

A. Project Summary Information

1. Project Title: Hydraulic Fracturing Reference Network
2. Track: 1 (NC WPP approved January 2013, prior to issuance of Region 4 WPDG RFP)
3. Core Elements addressed: NC WPP (Monitoring and Assessment Component); EPA Core Elements: Regulatory, Restoration and Protection
4. Actions applying to Core Elements: NC WPP # 1.1.c (page 7), 2.2a (page 9), 2.3b, 2.4c, 2.5b (Page 10), 2.5e, 3.1a (page 11), 3.2b (page 12); EPA Core Elements: Regulatory 3.b, Restoration and Protection 1.a and c.
5. Name of applicant (DUNS): NC Division of Water Quality, Wetlands and Stormwater Branch (809785280)
6. Contact information: Lori Montgomery, NC Division of Water Quality, Program Development Unit, 919-807-6479, (fax) 919-807-6470, email – lori.montgomery@ncdenr.gov

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7. Geographic location: Lee, Moore, Chatham, Durham, Wake, Granville, Anson, Richmond, Stokes, Rockingham Counties, NC
8. Total cost and federal funding requested: Federal funding requested: \$222,595; State Match: \$74,198; Total: \$296,793.

9. Abstract:

In July 2012 the NC legislature repealed the ban on horizontal drilling that prohibited hydraulic fracturing in NC. The “Clean Energy and Economic Security Act” (Session Law 2012-143) directs the NC Division of Energy, Mineral, and Land Resources (a Division of DENR) to assist the NC mining and Energy Commission in developing a modern regulatory program for the management of oil and gas exploration and development in North Carolina, including the use of horizontal drilling and hydraulic fracturing. Accounts from other States have shown that fracturing fluid and produced water spills from shale gas production, as well as released methane seeping through the aquifer into surface waters, can have environmental effects that need to be carefully monitored and managed. This grant seeks to identify a network of reference streams and wetlands in the areas of NC most likely to be drilled and characterize the water quality and aquatic community in these systems prior to drilling. With solid baseline data for these resources, it will be possible to document hydraulic fracturing related impacts to aquatic resources and more accurately provide an end point for any necessary restoration/mitigation of impacted sites. In addition, the development of a spill response plan should help to minimize the size of spills by eliminating uncertainty in the industry as to whom to be notified and procedures to be used to minimize impacts to aquatic resources.

B. Project Description

1. WPP Program Priorities

WPP#	Activity
1.1.c.	This project will use the developed monitoring protocols to obtain baseline stream and wetland data in areas that may be impacted by hydraulic fracturing to assess issues that may arise from the development and implementation of these methods in NC.
2.2.a.	Data from the areas likely to experience hydraulic fracturing will help provide need based, targeted monitoring data in a basinwide/watershed area.
2.3.b.	The baseline monitoring data will be utilized to develop typical profiles for wetland types that will potentially be impacted, and can be used to establish reference wetland parameters.
2.4.c.	The details of the baseline monitoring activities and results that are obtained will be reported in the State’s 303(d)/305(b) Integrated Water Quality report.

2.5.b.	Use of the monitoring data can establish baseline wetland conditions for streams and wetlands in areas that are likely to be impacted by hydraulic fracturing.
2.5.e.	Establishment of the baseline stream and wetland conditions in areas likely to be impacted by hydraulic fracturing will allow for the identification of any changes in streams or wetlands due to hydraulic fracturing activities.
3.1.a.	Baseline stream and wetland data and any subsequent impact data can be integrated into other existing North Carolina monitoring programs (e.g. Ambient Monitoring Program, Biological Assessment Program, etc.)
3.2.b	The monitoring data that is obtained can be analyzed and used to guide regulatory decisions as they apply to hydraulic fracturing practices in NC.

EPA Core Elements.

Reg 3.b	Establishment of baseline stream and wetland conditions in areas most likely to be impacted by hydraulic fracturing will ensure that impact assessments and mitigation crediting lead to replacement of aquatic resources with similar structural, functional or condition attributes.
R&P 1.a	The data collected in this project will facilitate the establishment of goals and program guidance that are consistent or compatible across relevant agencies.
R&P 1.c	Having a greater understanding of what resources are impacted or lost due to hydraulic fracturing will help provide clearer guidance on appropriate restoration and management techniques, and success measures.

2. Description of Need:

In recent years, new technologies have increased the availability of natural gas resources in the United States, resulting in an abundant energy source to supplement oil production. Current technology allows natural gas to be extracted from shale rock formations. Hydraulic fracturing, commonly known as “hydrofracking” or simply “fracking”, involves drilling a well into rock that contains natural gas; injecting fluids under pressure to fracture the rock; and extracting the natural gas from the fractures that are created. While development of this resource can provide economic benefits, many states have found that shale gas production can have both environmental and social impacts that need to be carefully monitored and managed. The viability of shale gas production in North Carolina has only recently been investigated.

In 2008, the USGS conducted a study of the hydrocarbon producing potential of strata in the Triassic Basin of North Carolina (Figure 1). <http://pubs.usgs.gov/of/2008/1108/ofr2008-1108.pdf>. This ecoregion, which covers parts of 17 counties in NC, was formed by deposits of sediment and organic

material (both woody plant and algal) over millions of years and thus was believed to have the highest probability of coal, oil and gas resources in the State. The USGS found conditions favorable for small gas and oil deposits in some of these formations, with the highest probability of significant natural gas deposits existing in the Sanford sub-basin in Lee County, just west of the town of Sanford (red star on map).

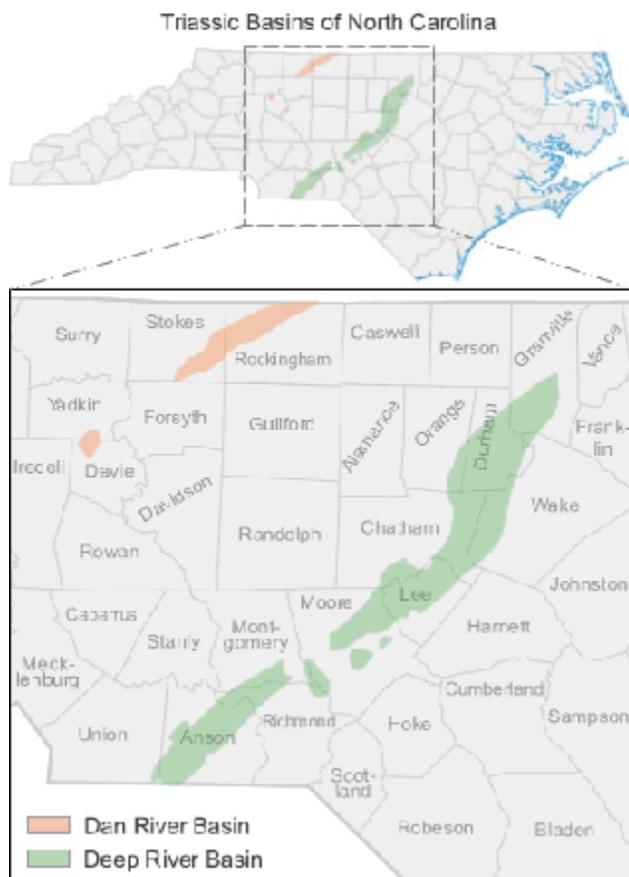


Figure 1. Triassic Basins in North Carolina

In the past two years, shale gas production in North Carolina has been the focus of various legislative actions. Session Law 2011-276 (House Bill 242) required the North Carolina Department of Environment and Natural Resources (NC DENR) to partner with the NC Department of Commerce and the NC Department of Justice to study the potential impacts of hydraulic fracturing in North Carolina. The study was completed in April 2012 (<http://portal.ncdenr.org/web/guest/denr-study>). With regards to environmental impacts, the study found that in the Sanford sub-basin, there appears to be less

separation between groundwater used for drinking and the gas-producing layer of shale than is present in most other gas producing states. The study also found that water quality problems associated with oil and gas operations in general are often traced to either the production phase of well operations or to waste management and disposal activities. Oil and gas exploration and production activities can disturb large areas of land to develop infrastructure needed for these facilities. Similar to other industrial functions, these activities can result in sedimentation and erosion, wastewater discharges, water withdrawal issues, and other storm water-related concerns. Unlike other construction projects, oil and gas exploration and production activities are exempt from federal Clean Water Act stormwater requirements.

These findings are echoed in the Dec 2012 EPA Study of the Potential Impacts of Hydraulic Fracturing that found three of the five water uses in the hydraulic fracturing process involves the possibility of surface water pollution. <http://www.epa.gov/hfstudy/pdfs/hf-report20121214.pdf> (page 13). The study estimates that between 9 to 35 percent of the fluid pumped into a well for hydraulic fracturing returns to the surface, with smaller percentages being generated during the production phase. While this backflow, as all drilling spills, are required to be contained, collected and properly disposed, experience in other States currently allowing hydraulic fracturing has shown that there have been instances of inattention, and spills have occurred (<http://ecowatch.com/2013/must-read-fracking-colorado/> (page 14)). In many states flowback and production wastewater is disposed of via underground injection. NC General Statute 143-214.2(b) currently prohibits the use of wells for disposal of waste. Options for wastewater disposal under current NC regulations would include: transporting wastewater to a publicly owned treatment facility, land application of wastewater, and recycle back into the production process. Additional concerns include the withdrawal of high volumes of ground water and/or surface water during drilling, accidental spills of wastewater and/or chemicals used throughout the process and aquifer contaminants reaching streams. Methane and other contaminants may enter

an aquifer from underlying natural gas reservoirs through natural migration or as a result of drilling and hydraulic fracturing associated with gas development. Gases can enter the aquifer either in dissolved form through the upward migration of fluids (brines) through fractures or as gas phase (stray gas) through improperly completed wells, dissolving into groundwater at elevated hydrostatic pressure. These constituents then move through the aquifer towards groundwater discharge points, including wells, gaining streams and springs (Figure 2). Sampling of dissolved methane and other constituents along a gaining stream or spring yields a composite weighted average of many different groundwater flow paths within the aquifer. While dissolved methane and other gases in a stream eventually dissipate into the atmosphere, this loss does not occur instantaneously, but rather can persist for kilometers downstream and is based on the groundwater methane concentrations and gas transfer velocity (turbulence and depth) of the particular stream reach.

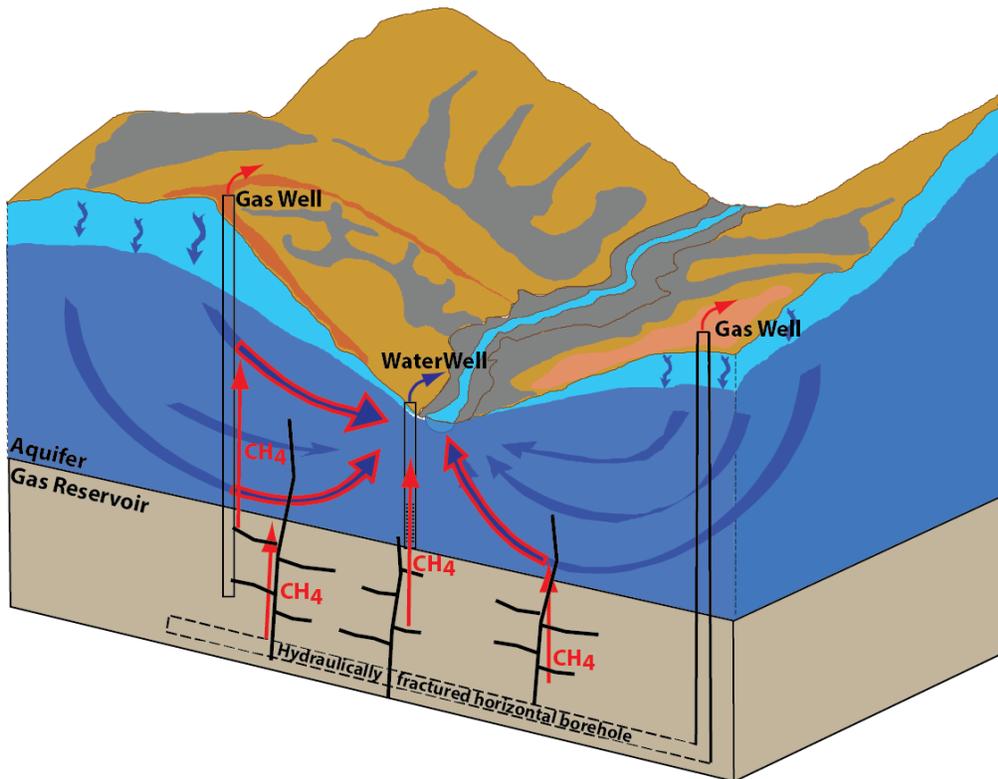


Figure 2. Conceptual model of methane transport from an underlying natural gas reservoir to groundwater and surface water.

One of the primary water quality recommendations resulting from the April 2012 NC DENR study was that baseline data concerning groundwater and surface water needs to be collected for areas near proposed drill sites. Other issues of concern, including possible contamination of drinking water supplies, either from hydraulic fracturing or deep well injection of wastes, and possible air quality impacts from well off gassing or engine exhaust at well head pads, are beyond the scope of this grant.

In 2012, the NC General Assembly ratified the “Clean Energy and Economic Security Act” (Session Law 2012-143/Senate Bill 820).

<http://www.ncleg.net/Sessions/2011/Bills/Senate/PDF/S820v6.pdf>. The law removes prohibitions on horizontal drilling and allows hydraulic fracturing, with the stipulation that no permits for such activity will be issued until further legislative action occurs. The law further directs the NC Division of Energy, Mineral, and Land Resources (a Division of DENR) to assist the NC mining and Energy Commission in developing a modern regulatory program for the management of oil and gas exploration and development in North Carolina, including the use of horizontal drilling and hydraulic fracturing. The law states that rules to be developed will specify collection of baseline data including groundwater and surface water quality in areas where oil and gas exploration and development activities are proposed. Work done under this grant will support this requirement and can provide information needed to develop scientifically based requirements for pre-drilling testing criteria. The Act requires that such rules be developed by October 1, 2014. Considering the amount of time hydraulic fracturing has been taking place in other States (e.g. Pennsylvania, Colorado, Ohio, Wyoming) this is a very short time span to make a comprehensive set of rules, thus it is likely the initial rules may need to be amended as production of shale gas evolves in North Carolina. Little data exists with regards to resource inventory or water quality in the area of interest. Establishment of a monitoring network in the area of proposed hydraulic fracturing will provide much needed information that can be used to assess water quality conditions and to evaluate the existence of any sensitive resources that could be present. This grant

would identify and characterize reference wetlands and streams in the Triassic Basins to be used as goals for remediation of wetlands and streams that may be impacted during the hydraulic fracturing process.

3.Outputs and Outcomes

i Outputs

- a) Write a Quality Assurance Project Plan detailing project methods and QA/QC procedures.
- b) Identify a variety of wetlands and stream reference sites within the Triassic Basin that can be used for evaluating possible impacts from future hydraulic fracturing activity.
- c) Provide the results of NC rapid assessment method evaluations used to determine wetland/stream function prior to hydraulic fracturing activity.
- d) Establish baseline populations/concentrations, based on biological and chemical data from these reference sites, with emphasis on chemicals found in hydraulic fracturing fluid.
- e) Develop a spill response protocol for use in industry accident clean up.
- f) Submit semi-annual progress reports and a comprehensive final report.

ii Outcomes and Results

- a) The network of reference wetland and stream sites will be used to expand North Carolina's existing long term monitoring network.
- b) Improvements in the spill cleanup success criteria and subsequent success in clean up measures for returning an area to a reference condition using baseline data collected before a spill or discharge.

c) Biological data collected in this study, when combined with existing data, may provide the foundation for development of stream biological criteria in an ecoregion where standard methods and metrics do not work. If developed, biological criteria will provide firm success endpoints for spill cleanup.

d) Improvements in spill response time; thus decreasing the amount of environmental damage as a result of developing a spill response protocol, including monitoring requirements.

iii Link to EPA Strategic Plan

As hydraulic fracturing becomes more widespread in the US, the number of spills of fracking fluid and produced water has increased. In many cases, remediation and clean up has been hampered because there has been little to no pre-fracturing monitoring of the resources in the area, so the company responsible for the spill often claims that the spill caused no damage so there should be no clean up (<http://www.dallasnews.com/news/state/headlines/20130116-epa-backed-off-weatherford-water-contamination-probe-after-gas-drilling-company-protested.ece>). This grant is strongly linked with the monitoring and assessment part of EPA's Strategic Plan as it attempts to document resources in an area before potential impacts. There is also a component associated with Restoration and Protection in that, if a spill happens, this data can be used to require mitigation and clean up to return lost aquatic functions to impacted resources. These measures will help prevent the loss of stream and wetland acres and functions and will help restore the lost functions and increased acres in impacted areas.

iv Tracking Outputs and Outcomes

Progress on outputs and outcomes will be documented through semiannual reports to the EPA Project Manager, and will include summaries of the number and type of wetland and stream sites identified, field data collection activities completed, and any needed adjustments to the original study plan or project.

4. Project Tasks

The intent of this project is to locate and characterize an array of jurisdictional waters in advance of anticipated spills to waters of the State from hydraulic fracturing activity. Major tasks for this project are described below.

Task 1. Three to four representatives of reference quality water bodies of various types will be selected for monitoring. Water body types are small streams, large streams/river, wetlands over diabase dikes and other types of wetlands such as headwater forests, bottom land hardwood forests, riverine swamp forests etc (16-20 sites total). Site searches will begin in Lee County in the area most likely to contain economically viable amounts of shale gas and expand out to other Triassic Basin sites as the grant proceeds. In addition to sites being minimally impaired, selection will also be based on continuing ability to access that site.

Initial candidate reference sites will come from sites sampled by USGS and City of Durham in or near the initial target area and augmented with wetland sites identified by the National Hydrography Dataset (NHD) and the Lee County wetland model developed by NCDOT. Identified sites will be visited to verify their existence. Viable sites will be assessed for reference quality by stream and wetland experts and assessments made using the NC Wetland Assessment Method (NCWAM)

(http://portal.ncdenr.org/c/document_library/get_file?uuid=76f3c58b-dab8-4960-ba43-45b7faf06f4c&groupId=38364), NC DWQ Habitat Assessment forms,

(http://portal.ncdenr.org/c/document_library/get_file?uuid=f3cfa483-16de-4c18-95b7-93684c1b64aa&groupId=38364) and NC Stream Assessment Method (NCSAM) (currently in draft form).

Task 2. Collect biological and chemical data from these reference sites to establish baseline populations/concentrations/functions with emphasis on chemicals found in hydraulic fracturing fluid.

The comprehensive list of these chemicals is in Appendix A of EPA's Hydrofracking Study

(www.epa.gov/hfstudy). This list is exhaustive; however and we anticipate sampling for a subset of these chemicals based on the chemical makeup of the fluid used in NC wells. In addition to specific constituents found in produced water, including hydrocarbons such as benzene, toluene and total dissolved methane (including isotopic ratios ($\delta^{13}\text{C}_{\text{CH}_4}$, $\delta^2\text{H}_{\text{CH}_4}$) and methane C1:ethane C2+propane C3) hydrocarbon ratios which differentiate between thermogenic and biogenic methane), radionuclides such as barium and strontium and heavy metals such as arsenic and mercury, chloride, TSS, specific conductance, and pH will also be measured as the first two have been found to be elevated in hydraulic fracturing fluid spills in other locations, and the latter two parameters are good general indicators, especially when acids are expected to be part of any spill. Biological samples in streams will be collected using DWQ protocols (http://portal.ncdenr.org/c/document_library/get_file?uuid=f3cfa483-16de-4c18-95b7-93684c1b64aa&groupId=38364); however sampling season and biocriteria may be altered to compensate for the tendency of streams in this ecoregion to go dry in summer. Wetland sampling will include methods used by DWQ in previous wetland macroinvertebrate sampling activities.

Task 3. Develop a spill response protocol for use in industry accident clean up. Once methods and locations are identified, this information will be compiled and made available to companies and landowners engaged in hydraulic fracturing operations. We anticipate improved response to a spill if we can provide a document laying out whom to contact, immediate spill containment procedures, and long term clean up expectations.

Task 4 Produce a QAPP, semiannual reports and comprehensive final report. This involves assembling a map and list of all identified reference streams and wetlands located in the hydraulic fracturing region. Reports will also include the water chemistry and macroinvertebrate data collected before fracturing starts in the area. In addition, a final report will include the spill response protocol developed as part of this grant.

5. Partnership Information

No funding is requested to cover costs for any other agencies; however US Geological Survey (USGS), NC Department of Transportation (NCDOT), and US Fish and Wildlife Service (USFWS) have expressed interest in cooperation. We plan to cooperate with the USGS personnel to identify the locations of past stream sampling in the Lee County area. The NCDOT has offered the use of their wetland mapping software to help find wetlands in the possible impact area, while USFWS has offered their expertise in identifying rare organisms and communities that may be encountered in this project. See attached letters of support.

6. Milestone Schedule

Month	Tasks
1-6	<ol style="list-style-type: none">1. Develop a QAPP2. Obtain possible wetland sites from DOT.3. Meet with USGS about integrating their work with this project.4. Identify locations for small and large stream collections.5. Purchase equipment.6. Decide suite of chemical analyses to be sampled.
7-12	<ol style="list-style-type: none">7. Begin visiting possible wetland sites to identify candidates.8. Begin collecting water chemistry and macroinvertebrates in streams and wetland sites as they are identified.9. Develop and maintain database for generated data.10. Begin working up stream data.
13-18	<ol style="list-style-type: none">11. Complete stream sampling.12. Continue wetland sampling.13. Continue sample analysis.14. Continue data entry.
19-24	<ol style="list-style-type: none">15. Complete data collection.16. Complete data entry.17. Perform data analysis.18. Write final report.19. Present results to USGS and EPA staff.

7. Detailed Budget Workplan:

The total amount of federal funding requested is \$222,595; state match provided will total \$74,198; the total cost of the project will be \$296,793. A detailed breakdown of the funding request is provided as an attachment to this grant application. The majority of the federal funding requested is for wages (\$136,635) to cover the cost of an Environmental Senior Specialist to do the majority of work on this grant. The indirect cost percentage shown is consistent with what has been negotiated between the NC Office of State Controller and EPA. The second largest expenditure (\$75,060) is for contractual services – a temporary employee for a year, the cost of water analyses at each site for the 12 metals and four hydrocarbons most likely to be in produced water and \$27,000 for biogenic/thermogenic methane analyses at two or three sites. \$5,000 was budgeted for the estimated 20 nights and 70 days of travel necessary for completing this work, while \$3,000 is proposed for office and field supplies, including a conductivity meter, a pH meter and a Geiger counter, since produced water frequently contains radionuclides such as Radium, Barium and Strontium.

8. Restoration Demonstration Project Information:

This project is not a restoration demonstration project.

9. Programmatic Capability/Technical Experience/Qualifications: The NC DWQ Program Development Unit (PDU) provides data used to inform regulatory decision making for the Division's 401 Certification, Isolated Wetland, and Riparian Buffer protection programs with the goal of improving the program's overall consistency, effectiveness, and efficiency. The staff uses professional expertise in aquatic ecosystems to provide scientific data for management decisions, policies, project reviews and approvals, enforcement actions, and evaluation of wetland status and trends. The PDU staff has successfully completed various EPA Wetlands Program Development Grants focused on wetland and stream assessment and protection which are detailed in Section C – Past Performance, below.

10. Transfer of Results: Data collected as part of this effort will be disseminated to the Raleigh, Fayetteville, Mooresville and Winston-Salem NCDWQ regional office personnel, since they will be the responders to any fluid spills that escape containment. The information will also be shared with USGS, who maintains their own sampling network in the area. Any rare species or ecosystems found as part of this work will be reported to the Natural Heritage Program and USFWS. The spill response procedure developed as part of this grant will be posted on the DENR website. Written reports will also be provided to EPA Region 4 staff in the form of semi-annual reports and a final report.

C. Past Performance:

In addition to the projects specified below, NC DWQ has successfully completed and submitted final reports for two Wetland Program Development Grants (WPDGs) (CD 95415509, CD95415709) and one Implementation Grant (WL96435005) over the past three years. Data collection, data analysis, and drafting of final documents are also taking place on nine additional WPDGs that have been issued since early 2009. NC DWQ consistently submits timely semiannual reports to the EPA providing updates on the status of all active WPDGs. These projects have included documentation of a significant nexus between headwater streams and navigable waters, hydrologic connectivity of isolated wetlands, assessment of wetland and stream mitigation projects, tracking system upgrades, development of compliance and mitigation monitoring programs, several wetland monitoring efforts which are presently underway, and multiple training efforts.

The following agreements show the success and relevance NC DWQ's assistance agreements to this proposed project:

Intermittent streams/Significant Nexus (CD 95415609): This work involved collection of intensive hydrology and aquatic macrobenthos data from ephemeral, intermittent and perennial streams across the state of North Carolina and throughout the southeastern US in order to document their flow regime and aquatic life. This work resulted in new policies to more accurately define intermittent and perennial

streams across the state, use by the US Army Corps of Engineers and EPA for Significant Nexus decisions across the southeastern US, and implementation of a policy requiring compensatory mitigation for impacts to intermittent streams. The technical report was submitted and the grant was closed in February 2012.

Small Impoundment Study (CD 95471111) – This grant focused on 12 small impoundments and their associated streams, six in the Piedmont and six in the Blue Ridge physiographic province. On-site water quality data and water samples for chemical analyses were collected during three sampling events from upstream of each impoundment, at two locations within each impoundment, and at a downstream location. Limited biological sampling was also conducted. Biological sampling was also conducted which showed temperature increases below ponds consistently in excess of standards, especially in trout waters and shifts in the benthic community in streams below ponds. The final report for this project was completed by March 1, 2013.

Isolated Wetland Grants (COA RM-83340001, CD 95415809): NC DWQ was contracted as part of the REMAP EPA (2011 COA RM-83340001) grant for the Level II (rapid assessment) and Level III (long term monitoring) work. Amphibians and macroinvertebrates were characterized during this project in the Level III assessment. The second grant (CD 95415809) expands the Level III work of the REMAP study to characterize the biocriteria (including amphibian and macroinvertebrates), determine their pollution absorption capacity, and determine the hydrological connectivity between isolated wetlands and downstream waterbodies. The two grants involve mapping, rapid field assessment, and long term monitoring of isolated wetlands in North and South Carolina. These data will be used in South Carolina to address legislative questions concerning the extent and value of isolated wetlands and will be used in North Carolina to bolster our existing isolated wetland permitting program. An extension was granted to accommodate delays in the establishment of grant sub-contracts. This grant Project results were

presented at the Society of Wetland Scientists (June 2012) and the Geological Society of America (November 2012). The final report was submitted February 19, 2013.

D. Quality Assurance/Quality Control

A Quality Assurance Project Plan will be submitted to the EPA as necessary to ensure proper and accurate measures are taken in all stages of the project: site selection, methods development, data collection, data maintenance and analysis.

E. Invasive Species Control

There are no known invasive or exotic insects in these headwater areas. Exotic plants will not be removed from a site unless for voucher purposes and will not be transported to another site.