tape is stretched taut across the cross-section from a permanently-marked starting point to an ending point located above top of bank. Elevation measurements are taken at a minimum at every break in slope, or every foot (whichever is the shorter distance), to a precision of hundredths of a foot. Standard survey procedures should be used to reference the elevation back to a known benchmark.

Photos are to be taken at marked photo points, facing the same direction for each set of shots. An object of a standard size should be placed in the field of view to provide a replicable visual comparison from shot to shot.

Vegetation survivorship plots should have at least one corner permanently marked; which corner is recorded in field notes, as well as the plot size and dimensions. Numbers of surviving planted individuals, as well as "volunteers" should be counted, recorded by species. Presence of any invasive species should be noted and an estimate of percent area covered made.

Sources and References used as Guidance for Typical Data Collection (e.g., USGS field collection methods, data needs for watershed models, monitoring design guidance documents)

Water sample collection, water level (using bubbler) – 6712 Portable Samplers: Installation and Operation Guide. 730 Bubbler Module: Installation and Operation Guide. FlowLink software manual. Teledyne ISCO.

Water level (using staff gage) – Buchanan, T.J. and Somers, W.P. 1982. Stage Measurement at Gaging Stations. Techniques of Water-Resources Investigations of the US Geological Survey. Book 3, Chapter A7.

Water temperature – HOBOWare Pro Manual and related HOBO manuals. Onset Corp.

Discharge measurement – Nolan, Michael K. and Shields, Ronald R. 2000. Measurement of Stream Discharge by Wading. Water Resources Investigations Report 00-4036, version 1.1. US Geological Survey. (MPEG format on CD), also Sontek FlowTracker Manuals (v2.6)

Precipitation – Rain Collector II manual, Davis Instruments.

Stage-discharge rating curve development – Kennedy, E.J. 1984. Discharge Ratings at Gaging Stations. Techniques of Water-Resources Investigations of the US Geological Survey. Book 3, Chapter A10.

Benthic Macroinvertebrates and Habitat – Standard Operating Procedures for Benthic Macroinvertebrates. 2003. Biological Assessment Unit, NC Department of Environment and Natural Resources.

Photo documentation – Hall, Frederick C. 2002. Photo Point Monitoring Handbook. US Forest Service General Technical Report PNW-GTR-526. US Department of Agriculture.

Safe Field Techniques – Yobbi, D.K, Yorke, T.H., and Mycyk, R.T. 1996. A Guide to Safe Field Operations. Open-File Report 95-777. US Geological Survey.

B3. Sample Handling and Custody - Identify how the samples will be physically handled, transported, and received; and describe the documentation of sample information handling and chain-of-custody. Include maximum allowed holding times from collection to analysis and lab preservation procedures.

See Standard Methods for the Examination of Water and Wastewater 20th Edition. Section 1060 on Collection and Preservation of Samples with an emphasis on filling the sample container full, take care not to overfill the bottle if it already contains a preservative. Sample bottles can be submitted to the BAE/EAL between the hours of 7:30 am and 4:00 pm. Sample Bottles will be clearly labeled (with a permanent label and marker) with Sample Site/Date/ID Code/ if the sample has been acidified indicate with "+". A separate "non-acidified" sample is taken for the analysis of suspended solids. A chain-of-custody form will be submitted with each batch of samples and include: sample code, name of collector, date of collection, date samples submitted to the lab, sample type, preservation measures taken. Samples will be placed on ice at collection and remain on ice until the lab receives them. Deliver samples to the EAL as soon as practicable after collection. The EAL follows the recommendations for "Special Sampling and Handling Requirements" listed in Standard Methods. Samples are refrigerated at 4 degrees C until analysis. NO3/NO2 and O-PO4-P analysis are done 48-72 hours upon arrival to the lab. Completed samples are held in storage at 4 degrees C for 1 month.

EAL=Environmental Analysis Laboratory.
See Appendix B for the Chain of Custody form.

B4. Analytical Methods

Identify laboratory(ies) to conduct testing and indicated if they are State certified. Identify all analytical SOPs including field and laboratory procedures (include method for every parameter being monitored). Specify needed laboratory turnaround time. Identify individuals responsible for corrective action.

Nitrate + Nitrite (NO_3^- and NO_2^- as N). Copper Cadmium Reduction Method. EPA 353.2 and SM 4500-NO3 F (Colorimetric, Automated).Nitrate is reduced to nitrite be a copper cadmium column. The nitite ion then reacts with sulfanilamide under acidic conditions to form a diazo compound. This compound couples with N-1 naphthylethylenediamine dihydrochoride to form a reddish purple azo dye. Colorimetric procedure is read at 520 nm using Seal Analytical Autoanalyzer II system

Ammonia/Ammonium (NH_3/NH_4^+ as N). EPA 351.2 Automated procedure is based on a colorimetric procedure in which an emerald green color is formed by the reaction of ammonia, sodium salicylate, sodium nitroprusside and sodium hypochorite in a buffered alkaline medium at a pH of 12.8-13. The ammonia salicylate complex is read at 660 nm using Seal Analytical Autoanalyzer III system.

Ortho-phosphate (O-PO4-P). EPA 365.1 Automated Ascorbic Acid Method in which orthophosphate reacts with ammonium molybdate and antimony potassium tartrate in an acid medium and then is reduced with ascorbic acid to form a phosphomoybdenum complex. Complex is read at 660 nm using a Seal Analytical Autoanalyzer III system.

Total Kjeldhal Nitrogen (TKN) – Digestion: EPA 351.2 (Colorimetric, semi-automated block digestor AAII), Standard Methods 420A Macro Kjeldahl Method. Automated Analysis: see Ammonia/Ammonium. Digestion converts free ammonia and most organic nitrogen compounds to (NH4)2SO4. TKN includes ammonia and organic nitrogen, but does not include nitrate nitrogen. The ammonia-salicylate complex is read at 660 nm using automated

Seal Analytical Autoanalyzer III system

Total Phosphorus (TP) Digestion: EPA 365.4 (Colorimetric, semi-automated block digestor AAII), Standard Methods 424 C Preliminary Digestion Steps for Total Phosphorus III. Automated Analysis: Automated ascorbic acid method, see Ortho-phosphate.

Total Suspended Solds: Filtration method. Reference: Standard Methods for the Examination of Water and Wastewater, American Public Health Association, American Water Works Association, and Water Pollution and Control Federation, Total Suspended Solids Dried at 103°-105° C, Washington, D.C., American Public Health Association, Method 2540D.

All nutrients are analyzed by the NCSU Biological and Agricultural Engineering Departments Environmental Analysis Laboratory using Seal Analytical Autoanalyzer III systems. Nutrient samples are submitted to the Laboratory within 48 hours of storm events. Total Suspended Solid analysis is performed in the laboratory within 24 hours. Bring samples to room temperature before analysis. Max holding time 7 days.

B5. Quality Control - Identify QC activities which will be used for each type of sampling, analysis, or measurement technique; for example, blanks, spikes, duplicates, etc., and at what frequency (also include what criteria will be used to determine if a corrective action is needed and what that corrective action will be).

Field QC Checks

The following table outlines QC procedures

Activity	QC Procedure	Purpose
Water chemistry replicates	3 replicate samples for each site – fall 2009, fall 2010, fall 2011	Check for replicability of field sampling. Assess field precision in sampling
Water chemistry field blanks	3 field blanks for each site – fall 2009, fall 2010, fall 2011	Check for field sources of sample contamination
Data downloads from autosamplers, temperature logger, rain gauge, multiparameter meter	Data downloads are observed to ensure recording instrument doesn't run out of memory or have another kind of error	Retrieve all electronic records with minimal errors
Field data recording	Paper forms and labels are checked for competeness before leaving the site	Reduce missing data

Laboratory QC Checks - Describe Laboratory QC procedures

The BAE-EAL QA/QC protocol is as follows:

- Initial Calibration Curves are performed for each analysis run (7-9 points)
- QC- check standards (mid level calibration standard). QC check standards are run at least 5 % of the samples in the batch.
- Laboratory Certified Samples (run once a week or when changes are made to the system – such as new reagents or instrument maintenance). Standards are purchased from an outside source, diluted to fit the range and analyzed using a 95% confidence interval.
- Duplicate Analysis – Duplicates are run every 10 samples.
- Sample Spikes – Spikes are run every 15 samples.
- % Recoveries must be between 85% and 115% to be considered acceptable.
- Duplicates must fall within 25% of each other.
- All duplicates and % Recovery results are recorded in the labs record books. Charts for each QC per parameter are also recorded and updated monthly.

See Appendix B for the lab's QA/QC pamphlet.

Data Analysis QC Checks- Describe data analysis QC procedures. Include what criteria will be used to determine if a corrective action is needed and what that corrective action will be. Provide or reference QC statistics used to determine precision and bias, if applicable.

Sample results will be reviewed and summarized every quarter as part of the quarterly report. Part of the summary process will be to look for outliers and other probable bad values, look for missing data, look for unusual/unexpected trends. The summary process should compare the current quarter's results to those of previous quarters to best identify outliers and other errors. For outliers, the QA Officer or Sampling Leader should review field notes and lab results from the affected dates and discuss these with staff that collected/analyzed the data to determine likely sources of error and appropriate corrective actions to take (i.e. such as special cleaning, clarifying sampling procedures, etc.). The QA Officer or Sampling Leader should follow similar actions in the case of unusual or unexpected trends in data. For missing data, the QA officer or Sampling Leader should review the field notes with staff that collected the affected samples to determine why data are not being collected, and institute new procedures to minimize more such events.

B6. Instrument/Equipment Testing, Inspection, and Maintenance - Identify field and laboratory equipment needing periodic maintenance, and the required inspection schedule. Describe preventative and corrective maintenance activities.

Equipment Type	Inspection Frequency	Responsible Party	Type of Inspection / Preventative / Corrective Action
Automated Sampler	Biweekly	D'Arconte / Almond / Shaffer / Dodd	Check functioning prior to installation; Clean enclosure; clear away weeds/vines (unless used for camouflage); check tubing connections/lengths for clogs/kinks, jammed distributor, pump (for fine gravel/sand), animal nests/damage, sampling report/errors/warnings, vandalism; change dessicant; download data
Bubbler Module	Biweekly	D'Arconte / Almond / Shaffer / Dodd	Check functioning prior to installation; Check for algae on end of tube, obstructions, kinks, make sure it's buried/secure; adjust water level/stage; download data
Sontek Flow meter	Biweekly	D'Arconte / Almond	Check battery level
Hanna multiparameter meter	Biweekly	D'Arconte / Almond	Check functioning, order new cable and/or probes if any difficulties, check battery level
Water	Biweekly	D'Arconte /	Check functioning prior to installation; Check

temperature logger and solar radiation shield		Almond / Shaffer / Dodd	anchoring of logger and shield; clear debris; download data
Rain gauge	Each storm event	D'Arconte / Almond / Dodd	Check functioning prior to installation; Check for obstruction, debris; download data
Bank pins/scour chains	After every storm event	D'Arconte / Almond / Shaffer / Dodd	Measure exposed section; check for looseness – replace and resurvey if necessary
Reference points, photo points, vegetation plots, cross-section markers	Annual	D'Arconte / Almond / Shaffer / Dodd	Check markers annually to make sure they can be found, replace/remark if necessary
Staff gage	Biweekly	D'Arconte / Almond / Shaffer / Dodd	Clean; check for looseness
Solar array/power	Biweekly	D'Arconte / Almond / Shaffer / Dodd	Charge batteries prior to installation; Clean solar panel; check connections, battery power; exchange battery with new charged one if insufficient solar

B7. Instrument/Equipment Calibration and Frequency - Identify equipment, tools, and instruments that should be calibrated, and the frequency and method for this calibration (include summary of method for calibrating laboratory equipment unless a state certified lab is used; also include calibration of field equipment such as stage recorders and flow meters). Note how calibration records will be kept and traceable to equipment.

Equipment Type	Calibration Frequency	Responsible Party	Standard or Calibration Instrument Used	Recordkeeping
Bubbler Module	At installation and monthly baseflow sampling	D'Arconte / Almond / Shaffer / Dodd	Installed nearby staff gage	Note in site visit field notes
Flowmeter	Annual	D'Arconte / Almond	Check/update firmware	Note in quarterly report when conducted
Rain gauge	None required	D'Arconte / Almond / Shaffer / Dodd	N/A	Clean and note condition in field notes
Multiparameter meter	Monthly	D'Arconte / Almond	Hanna Quick Calibration Solution (HI 9828-25)	Calibration records stored in meter and downloaded with data
Staff gage	Survey elevation at installation and at annual survey time	D'Arconte / Almond / Shaffer / Dodd	N/A	Clean and note condition in field notes

B8. Inspection/Acceptance of Supplies and Consumables

Identify critical supplies and consumables for field and laboratory, and acceptance criteria. Note responsible individual(s).

Equipment / Supply	Inspection / Maintenance Activity	Responsible Party	Vendor / Source
Sample bottles	Properly labeled, pre-preserved (if appropriate), proper number and size for sampling	D'Arconte / Almond	NCSU lab
Automated sampler bottles	Check for cleanliness, damage	D'Arconte / Almond	Johnson Controls (local ISCO distributor)
Automated sampler tubing	Check for cracks, holes, obstructions	D'Arconte / Almond	Johnson Controls (local ISCO distributor)
Calibration solutions for multiparameter meter	Check remaining left, order new solution if necessary	D'Arconte / Almond	various

B9. Non-Direct Measurements - Identify data sources, for example, computer databases or literature files, or models that will be accessed and used, data recording methods, and references for this information.

Non-direct Measurements.

Identify data sources, for example, computer databases or literature files, or models that will be accessed and used. Describe limitations of the secondary data. Document rationale for original collection of data and its relevance to this project.

GIS data layers – parcels, impervious surfaces, hydrology, 2-foot contours, street centerlines, others as available from the Towns of Chapel Hill and Carrboro These data layers are used primarily for cartography and other presentations, rather than for specific analysis purposes. Data have been collected and processed at a non-survey-grade and are not meant for scientific analysis except at full watershed scales.

Data Recording Methods for Non-Direct Measurements

Data Element/Measurement	Minimum Data Recording Method
GIS data	N/A

B10. Data Management

Describe data management scheme from field to final use and storage, and describe the process for data archival and retrieval. Include a summary of data analysis procedures, data transformations, and statistical analyses, if applicable.

Data Type and Data Management/Storage

Data Type	Format/Medium	Archival Duration	Responsible Party
Water level	raw ISCO file (FlowLink v.5.10)	6 years	Chapel Hill Stormwater Management Program

Water velocity, discharge	FlowTracker file	6 years	Chapel Hill Stormwater Management Program
Water velocity QA data	FlowTracker file	6 years	Chapel Hill Stormwater Management Program
Water temperature	Raw data file (HOBOWare)	6 years	Chapel Hill Stormwater Management Program
Precipitation	Raw data file	6 years	Chapel Hill Stormwater Management Program
Water field parameters	Raw data file	6 yaers	Chapel Hill Stormwater Management Program
Chain-of-custody forms	Paper forms	6 years	NCSU Soil Science Lab
Lab analysis results (includes field QA samples)	Excel spreadsheets	6 years	NCSU Soil Science Lab
Lab QA records	Excel spreadsheets	6 years	NCSU Soil Science Lab
Field Notes, maintenance/inspection notes, bank/bed erosion measurements	Paper field notes	6 years	Chapel Hill Stormwater Management Program
Macroinvertebrate ID data	Excel spreadsheets	6 years	Dave Lenat
Macroinvertebrate, habitat collection field notes/data	Paper forms	6 years	Dave Lenat
Macroinvertebrate voucher specimens	Preserved organisms	6 years	Dave Lenat
Macroinvertebrate Report	MS Word Document	6 years	Dave Lenat
Longitudinal, cross-sectional, bed sediment, vegetation surveys	AutoCAD, Paper field notes	6 years	Chapel Hill Stormwater Management Program
Photos	Digital (JPG)	6 years	Chapel Hill Stormwater Management Program
GIS data	ArcGIS shapefiles and geodatabase	6 years	Chapel Hill Stormwater Management Program

Data Management and Analysis. Describe data management scheme from field to final use, data compiling and data storage. Describe the process for data archival and retrieval. Include summary of data analysis procedures, data transformations, and statistical analyses, if applicable. Include project-specific calculations or algorithms, if applicable.

Digital data files will be saved to the Town of Chapel Hill's Stormwater server, copies may be made to the Town of Carrboro and others as requested.

Hardcopy data, such as field sheets or faxed laboratory data (if not available electronically), will be scanned into PDF file format and given descriptive file names. Where such data would be best used for graphing, GIS, or other electronic analysis or display, the data values themselves should be entered into a specially-prepared Excel spreadsheet or MS-Access database. This provides another QA check.

At the end of the project, after the Final Report has been prepared, all data and documents will be collected together into a single directory with subdirectories on Chapel Hill's server, and backed up digitally to a CD or DVD. The QA Officer, Sampling Leader, and Project Manager will review the collected information to ensure all raw and processed data, reports, presentations, and associated project documents (including the original 319 grant application and budget) have been included. This includes data that will be formally archived by others (e.g. NCSU Soil Science Lab and Dave Lenat) in order to maintain a "full-picture" collection of data for this project. Copies would be made for the Town of Chapel Hill, the Town of Carrboro, NCSU, DWQ, and any other interested members of the project. Records will be maintained in accordance with the NC Records Retention and Deposition

Schedule for Municipalities by the Town of Chapel Hill's Stormwater Management Program (6 years for Engineering Project Records).

Data requests should be made to the Town of Chapel Hill's Stormwater Management Program.

C1. Assessments and Response Actions - List the number, frequency, and type of assessment activities that should be conducted. Specific response actions for the situations listed below will generally apply. Also list who is responsible for each action.

Situation	Response Action	Responsible Person/Organization
Autosampler malfunction	Rent replacement from ISCO while original is repaired	Shaffer
Quarterly review of field notes (including maintenance notes)	Resolution of problems with field staff	D'Arconte
Review of lab reports	Discuss problems with lab contact	D'Arconte

C2. Reports to Management - Identify what project QA status reports are needed and how frequently they will be prepared

Report	Frequency	Who Prepares Report	Who Receives Report
Project Status	Quarterly	D'Arconte	Nimmer, Jennings, Dodd
Results of performance evaluation and audits (if applicable)	Quarterly	D'Arconte	Nimmer, Jennings, Dodd
Results of periodic data quality assessments (if applicable)	Quarterly	D'Arconte	Nimmer, Jennings, Dodd
Any significant QA problems	Quarterly	D'Arconte	Nimmer, Jennings, Dodd

D1. Data Review, Verification and Validation - Describe the criteria that will be used for accepting, rejecting, or qualifying project data. (include criteria for determining anomalies or outliers, what portion of data will be reviewed, who will do it, and what happens if data deemed 'bad')

Criteria for Accepting, Rejecting, or Qualifying Project Data.

Include criteria for determining anomalies or outliers, what portion of data will be reviewed, who will do it, and what happens if data deemed 'bad'

Water chemistry data generated by the laboratory will undergo internal lab QA/QC checks to identify data outside of the Data Quality Objectives. While Project staff will receive and archive these data, they will be excluded from analysis.

Continuous-measurement devices (such as the bubbler module, the flowmeter, precipitation, and temperature logger) record large numbers of data points and it is not uncommon for there to be a few isolated outlier data points. When these instruments are malfunctioning they tend to record a single value, multiple extreme values, or no value. These are easily detected by plotting out newly-retrieved data and discarding suspect points. If the review indicates a potential equipment failure, field staff will repair or replace the equipment as soon as possible. These devices may also experience some measurement drift over time, but a two-week recalibration cycle should be sufficient to avoid these errors as they tend to occur during long deployments.

Cross-section and longitudinal-profile surveying involves the measurement of the elevation of a known benchmark at the beginning and ending of data collection for each location of the tripod. When these measurements don't match, that round of surveying must be redone. For this reason, data quality checks are first done in the field. A secondary check using the plotted data will detect outliers to be corrected (if correct data can be interpreted from field notes) or discarded. Biases and offsets can also be detected from plotted data. If a correction can be determined from field notes, then the full set of data will be corrected.

Field leaders and assistants will confirm data have been entered and reviewed properly, checking for errors or omissions. Throughout the course of the project, Project staff will review data and modify protocols where there are problems with them or they generate considerable errors.

Decision Rule or "if/then" Statement. Provide if applicable.
Note: Some projects, especially research or preliminary investigations, may not require a specific "if/then" statement. This is also applicable for decisions regarding data "outliers."

N/A

D2. Verification and Validation Methods -
Describe the process for data verification and validation, providing SOPs and indicate what data validation software will be used. State the percentage of the data to be reviewed. List the responsible individual/organization.

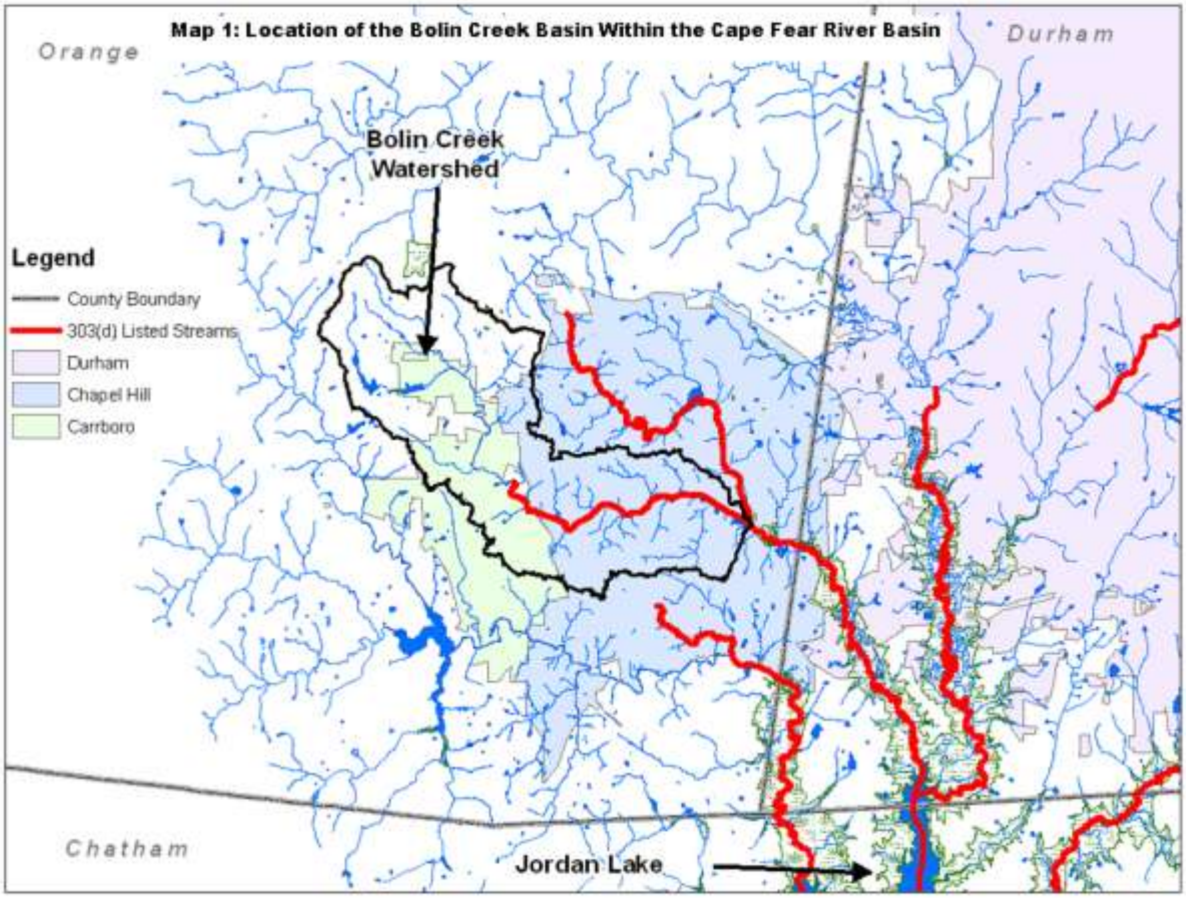
Data Element	Typical Validation and Verification Methods
Water velocity/discharge	Use recommended signal-to-noise cutoff values, use recommended QA methods in FlowTracker software to check for equipment errors, data quality problems, etc.
Water level	Check for outliers, continuous single value measurements
Water temperature	Check for outliers, continuous single value measurements
Nutrients	(see Lab QA procedures)
Total Suspended Solids	(see Lab QA procedures)
Precipitation	Check for outliers, continuous single value measurements
Macroinvertebrates	Voucher samples retained

D3. Reconciliation with User Requirements and Data Quality Objectives

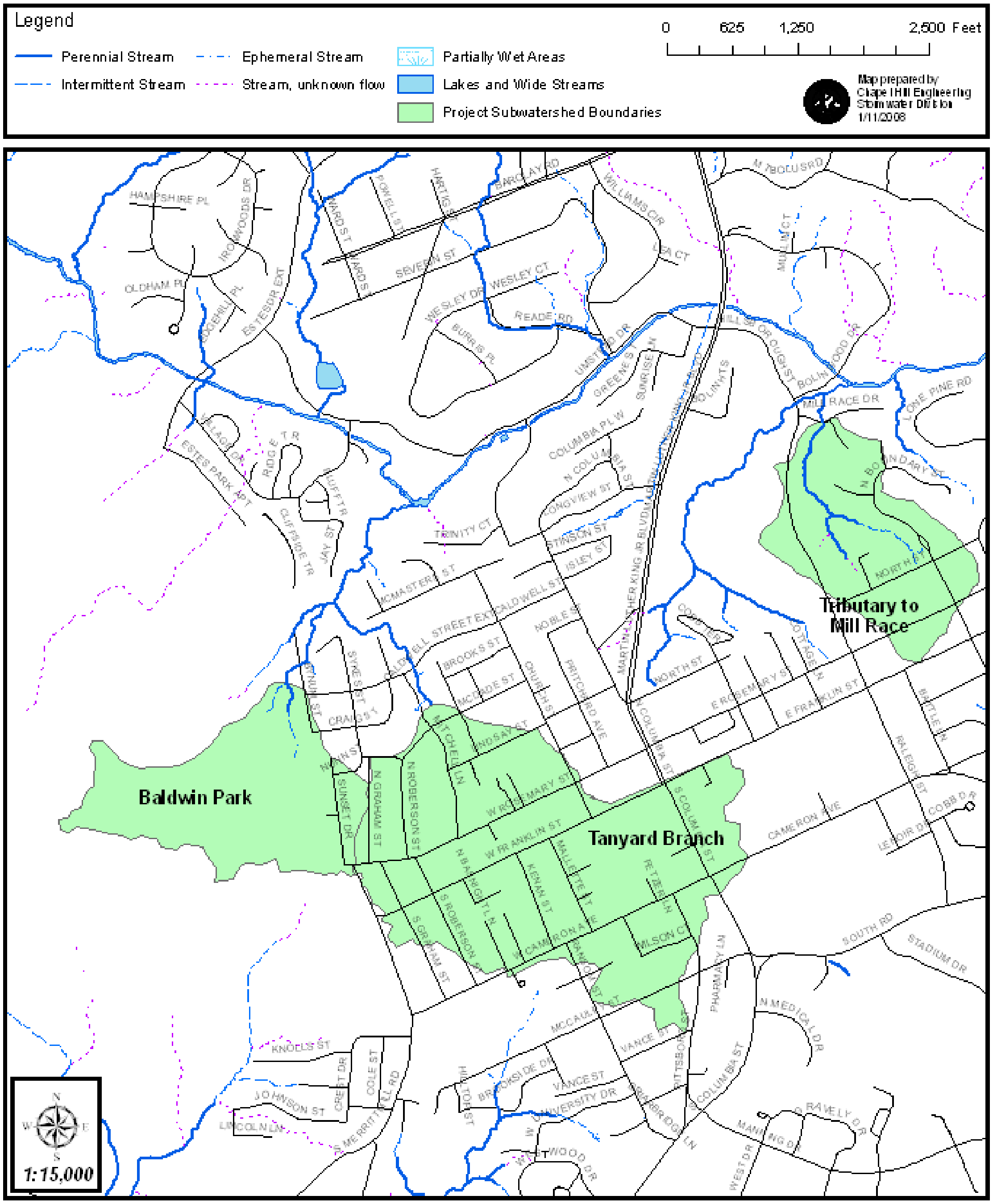
Also include how the data will be summarized to be able to report results to decision makers. Describe process for reconciling project results with data quality objectives (DQOs) and reporting limitations on use of data. Identify issue resolution procedure(s) and responsible individuals

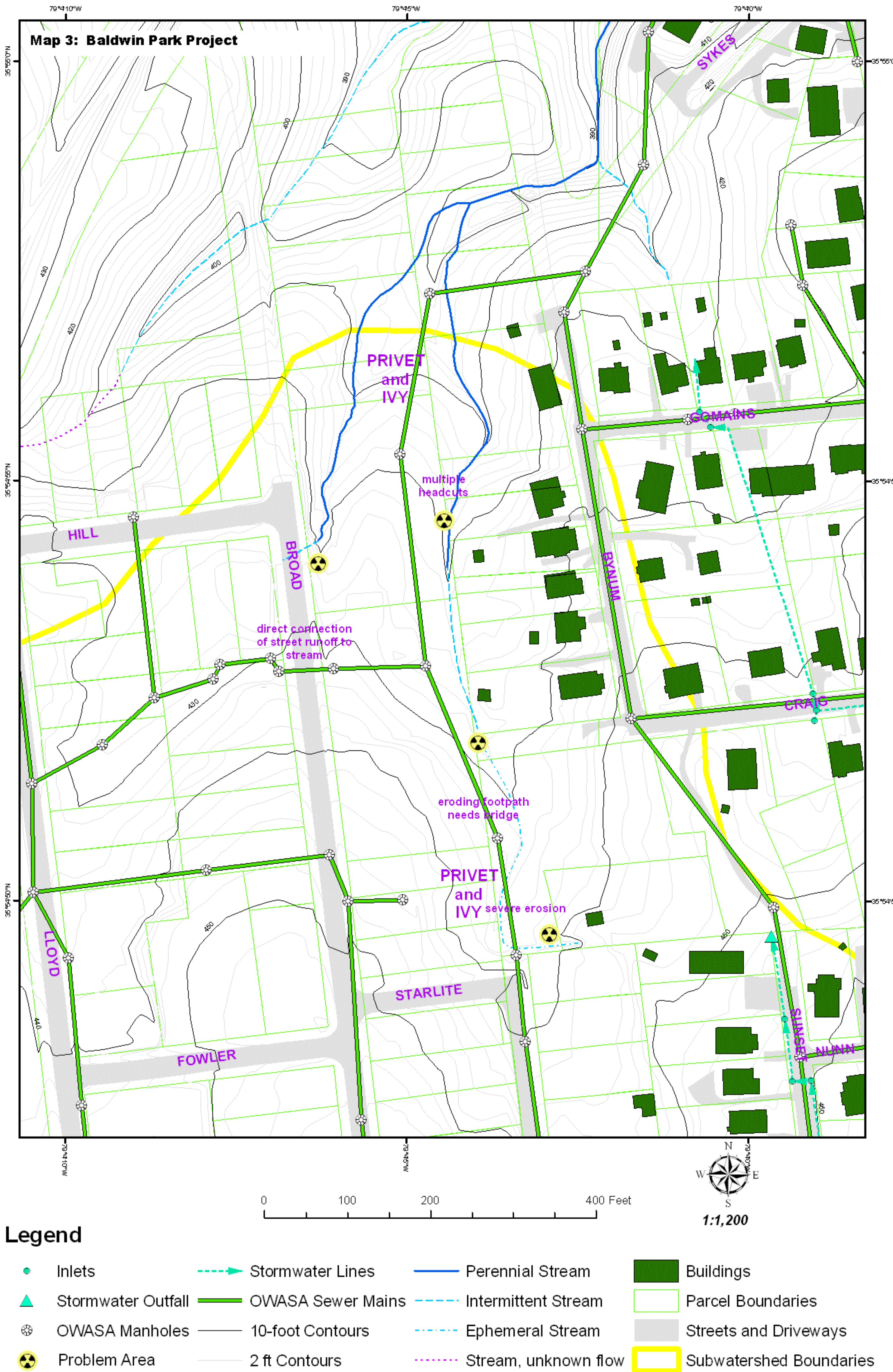
Quarterly data reports summarizing the data will be prepared by Chapel Hill staff and distributed to team members from Chapel Hill, Carrboro, NCSU, and EEP. Others will receive copies as requested. Insufficient acceptable base flow or storm flow samples will push back the construction schedule for either site, as additional sampling can go on beyond the 3 year period if needed.

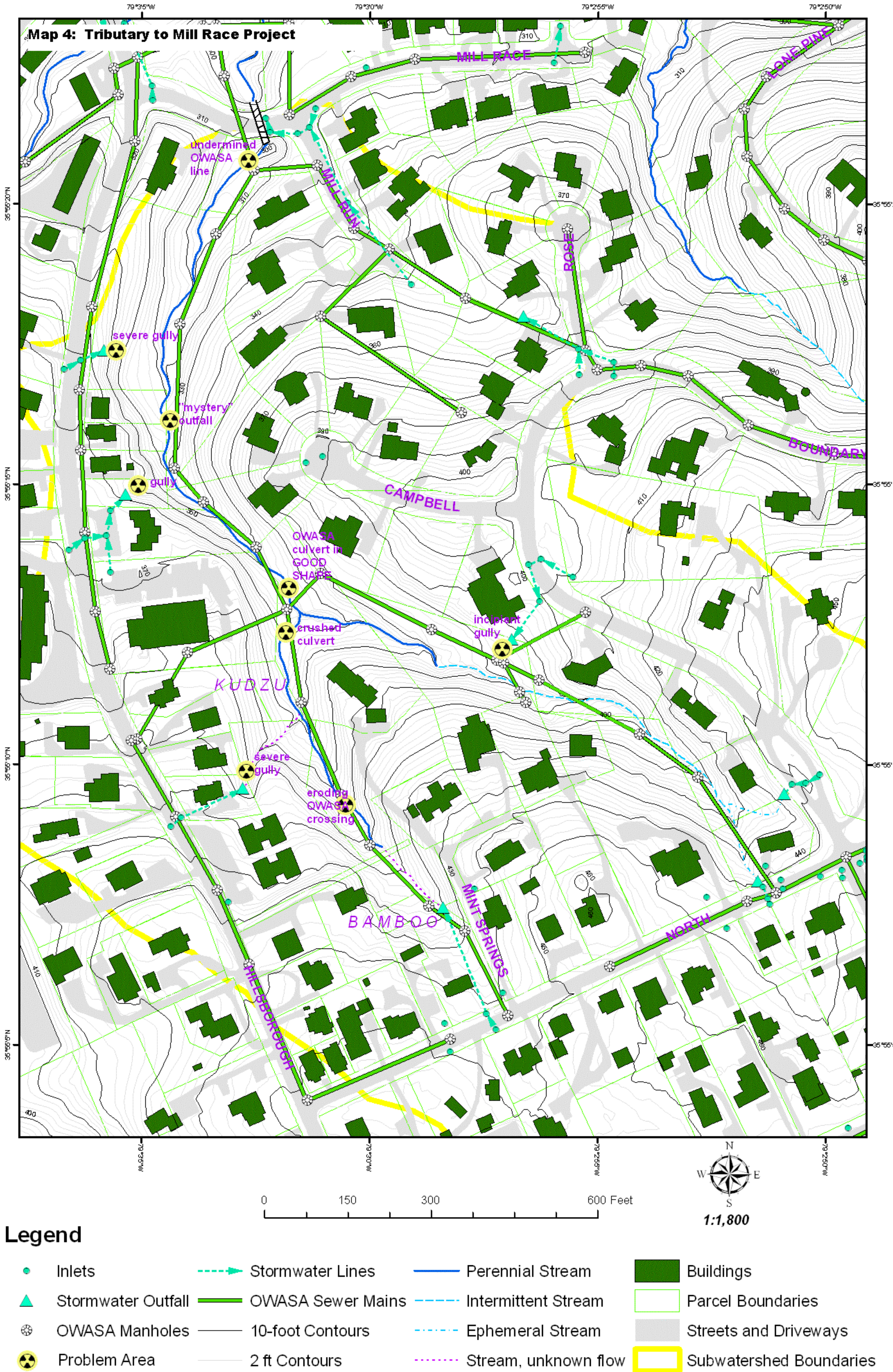
Appendix A: Location and Site Maps


Map 1: Location of the Bolin Creek Basin Within the Cape Fear River Basin
Orange
Durham
Bolin Creek Watershed
Legend
County Boundary
303(d) Listed Streams
Durham
Chapel Hill
Carrboro
Chatham
Jordan Lake

Map 2: Bolin Creek Watershed Restoration Project Locations




Map 3: Baldwin Park Project
79°4'10"W
79°4'5"W
79°4'0"W
35°55'0"N
35°54'55"N
35°54'50"N
SYKES
GOMAINS
HILL
BROAD
BYNUM
CRAIG
LLOYD
STARLITE
FOWLER
SUNSET
NUNN
PRIVET and IVY
multiple headcuts
direct connection of street runoff to stream
eroding footpath needs bridge
PRIVET and IVY
severe erosion
0
100
200
400 Feet
1:1,200
N
S
E
W
Legend
Inlets
Stormwater Outfall
OWASA Manholes
Problem Area
Stormwater Lines
OWASA Sewer Mains
10-foot Contours
2 ft Contours
Perennial Stream
Intermittent Stream
Ephemeral Stream
Stream, unknown flow
Buildings
Parcel Boundaries
Streets and Driveways
Subwatershed Boundaries


Map 4: Tributary to Mill Race Project
MILL RACE
LONE PINE
MILL RUN
ROSE
BOUNDARY
CAMPBELL
KUDZU
BAMBOO
MINT SPRINGS
NORTH
HILLSBOROUGH
undermined OWASA line
severe gully
"mystery" outfall
gully
OWASA culvert in GOOD SHAPE
crushed culvert
incipient gully
severe gully
eroding OWASA crossing
0
150
300
600 Feet
1:1,800
N
S
E
W
Legend
Inlets
Stormwater Outfall
OWASA Manholes
Problem Area
Stormwater Lines
OWASA Sewer Mains
10-foot Contours
2 ft Contours
Perennial Stream
Intermittent Stream
Ephemeral Stream
Stream, unknown flow
Buildings
Parcel Boundaries
Streets and Driveways
Subwatershed Boundaries