Stream Ecological Health Assessment for the Chowan River Basin, Virginia and North Carolina

Final Report to the Virginia Department of Conservation and Recreation and the Virginia Department of Environmental Quality

Todd Janeski
Healthy Waters Program Manager, DCR Division of Natural Heritage and
Virginia Commonwealth University

Greg Garman
Stephen McIninch
David Hopler
William Shuart
Jennifer Ciminelli
Richard Hill
Center for Environmental Studies and Rice Rivers Center
Virginia Commonwealth University

June 24, 2016

Cover Photo: Blackbanded Sunfish (*Enneacanthus chaetodon*; Virginia Endangered) from the Chowan River Basin of Virginia

Correct Citation: T. Janeski, G. Garman, S. McIninch, D. Hopler, W. Shuart, J. Ciminelli, and R. Hill. 2014. Stream Ecological Health Assessment for the Chowan River Basin, Virginia and North Carolina. Final Report to the Virginia Department of Conservation and Recreation and the Virginia Department of Environmental Quality. Virginia Commonwealth University, Richmond, Virginia. 80 pages.

Executive Summary

Through Section 319 funding support from the Nonpoint Source Program at EPA Region III, the Chowan River Basin Healthy Waters Conservation Implementation Plan will help advance interstate watershed management efforts between North Carolina and Virginia. This project will expand and leverage existing activities underway within the Albemarle-Pamlico National Estuary Partnership, Virginia's Healthy Waters Program and entities such as The Nature Conservancy. It will result in a plan that sets ambitious goals to conserve and help restore the health of rivers and streams throughout the basin. In addition, this plan will provide recommended modifications to the guidance and objectives of the nine key elements of a Watershed Implementation Plan to be used for the purpose of protection as opposed to restoration of water quality. This plan and suggested recommendations will be provided to EPA, for consideration.

Overall, the project develops a Ecologically Healthy Watershed Conservation Plan that will be used to identify critical areas for protection and be used as the basis for the healthy watershed protection goals of the Albemarle-Pamlico National Estuary Partnership's Comprehensive Conservation and Management Plan. It assures these ecologically healthy streams are incorporated into the Department of Conservation and Recreation's Natural Heritage Biotics Database and integrated into land conservation and land planning projects in Virginia. It expands Virginia's Healthy Waters Program by expanding into a basin that has limited data and will include an assessment of stream ecological health using the existing protocol that integrates fish, aquatic life as well as habitat indicators to determine condition. To facilitate the success of this project, the Virginia partnership will include the Virginia Department of Conservation and Recreation, the Virginia Department of Environmental Quality, Virginia Commonwealth University North Carolina Department of Environment and Natural Resources, the Albemarle-Pamlico National Estuary Partnership, US Environmental Protection Agency, The Nature Conservancy, local governments and other interested stakeholders.

Background

The role of Virginia's Department of Conservation and Recreation (VDCR), Division of Natural Heritage (DNH) is the identification and protection of aquatic and terrestrial communities and rare plant and animal species that contribute important ecosystem services or represent significant ecological resources. Virginia is a member of the NatureServe Natural Heritage Network and draws upon resources throughout the Western Hemisphere to advance biodiversity conservation and shares Virginia conservation information and successes throughout the Hemisphere. Virginia has a well established record of identifying and achieving protection for rare species and terrestrial communities; the Healthy Waters Program, in strong collaboration with Virginia Commonwealth University (VCU), is finally able to identify the most biologically diverse streams in the state. In Virginia, the challenges associated with these important efforts, specifically as they relate to aquatic communities, include: 1) development and application of objective, quantitative, and diagnostic stream assessment protocols and 2) defining a set of measurable and appropriate stream conditions, based on empirical data, as goals for protection efforts. Both of these challenges are dependent on an understanding of, and comparison to, relevant reference conditions that describe accurately and quantitatively the ecological potential of streams and rivers within a specific region. In Virginia, the scarcity of relatively undisturbed streams to serve as reference systems is problematic in many ecoregions. In early 2000, in response to national US Environmental Protection Agency (US EPA) Region III initiatives, Virginia created the *Healthy Waters Program*, with the goal of identifying and protecting ecologically intact streams, riparian habitats, and stream-dependent living resources. Identification of healthy streams is a prerequisite for any resource protection program; however, current state agency-based stream monitoring and assessment activities focus primarily on water quality impairments and target degraded streams for rehabilitation.

Traditionally, water quality based programs have emphasized the assessment of streams to determine if water bodies meet water quality standards with a subsequent restoration plan to improve degraded surface waters. While this is a critical activity to provide the Commonwealth a healthy ecosystem it is equally as important to seek viable opportunities for best management practices to protect streams that are already considered healthy/biologically diverse. It is economically and ecologically preferable to conserve and protect healthy ecosystems than to restore them after they have been damaged. Agricultural BMPs may serve as a key role in the protection of healthy waters and healthy watersheds. The integrity (health) of aquatic ecosystems (streams) is tightly linked to the watersheds of which they are a part. There is a direct relationship between land cover, key watershed processes and the ecological health of streams.

As stated, in early 2000, in response to the problems outlined above, Virginia Commonwealth University, the Virginia Department of Conservation and Recreation, and the Virginia Coastal Zone Management Program (VCZM) initiated a multi-phase project to develop an integrative, objective, and statistically valid stream ecological health assessment application. The project uses high quality archival data, combined with extensive, new data collected by the VCU stream assessment team, to develop a broad suite of georeferenced databases of aquatic resources, including fish and macroinvertebrate communities, instream and riparian habitat, and geomorphological data. These databases are the foundation for the ***IN***teractive ***ST***ream ***A***ssessment ***R***esource (***INSTAR;***http://gis.vcu.edu/instar/) application: an online, interactive mapping and database application designed to quantitatively assess stream conditions based on comparisons among a suite of integrative, multimetric indices and models of regional reference conditions. An ecologically-based approach to water quality assessment has been adopted by most state and federal natural resources agencies because it effectively integrates water quality and instream habitat conditions across spatial and temporal scales. Such an approach also provides a direct evaluation of stream biological and ecological integrity (i.e., stream 'health') and an inventory of economically and ecologically important living resources. Due to this assessment approach, Virginia has identified more than 300 ecologically healthy streams, creeks and rivers throughout the state, and there are more to be identified. Healthy streams are identified by factors that include: high numbers of native species and a broad diversity of species, few or no non-native species, few generalist species that are tolerant of degraded water quality, high numbers of native predators, migratory species whose presence indicates that river or stream systems are not blocked by dams or other impediments, and low incidence of disease or parasites.

INSTAR, and the extensive aquatic resource database on which it runs, were developed to support a variety of stream assessment, management and planning activities aimed at restoring and protecting water quality and aquatic living resources throughout the Commonwealth. The project is currently focused on developing an aquatic resources (blue infrastructure) database and stream health assessment protocols for Virginia's portion of the Chesapeake Bay and Chowan watersheds. In addition, regional reference stream models (i.e., *virtual* streams) for both non-tidal and small to medium-sized tidal tributaries are developed as criteria for prioritization of candidate streams and watersheds for protection and restoration, objective and quantitative performance measures, and as a decision support tool for environmental planning and implementation. The *INSTAR* program (http://gis.vcu.edu/instar/) and related applications developed by VCU leverage cutting-edge, information technologies and an expanding database of high-quality, geospatial information to conduct both watershed (sixth-order hydrologic units) and reach-specific assessments of stream and river health throughout the Commonwealth. Currently, *INSTAR* has compiled information on approximately 2,300 Virginia and North Carolina streams and representing over 265,000 records. The INSTAR application is currently the only tool available to identify ecologically healthy, freshwater streams and rivers in the Commonwealth.

Some actions that typically support healthy waters protection:

- Create, maintain, or expand riparian buffers: Vegetative corridors of at least 35' in width buffer streams from activities in the watershed by intercepting runoff that would otherwise transport sediment and other pollutants to the stream. This is one of the most effective measures for protecting streams. However, to achieve protection of steam corridors to maintain and ensure aquatic and terrestrial communities, we recommend forested riparian buffers along the river and any streams on the property. These buffers should be at least 100 feet wide on both sides of the waterways. If slopes are 11-25 % the buffers should be 150 feet wide and if slopes are greater than 25% buffers should be at least 200 feet wide. These buffers should be kept free of livestock and soil disturbances. Timber harvesting of 50% cover of the landward 50 feet these buffers may be acceptable.
- Protect headwater streams: Often intermittent, and therefore not recognized as a "blue line stream" and underserved by regulation, these streams are extremely important to the natural function of downstream waters and habitat for aquatic communities. Exclusion such as fencing livestock out of these areas can prevent downstream degradation of high quality perennial streams.
- Maintain natural stream flow to ensure aquatic habitat consistent with healthy ecosystems: The natural, seasonal pattern of stream flow, the stream's response to storm events, and maintaining minimum flow levels may be as critical to a stream's health as water quality.
- Protect natural stream channels: Stream channels naturally adjust across their floodplain and are continually changing. By protecting riparian corridors, through easements or by excluding livestock from unlimited access to stream channels, direct introduction of some pollution (bacteria) may be minimized as well as reducing the direct impacts to aquatic habitat and the creation of erosion problems.

<u>Project Overview</u>

The Chowan Healthy Waters Project was developed to advance protection of healthy watersheds within a river basin that is known to have significant natural resources and anadromous fish spawning habitat. The unique opportunity leveraged and built upon existing healthy watershed conservation efforts within both Virginia and North Carolina, within EPA regions III and IV, and the EPA National Estuary Program. The Virginia Healthy Waters Program is administered by the Division of Natural Heritage at the Virginia Department of Conservation and Recreation. This project was developed with specific goals:

1. Identify ecologically healthy waters in the Chowan basin
2. Provide suggested modifications to the USEPA and Virginia Implementation Plan Guidance A-I with a focus on resource protection as opposed to restoration
3. Develop an Ecologically Healthy Watershed Conservation Plan for the Raccoon Creek in the Chowan Basin and include possible additional sites that could be crafted into conservation plants. These include: two from Virginia, one shared resource site, and one North Carolina site.

To meet these goals, the Project identified the following objectives:

1. Advance interstate watershed and basin activities between the Commonwealth of Virginia and the State of North Carolina
2. Expand the partnership between the Commonwealth of Virginia and the State of North Carolina on shared watershed activities and create a comprehensive interstate watershed Memorandum of Agreement
3. Demonstrate applicability of Healthy Waters Program and the protection of significant Natural Heritage Resources in three watersheds: one in Virginia, one in North Carolina and one shared between the two States.
4. Demonstrate strategic partnerships to achieve resource protection with such entities as the Albemarle Pamlico National Estuary Partnership, The Nature Conservancy, North Carolina Agencies, Virginia Agencies, private companies Conservation SWCDs, and other nongovernmental organizations
5. Incorporate ecologically healthy waters locations into the Virginia Biotics Database and share with land conservation and land planning partners via DCR's Natural Heritage Data Explorer and other DCR information sharing venues
6. Identify and recommend protection strategies for ecologically healthy resources
7. Advance the Albemarle-Pamlico National Estuary Partnership Comprehensive Conservation and Management Plan

With USEPA Section 319 funding support from the Nonpoint Source Program at Region III, the Chowan River Basin Healthy Waters Conservation Implementation Plan advanced interstate watershed management efforts between state of North Carolina and the Commonwealth of Virginia by conducting a detailed assessment based upon the Virginia Healthy Waters Program at the VA DCR Division of Natural Heritage. This project expands existing activities underway within the Albemarle-Pamlico National Estuary Partnership (APNEP) and Virginia's Healthy Waters Program and contributes to effective conservation of ecologically healthy rivers and streams throughout the basin. The project implements natural resource protection goals of the Albemarle-Pamlico National Estuary Partnership, Comprehensive Conservation and Management Plan and expands Virginia's Healthy Waters efforts through an assessment of stream ecological health using a protocol that integrates aquatic communities and in-stream habitat indicators. Virginia Department of Conservation and Recreation partnered with the Virginia Department of Environmental Quality, Virginia Commonwealth University, North Carolina Department of Environment and Natural Resources (NCDENR), APNEP, USEPA, The Nature Conservancy (TNC), local governments and other interested stakeholders to accomplish the project goals.

The Interactive Stream Assessment Resource application has received national recognition as an objective, science-based tool for evaluating stream ecological integrity. The Chowan Healthy Waters project was used to make INSTAR-based stream assessments available to stakeholders interested in conserving the ecological integrity of waters in the basin through a web-based interactive mapping service (http://gis.vcu.edu/instar/). It built capacity for technical assistance and set the stage for further cooperative efforts to conserve and restore the outstanding aquatic resources of the Chowan Basin. Finally, the Chowan Healthy Waters project significantly expanded spatial coverage for Virginia's Healthy Waters Program and demonstrated successful coordination of interstate water resources issues.

Banded Sunfish (*Enneacanthus obesus*; top) and Bluespotted Sunfish (*E. gloriosus*; bottom) from the upper Chowan Basin of Virginia. Both are native indicators of ecological health. Photo credit: D. Hopler.

Water moccasin (*Agkistrodon piscivorus*) from the lower Chowan Basin of North Carolina. Photo credit: D. Hopler.

Basin Description

The Chowan River Basin is a shared resource in the southeastern region of the Commonwealth of Virginia and the northeastern region of the State of North Carolina. The basin is approximately 130 miles long, drains an area of nearly 5,000 square miles (3.2M ac), contains nearly 10,000 miles of streams and lies 75 percent within Virginia and 25 percent within North Carolina (Figure 1). In Virginia, the basin covers all, or a portion of, Brunswick, Dinwiddie, Isle of Wight, Lunenburg, Mecklenburg, Nottoway, Prince George, Surry, Southampton, and Sussex counties. In North Carolina, all or a portion, of Chowan, Gates, Bertie, Hertford, and Northampton are located in the basin. The Blackwater, Meherrin and Nottoway rivers are the major tributaries to the mainstem Chowan, which is located entirely in North Carolina. The Chowan Basin flows through the piedmont and coastal plain physiological provinces and is primarily in forestry or agricultural use with pine and peanuts being the primary crops. One of the driving factors for initiating the Chowan Project is that it is mostly rural - approximately 64 percent of its land covered by forest. Cropland and pasture make up another 28 percent, while only about 6 percent is classified as urban.

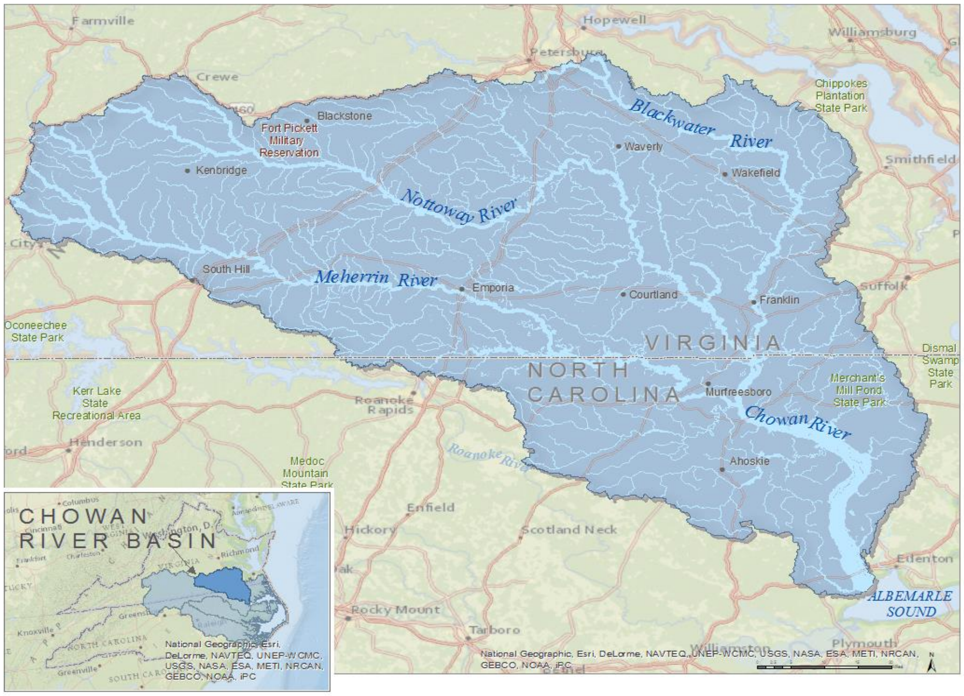


Figure 1 Chowan Basin

The piedmont physiographic province within the Chowan Basin is home to important warm water fisheries including habit and significant populations of the endangered Roanoke Logperch *(Percina rex)*. It also has good water quality and important habitat for freshwater mussel assemblages. The coastal plain physiological province includes low gradient black water swamps and bottomland hardwood forests.

Planning Process

The planning process for the Chowan Project was driven by a number of distinctive factors. The first is the planning effort was designed to identify streams with high ecological integrity and to develop a conservation strategy rather than one based on restoration, as is typical for many watershed planning activities. Second, the assessment process involved both a landscape scale screening and a probabilistic in-stream assessment guided by the landscape scale screening. The landscape scale assessment used remotely-sensed indicators for monitoring the general condition of “natural habitat” in basin. Another unique aspect of the basin is that it is largely forested and is comparatively less populated than other regions of the State, especially compared to other basins of this scale. As described below, this factor was significant because it shaped the efforts of the planning team and the approach to stakeholder engagement. The plan was intended to take an interstate approach and to involve two Environmental Protection Agency regions, other federal agencies, two state agencies and local nongovernmental partners to develop a comprehensive planning process. The in-stream and landscape scale assessments drove the final element of the planning process: identifying watersheds to develop specific protection-based implementation plans. The Section 319 Scope of Work for the project committed to developing three discreet watershed implementation plans. As the project advanced, the opportunity to target additional areas arose, however, the final project deliverable includes one complete conservation plan for Raccoon Creek and four watersheds where conservation plans that could be developed utilizing adapted plan elements adapted to a conservation based planning framework.

Planning Team

The initial development of the Chowan assessment was the formation of the project planning team. As noted above, the Virginia Healthy Waters Program has been developed through a collaborative multi-agency effort between VDCR, VDEQ and VCU. The Chowan Project has also benefited from this multi-agency involvement and was expanded with the addition of the North Carolina Agencies. The Project Team, lead by the VDCR, Division of Natural Heritage, in collaboration with VCU staff, engaged numerous cooperating state agencies including VDEQ, the Virginia Department of Forestry (DOF) and The Nature Conservancy, throughout the planning process. As a demonstration of continuing cooperation on conservation initiatives, the Project Manager engaged the North Carolina Department of Environment and Natural Resources, NC Natural Heritage staff, along with staff from the Albemarle-Pamlico National Estuary Partnership. These relationships have benefited the planning process immeasurably and have further demonstrated the benefits of interstate cooperation and conservation planning. The VDCR Natural Heritage Division led the overall planning process and plays a lead role in Virginia with management and dissemination of biodiversity conservation information, with VCU staff being the primary science investigators for the project. The VCU staff served as the lead for field data acquisition, field study design, and data development and analysis. VCU staff designed and developed the landscape scale assessment and stream ecological health assessment for the targeted watersheds. VCU has continued to be an important partner is the state of Virginia's Healthy Waters Program. Specifically, VCU leads the stream assessment design, data collection, analysis and hosts the Healthy Waters data and geographic information system (GIS).

On January 30, 2012, the Project Manager organized a kickoff meeting hosted by the APNEP to develop the Chowan Project Team and to establish an ongoing collaborative and cooperative effort. The APNEP has shared the funding of a conservation field staff, Watershed Field Coordinator, which was housed in Virginia but worked in both states for several years. This relationship proved extremely beneficial since the Watershed Field Coordinator identified the potential role for APNEP and the connection to the Comprehensive Conservation and Management Plan (CCMP) for the Basin and identified additional initial partners. The CCMP outlines several targeted strategies to address resource protection in watersheds draining into the Albemarle and Pamlico Sounds. The shared management and funding of the Watershed Field Coordinator is based on an identified Memorandum of Agreement (MOA) between both the Commonwealth of Virginia and the State of North Carolina for this watershed and staff. An intended outcome of this project was the expansion of the MOA between the two states to develop an overall, comprehensive, interstate, inter-basin, watershed coordination MOA between the States. The purpose was to encompass all watershed activities between the two states to improve efficiencies, capacity and share resources. Management of the VA DCR, Division of Soil and Water at that time deemed the concept was to be removed from consideration and would no longer be an outcome of the project or process.

Through the newly developed relationship with the state of North Carolina and the staff of the Department of Environment and Natural Resources, this project was embraced as an opportunity to connect land conservation activities throughout the basin and as a mechanism to inform future land conservation activities. The NCDENR recognized additionally the opportunity to develop a North Carolina Healthy Waters Program, based on the outcome of this process using the Commonwealth of Virginia as a model for their Program. The NCDENR also recognized the opportunity that the data to be developed from the assessments would inform their long range plans to expand and protect those areas near to significant and protected natural features, such as Merchants Mill Pond.

The Nature Conservancy staffs have long been an important partner in conservation efforts in the Chowan Basin and in the Commonwealth of Virginia. With regard to this project, The Nature Conservancy Southern Rivers staff helped coordinate and guide watershed prioritization, stakeholder identification and community engagement. In particular, TNC identified unique opportunities for focusing the work and recognized significant stakeholders such as the City of Norfolk, Department of Utilities, and Enviva Pellets Southampton LLC (Enviva). The City is an important watershed stakeholder because they have a water intake in the Nottoway River that is used to supply the reservoirs serving their communities. Currently, the City implements protective measures around reservoirs to minimize impacts to water quality. An opportunity sought to be realized was the protection of those riparian adjacent to the sites common for water withdrawal in river systems that supplied those reservoirs.

Much of the watershed is forested and has significant forestry operations throughout the basin. The VA Department of Forestry became another important partner in the project identifying opportunities and challenges. The DOF informed the planning process and assisted in bringing important forest industry partners, such as Enviva into the dialog. With a strong sustainability commitment, Enviva is an important partner in helping to ensure sustainability at the point of forest extraction. Point of extraction sustainability is vital to conserving the health of streams throughout the basin because the protection of bottomland hardwoods coincides with the protection of healthy aquatic ecosystems. The DOF also identified the opportunity to introduce the VA Sustainable Forestry Initiative (SFI) Board to the Healthy Waters Program and to inform them of the available data and resource protection goals. The prospect of sharing the resources of the VDCR DNH Healthy Waters Program is one to be capitalized upon since the reach would benefit not simply the region of the Chowan study area, but statewide. During discussions with both the TNC Southern Rivers Manager and the VDOF, Healthy Waters staff ascertained that two new forest product facilities were planned to be developed to support the growing pellet industry. The DOF and TNC confirmed the general locations of Franklin, VA and Roanoke Rapids, NC as the sites for the receiving of timber serving the pellet production process. Both DOF and TNC confirmed that theses two locations had a “fiber basket” radius of 75mi for each location. Geographically, this poses a significant challenge to the protection of resources. The two 75mi radii overlap and when shown in a Venn diagram-like manner demonstrate those areas most likely to be the focus of the majority of the extraction. Those overlapping radii can be seen in Figure 2.

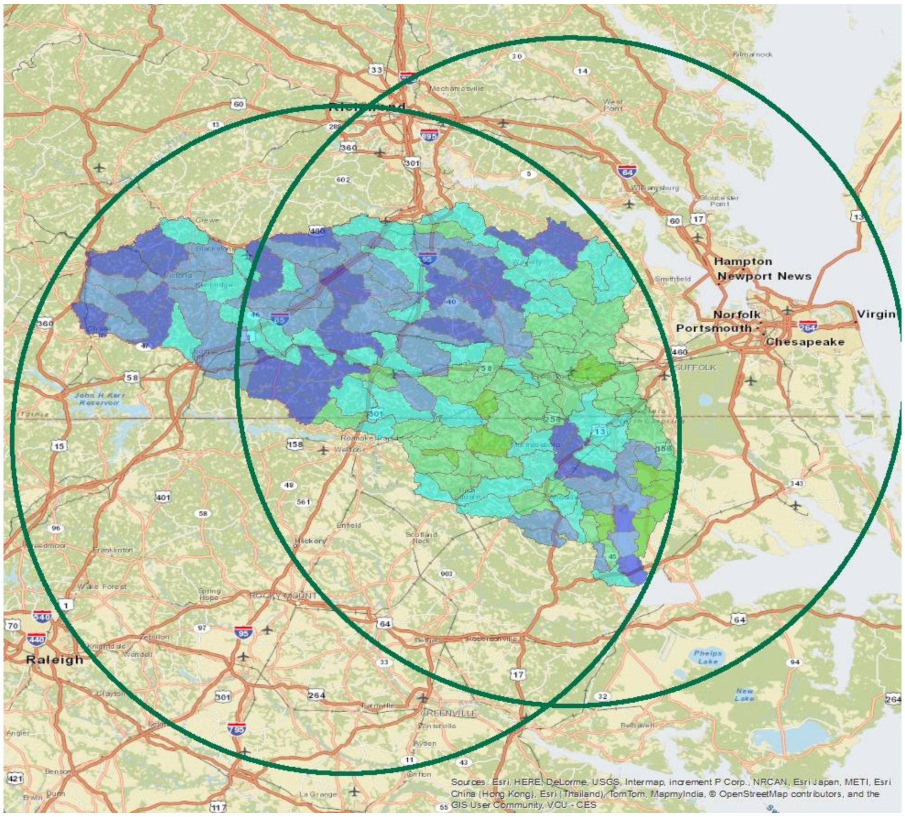


Figure 2. 75mi overlapping radii “fiber baskets” serving Roanoke Rapids, NC and Franklin, VA as centers.

The US Department of Defense, Fort Pickett staff also became an important cooperator with this project. In addition to hosting site visits and coordinating team meetings, such as a recent meeting between VDCR, North Carolina DENR and APNEP staff, Fort Pickett staff agreed to incorporate healthy waters conservation elements into the Integrated Base Management Plan. The Ft Pickett Base Natural Resources Manager offered the opportunity to broker a stronger relationship with the neighboring localities and landholders to permit an improved tie to resource protection benefiting the Healthy Waters Program and their own resource protection goals.

The Virginia Department of Environmental Quality provided grant administration and was engaged as an active participant in the modification of the watershed restoration planning elements to create conservation-based plan criteria. The outcome of that process was the development of the A-I Criteria for Ecologically Healthy Watershed Conservation. The VDEQ remains an active participant in the integration of the planning elements into the TMDL and restoration process. The VA DEQ had recently taken a step to allow the VDCR Division of Natural Heritage to outline strategies, share data for the identification and protection of critical resources and help with TMDL prioritization based on Healthy Waters data.

The Project Team focused the input of the Project Partners to identify those areas to direct the acquisition of field based data to inform the development of the INSTAR and Healthy Waters sites. Based on the outcome of the Index of Terrestrial Integrity assessment, or coarse-scale remote analysis, the areas of the Meherrin, Assamoosic, Nottaway and Chowan would be the areas assessed by field personnel. Illustrations of those areas can be found in the following section articulating those areas most likely to contain healthy resources. While not the typical probabilistic-based approach, the limited project budget necessitated the direct field assessment to these areas. A probabilistic approach was used in those watersheds to guide the acquisition of field data.

<u>Adapting Watershed Planning Elements to a Conservation Plan</u>
A deliverable of this project is the adaptation of EPA's Nine Key Elements of Watershed Planning to a create Healthy Watersheds Implementation Plan. The Project Team used an iterative and cooperative approach to adapt the planning elements with a focus on protection. As the lead nonpoint source agency, VDEQ was directly engaged in the development of these planning elements.

In 2004, EPA issued Federal Guidelines for the Award of Section 319 Nonpoint Source Grants to States and Territories. This guidance identified nine key elements that are critical for achieving improvements in water quality. EPA requires that these nine elements be addressed in watershed plans funded with incremental Clean Water Act section 319 funds and strongly recommends that they be included in all other watershed plans intended to address water quality impairments. For purposes of this project, the nine key elements are not directly applicable because the project is designed to proactively protect aquatic integrity rather than restore impaired waters. The deliverable of this project was to recommend conservation based planning elements that would be applicable to future conservation based watershed plans.

The planning team developed these conservation-based watershed planning elements considering how each element could be adapted to a Healthy Watershed Plan. To guide this effort the team identified fundamental differences between conservation based planning and restoration based planning. One consistent difference was the need to integrate ecosystem-based principles into the elements. This approach moves beyond physical and chemical water quality parameters and considers a holistic systems-based approach.

The team also considered differences between monitoring, resource assessment and that the actions typically taken to conserve natural resources may differ from corrective actions taken to restore degraded water quality. Protection measures such as land conservation and land use plan and ordinance development are strong factors for consideration. While code and ordinance conservation provisions were not the highest priority for conserving Healthy Waters in the Chowan Basin, they may be the most important components for other watersheds. Typically, the *A-I Criteria* is used as part of a watershed restoration strategy identifying the following points:

A. Identify and quantify causes and sources of impairments

B. Estimate expected load reductions

C. Identify BMPs and critical areas to achieve load reductions

D. Estimate needed technical and financial resources

E. Provide information, education and public participation component

F. Include schedule for implementing NPS management measures

G. Identify interim measurable milestones for implementation

H. Establish criteria to determine if load reductions are achieved

I. Provide a monitoring component to evaluate effectiveness

This iterative approach resulted in the following A-I Elements that where applied in developing the watershed based plans in the Chowan Basin, referred to as the A-I *Criteria for Ecologically Healthy Watershed Conservation*:

A. Quantify and verify the empirical basis for aquatic communities identified with high ecological integrity

   The watershed plan should include detailed description of assessments and those data that characterize an ecological basis for conservation, accompanied by a detailed map identifying those specific features and conditions. The plan should identify those aquatic community assessments, terrestrial assessments; National Land Cover Data; VA Department of Forestry Forest Conservation Values; catalogue of existing ownership and other relevant information quantify ecological health and aquatic integrity and inform prioritization. The conclusions are based on aquatic and terrestrial data and assessments that clearly identify ecological health. For Virginia, initial assessments utilize a remote assessment to identify prioritizations based on a modified Index of Terrestrial Integrity (mITI), to classify all 12-digit HUCs and to identify a prioritized subset of HUCs with high terrestrial integrity *prior to* on-the-ground stream and site assessment. By focusing on HUCs with relatively high terrestrial integrity, the ability to more effectively leverage the limited resources available for fieldwork improves the ability identify new Healthy Waters locations for conservation and protection activities. A field-based VA Department of Conservation and Recreation, Natural Heritage Division INSTAR assessment is the basis for identifying aquatic integrity to inform the development of Healthy Waters sites. This element will include an accounting of the significant terrestrial and aquatic natural resources within the basin.

B. Identify conditions needed to maintain existing ecological

   On the basis of the assessed existing ecological condition and characterization the plan will identify the area that would most likely be recommended for protection. Those areas will be variable bas based on the previous assessments but will be informed by National Land Cover Data, VA Natural Heritage Division data relevant to maintaining the ecological condition, existing conservation easements, and INSTAR data. An assessment that concludes with an indication of ecological aquatic health is based on the existing baseline conditions, therefore it is implied that those current conditions, if maintained, will ensure that classification.

C. Identify best management practices, preventative and protective actions to achieve and maintain the system with high ecological integrity

The plan should identify those specific actions required to ensure the assessed ecological condition is maintained. These might include such practices as direct acquisition of land, conservation easements with specific language relevant to the protection of aquatic integrity or the application of increased standards for water quality protection or improvement such as those identified in the Sustainable Forestry Initiative.

D. Estimate needed technical and financial resources

The plan should estimate the financial and technical assistance needed to implement the entire plan. This includes implementation and long-term operation and maintenance of management measures, I/E activities, monitoring, and evaluation activities. The plan should also document which relevant authorities might play a role in implementing the plan. Plan sponsors should consider the use of federal, state, local, and private funds or resources that might be available to assist in implementing the plan. Shortfalls between needs and available resources should be identified and addressed in the plan.

E. Provide information, education and public participation component

The plan should include an I/E component that identifies the education and outreach activities or actions that will be used to implement the plan. These I/E activities may support the adoption and long-term operation and maintenance of management practices and support stakeholder involvement efforts

F. Include schedule for implementing best management measures

You should include a schedule for implementing the management measures outlined in your watershed plan. The schedule should reflect the milestones you develop in g

G. Identify interim measurable milestones for implementation

The plan will include interim, measurable milestones to measure progress in implementing the management measures for your watershed plan. These milestones will measure the implementation of the management measures, such as whether they are being implemented on schedule, whereas element h (see below) will measure the effectiveness of the management measures, for example, by documenting those actions to protect aquatic integrity.

H. Establish criteria to determine high ecological integrity is maintained at baseline conditions

As projects are implemented in the watershed the plan should include specific benchmarks to track progress. The criteria in element h (not to be confused with water quality criteria in state regulations) are the benchmarks or waypoints to measure against through monitoring. These interim targets can be direct measurements or indirect indicators of resource protection. The plan should also indicate how to determine whether the watershed plan needs to be revised if interim targets are not met. These revisions could involve changing management practices, updating the loading analyses, and reassessing the time it takes for pollution concentrations to respond to treatment

I. Provide a monitoring component to evaluate effectiveness

The watershed plan should include a monitoring component to determine whether progress is being made toward attaining or maintaining the applicable characterization based on the outcome of the assessments. The monitoring program should be fully integrated with the established schedule and interim milestone criteria identified above. The monitoring component should be designed to track the progress of protecting those critical resources and maintaining the existing conditions as assessed. Watershed-scale monitoring can be used to measure the effects of multiple programs, projects, and trends over time. Instream monitoring does not have to be conducted for individual BMPs unless that type of monitoring is particularly relevant to the project.

VCU Accomplishments

As the lead research agency for the Chowan Project, VCU provided study design, ecological sampling, data analysis. The magnitude of associated accomplishments are provided below.

1. Completed a coarse-scale GIS analysis (Index of Terrestrial Integrity, ITI) using existing remotely-sensed geospatial data and established models for the Chowan basin to identify specific, high-integrity watersheds (sub-basins) within which to conduct on-the-ground site assessments.
2. Completed 109 new probabilistic and quantitative ecological site assessments (on-site) for first through forth order streams in targeted watersheds of the Chowan Basin based on quantitative ecological collections (aquatic assemblages & in-stream habitat) in Virginia and North Carolina.
3. Mined and filtered approximately 2,000 archival collections from state agencies to identify and acquire 284 useful collections for the INSTAR database.
4. Completed and applied statistically valid regional reference condition models for small and medium streams in both upper (e.g. upper Meherrin River) and lower (e.g. Chowan River) ecoregions.
5. Expanded development of the INSTAR interactive blue infrastructure database available to Natural Heritage agencies and substantially renovated the INSTAR online user interface with newly-available technology.
6. Expanded the available spatially-explicit digital inventory of aquatic species of greatest conservation need for the Chowan Basin of Virginia and North Carolina.
7. Identified specific, high-functioning streams and their catchments for the development of Conservation (Protection) Plans.
8. Completed a quality assurance performance plan (QAPP) for all fieldwork conducted under this contract.

GIS Prioritization

The Virginia Watershed Integrity Model (VWIM) was developed and published in 2007 by a team that included the Virginia Department of Forestry, Virginia Division of Natural Heritage, and Virginia Commonwealth University to show the relative value of land as it contributes to watershed integrity, water quality, or stream ecological health. As development pressure continues across the state, critical resources are being irretrievably lost to development. A large number of published and unpublished studies have demonstrated strong relationships between land use and the integrity of water resources (Hughes, 1999; Karr, 1981; Tiner, 2004, Garman, 2010). Hence, valid models of high quality green infrastructure like the VWIM should be useful in predicting—with remotely sensed data—which watersheds are most likely to support streams with high ecological integrity (i.e., Healthy and Outstanding Waters). For the Virginia Watershed Integrity Model, input parameters focused on important terrestrial features that contribute specifically to water and aquatic resources, and, therefore watershed integrity. Given the limited resources available for on-the-ground activities, the use of models like the VWIM to prioritize watersheds prior to direct stream assessment may be an effective approach.

Prioritizing watershed integrity on a large spatial scale (i.e., the Chowan River Basin of Virginia and North Carolina) should apply terrestrial ecological indictors or indices that "include site-specific, field-derived metrics and landscape-level properties" in an effort to get at finer scale information (Tiner 2004). The focus of the current project was to employ a GIS-based classification of terrestrial integrity for 12-digit watersheds (HUCs) in the Chowan Basin (Figure 3) to identify those HUCs that are most likely to harbor healthy streams.

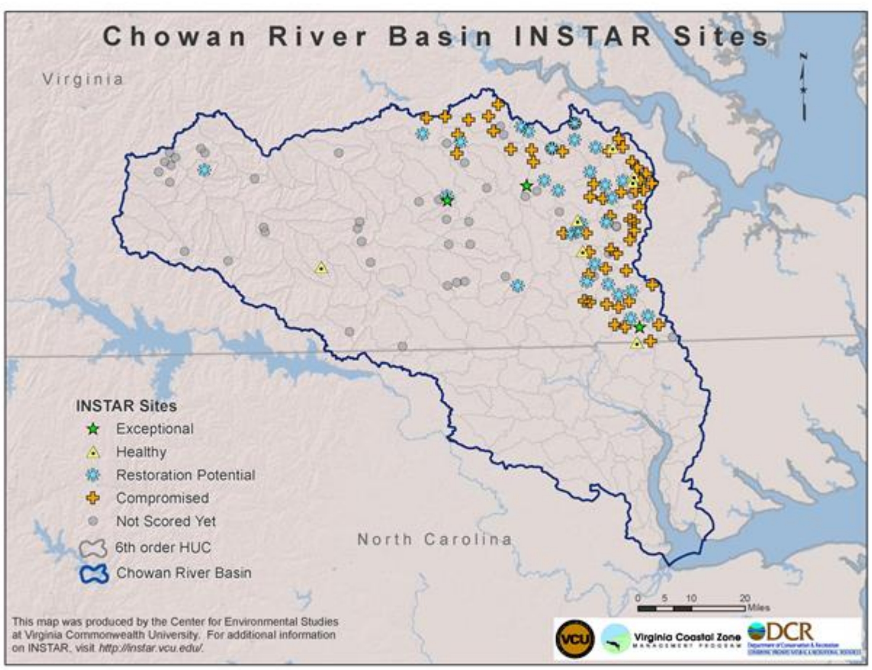


Figure 3. The Chowan River Basin of Virginia and North Carolina, showing Hydrologic Unit (HUC) boundaries and locations of **archival** (i.e., pre-project, *ca*. 2010) INSTAR collections (primarily in the Blackwater system). Per 2014 discussions between DCR and DEQ, the term, "Exceptional" as shown in the Figure, has been changed to, "Outstanding".

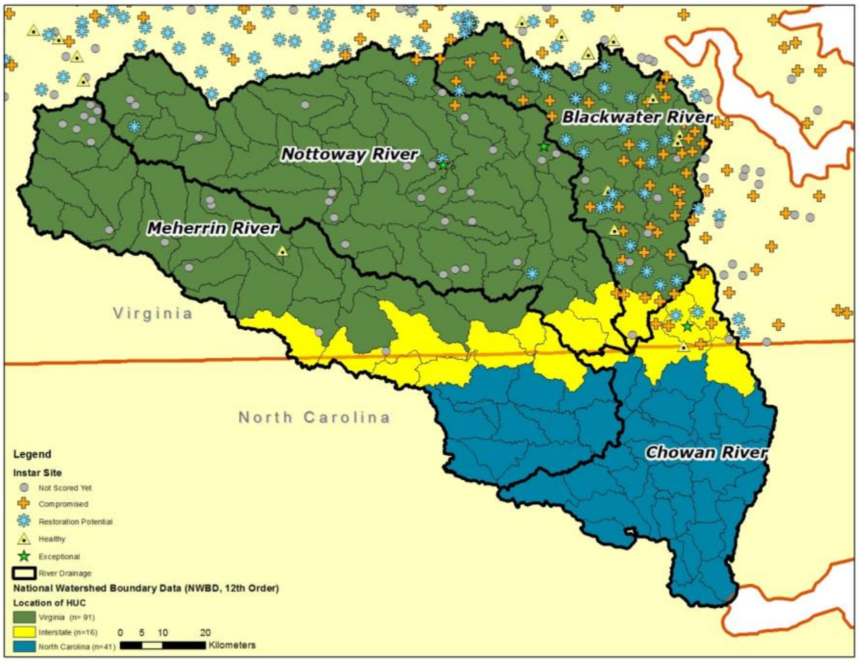


Figure 4. Division of the Chowan Basin between the Commonwealth of Virginia and the State of North Carolina, showing archival (pre-study) stream data. Per 2014 discussions between DCR and DEQ, the term, “Exceptional” as shown in the Figure, has been changed to, “Outstanding”.

Accessibility to GIS and remotely sensed information makes these processes easier to run and can provide an important monitoring tool for watershed integrity. These indices may also provide important information on aquatic ecosystem integrity (i.e., health) which can be used to develop indicators of overall stream health (Garman 2010). The Index of Terrestrial Integrity (ITI, Tiner 2004) is a component of the Virginia Watershed Integrity Model and was modified and applied to a GIS-based analysis of green infrastructure throughout the Chowan Basin. Results were used to classify HUCs (Figure 4) and to prioritize field activities that sought to identify ecologically healthy waters throughout the Chowan Basin. Specific input variables/metrics used for this application of a modified ITI in the Chowan Basin included:

a. The Natural Cover Index (INC) of Tiner (2004) based on the proportion of a watershed that is represented by natural vegetation (i.e., undeveloped landscapes);
b. The River-Stream Corridor Integrity Index (IRSCI) of Tiner (2004) that provides information on the status of vegetated riparian corridors;
c. The Habitat Fragmentation/Road Index (IHF) of Tiner (2004), which attempts to address habitat fragmentation by roads and reflects degradation of water quality, and terrestrial and aquatic ecosystems from associated development;
d. The Imperviousness Index (IP) was *not* used by Tiner (2004) but was added by VCU to this analysis to indicate degree of human development. It is based upon the proportion of a watershed that is identified as impervious cover and used the NLCD 2001 impervious dataset. While strongly correlated with the road density (and thereby IHF), it should add information where high density development is pervasive.

These four metrics, along with relevant and published geospatial coverages from Virginia and North Carolina sources, were used to compute a composite Index of Terrestrial Integrity (ITI) based on the formula: ITI = (0.75 * INC) + (0.25 * IRSCI) – (0.25 * IHF) – (0.25 * IP) (J. Scrivani, Virginia Department of Forestry, unpublished report). The model was used to classify all Chowan Basin 12-digit HUCs and then identify a prioritized subset of HUCs with high terrestrial integrity (Figure 5) *prior to* on-the-ground stream and site assessment by VCU biologists in 2012 and 2013. By focusing on HUCs with relatively high terrestrial integrity, VCU was able to more effectively leverage the limited resources available for fieldwork to identify new Healthy Waters locations for conservation and protection activities. In the Chowan Basin, the modified ITI was a good predictor of HUCs that harbored one or more new Healthy Waters Locations (Figure 5). Following the analysis, the Project Team determined those areas most likely to contain resources that may score a ranking of Healthy or higher would be located in the lower Meherrin, Assamoosic, or mainstem Chowan (eastern portion) (Figure 6).

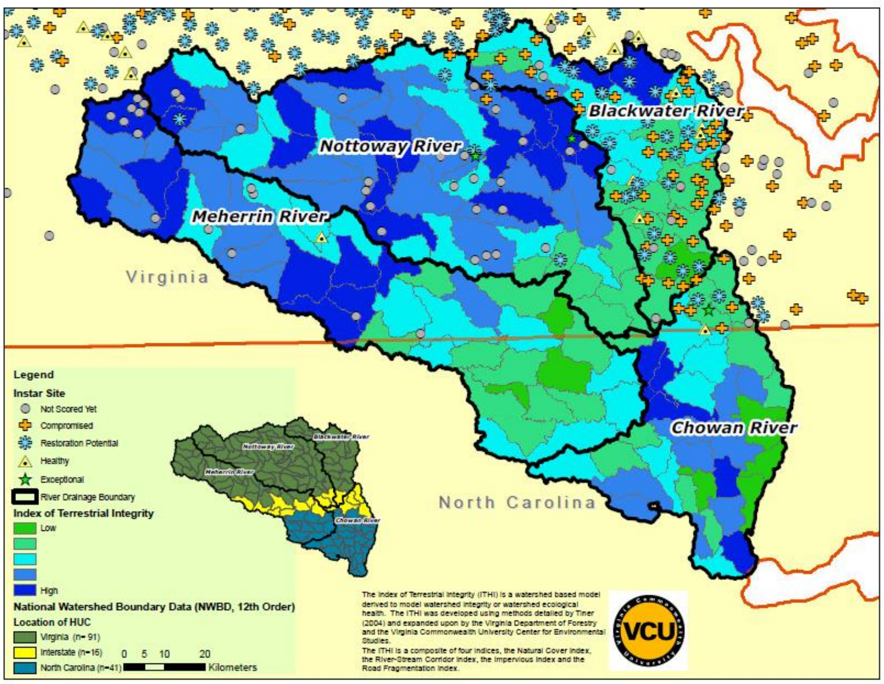


Figure 5. Application of the Index of Terrestrial Integrity to 12-digit HUCs of the Chowan Basin prior to field activities. Watersheds with high ITI scores were prioritized for field activities. A detailed explanation of the ITI and its application for this study is provided in the text. Per 2014 discussions between DCR and DEQ, the term, “Exceptional” as shown in the Figure, has been changed to, “Outstanding”.

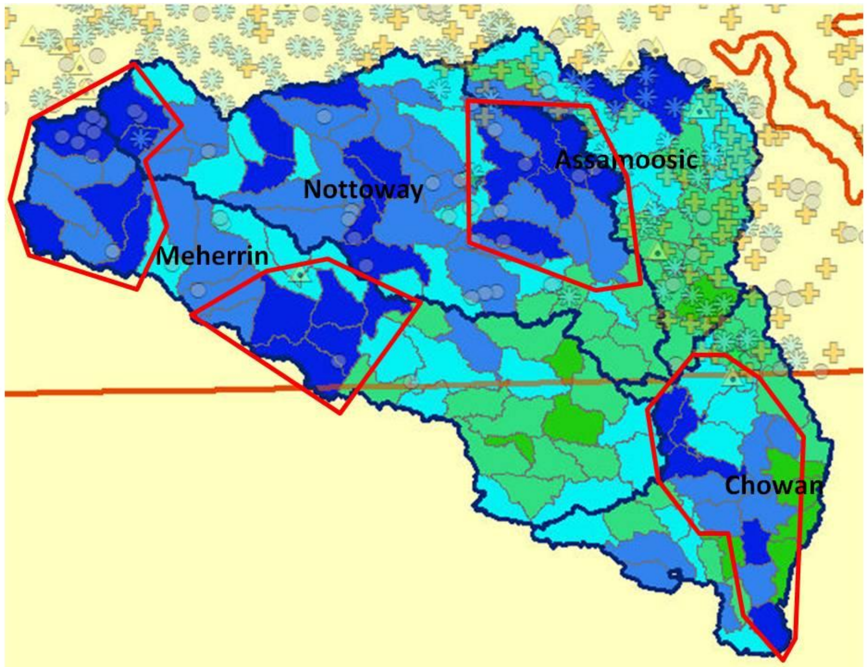


Figure 6. Focal areas of field-based INSTAR assessment (dark blue HUCs), overlaid on the Index of Terrestrial Integrity, illustrating the areas to achieve one watershed plan for Virginia, one for North Carolina and one shared watershed

Field Activities and Preliminary Data Analysis

Within prioritized HUCs of the Chowan, probabilistic study reaches (a minimum of 100 new stream reaches) for INSTAR sampling were selected for potential fieldwork through a statistically powerful, stratified (by stream order) randomizing protocol. Within geo-referenced reaches (150-500 m) and following methods outlined in the Quality Assurance Performance Plan (QAPP), fishes were sampled quantitatively using electrofishing equipment (Smith-Root backpacks, tote barge units, boats) and standard methods. Backpack and tote barge sampling was performed throughout the entire reach in a single pass. Boat electrofishing included additional sampling effort depending on stream width and habitat variability. Electrofisher settings (e.g. output voltage, waveform, etc.) for each sampling event were set to optimize sampling efficiency and minimize fish mortality based on ambient conditions and operator experience. Electrofishing settings and total effort (seconds of generator output) were recorded for each sampling event, along with any other relevant information. All fishes were identified to species in the field, checked for anomalies, and released. A synoptic assessment for instream habitat quality (EPA Rapid Habitat Assessment, RHA) was also performed at each site with the appropriate metrics for high *versus* low gradient. A total of 109 streams in Virginia and North Carolina were visited for this project during 2012 and 2013. A total of 24 sites had insufficient water to justify sampling and were neither sampled nor assessed. An additional 14 sites—primarily lower Chowan River locations—were not wadeable and were sampled by boat electrofishing. However, we had insufficient data to develop reference condition models for ‘big water’ sites in the Chowan and these 14 sites were not classified. Data from these locations were incorporated into INSTAR. A total of 71 stream reaches were sampled during 2012 and 2013 and classified for this project. Additional archival collections from various sources (VDGIF, NCDENR, VCU) met the criteria for database inclusion and/or stream ecological health.

Following data entry and QA procedures, biological and habitat data were compiled in SQL databases and application macros within INSTAR were used to calculate 47 separate metrics and ecological variables, including those typically generated for the Index of Biotic Integrity (IBI), Rapid Bioassessment Protocol (RBP), and Rapid Habitat Assessment (RHA). Variables and metrics were subjected to ordination and cluster analysis using uni-modal models (e.g. correspondence analysis (CA), de-trended correspondence analysis (DCA), and canonical correspondence analysis (CCA)) and linear response models (e.g. principal components analysis (PCA), multiple regression techniques). These multivariate analyses were used to develop regional reference condition models for comparison to empirical data for specific stream collections. We used Gower's similarity index to compare empirical scores obtained from each sampled stream reaches to the appropriate virtual reference stream, generating an index of stream health as a measure of percent comparability to the appropriate (virtual) reference condition model. High percent comparability scores (> 70%) were used as thresholds to classify streams as "healthy" and "outstanding" (> 80% comparability). Percent comparability scores below 70% were associated with streams that were "compromised" or represented "restoration potential." A more detailed explanation of field, laboratory, and data analysis methods is provided in an approved quality assurance (EPA-QAPP) document, provided in the Appendices. VCU held all necessary collection permits from State and Federal agencies to conduct fisheries fieldwork in Virginia and North Carolina.

<u>Data Interpretation</u>

Biotic metrics to evaluate stream health are increasingly utilized because of their ability to represent attributes or processes of the biological communities that respond to a gradient of anthropogenic influences (Karr 1981). Multmetric indices are commonly used as a mechanism to assess freshwater ecosystem quality (Hughes and Oberdorff, 1999) and are considered an efficient tool for evaluating the quality of running waters (Barbour et al. 1996). Often these indices are confined to a single taxonomic group (fishes, macroinvertebrates, diatoms, etc.) and are scored against some form of reference stream or hypothetical condition. This project's approach used data collected by uniform, statistically acceptable (probabilistic) methods to assess how the communities (primarily fish assemblages) under consideration are structured. Following the initial exploratory analyses, we evaluated variation among sites. We integrated the results from fish community analyses along with synoptic instream habitat data to strengthen our capacity to correctly assess impacts and stream condition.

Empirical data and derived metrics were compiled from the original data base and analyzed with multivariate techniques (e.g. detrended correspondence analysis (DCA), canonical correspondence analysis (CCA), principal components analysis (PCA), nonmetric multidimensional scaling (NMS) and linear regression). The goal for the first set of ordination analyses was to probe for underlying gradients or structure in the species data (NMS). We then used CCA and/or DCCA to assess community structure as it relates to the watershed metrics. Additional exploratory ordinations (PCA) examined the structure of the biotic communities based on functional attributes of the community members. A complete listing of candidate metrics, including those metrics selected by the analysis for model development, is provided in Table 1.

Fish Community Metrics	**Watershed Metrics**
Total species richness	Stream Order
Native species richness	Link Magnitude
Proportion Native species	Colonizing Link
Darter species	Distance to colonizing Link
Sucker species	Distance to mainstem
Sucker individuals	Distance to headwater
Sunfish species	Elevation
Introduced sunfish species	**Ecological Metrics**
Proportion of native sunfish species	Omnivorous species
Total sunfish individuals	Omnivorous individuals
Proportion of native sunfishes	Water Column Insectivore species
Sensitivity Metrics	Water Column Insectivorous individuals
Intolerant species	Benthic insectivore species
Intolerant individuals	Benthic Insectivore individuals
Intolerant of Biological Impairment	Apex predator species
Intolerant of Chemical Impairment	Apex predator individuals
Intolerant of Sedimentation	General carnivores species
Tolerant of Biological Impairment	General carnivores individuals
Tolerant of Chemical Impairment	General Invertivore species
Tolerant of Sedimentation	General Invertivore individuals
Tolerant species	**Fish Position Metrics**
Tolerant individuals	Benthic species
	Benthic Hiding species
Coastal Plain specialist	Water column species
Shannon’s diversity	Water column hiding species
Evenness	
Proportion with anomalies	
	Significant metric from regression analysis

Table 1. Candidate metrics generated by INSTAR and used for reference condition model development and stream assessment, Chowan River Basin (Virginia and North Carolina). A substantial number of the candidate metrics were based on previously published protocols (e.g. Index of Biotic Integrity, Rapid Habitat Assessment, Rapid Biomonitoring Protocols; Garman et al. 2010). Highlighted cells indicate metrics selected by initial ordination analyses and metrics included as variables in the final reference condition models.

Some metrics were of limited use for further analysis because of their lack of variability among sites sampled. Other metrics were highly correlated and as such do not add information to the analyses. These metrics were systematically removed from the data sets prior to further analysis. The refined (or ‘cleaned’) datasets were again analyzed using the appropriate ordination technique using species data, metrics, and habitat data. The resultant ordination diagrams (final response) plot similar sites together (or of close proximity to one another) and as such can be further examined for community structure and gradients among the stream sites. Often highly impacted streams and those of high quality are far removed from one another in these diagrams. Examination of the site scores and position of variables on the diagram indicate the relative importance of any given variable to the overall structure. Variables that exhibit a uniform or central distribution would not contribute to a more rigorous model and are thus not included in the final statistical analyses. Those variables and metrics that are important are included in the final stepwise linear regression analysis.

The site scores (i.e., coefficients from the final response model) are entered as the response variable and significant ($P<0.05$) biotic and abiotic variables and metrics are entered as explanatory variables. Finally, a series of reference stream condition models (i.e., virtual reference streams) are created for appropriate ecoregions and stream orders. The stream models use the resultant significant variables from the regression analysis and are scored depending on divisive categories (i.e., stream order). We used Gower's similarity index to compare empirical scores obtained from sampled stream sites and reaches to the appropriate reference stream, generating an index of stream health (i.e., Virtual Stream Assessment, VSA, score; range 0-100%) as a measure of percent comparability to the appropriate (virtual) reference condition model.

Results of initial ordinations (exploratory data analysis) revealed significant separation among samples based on the biota present (Figure 7). Strong clustering of some fish species on the plot suggests the presence of persistent habitat-based guilds, based on co-occurrence. The strongest gradient observed was along the 1st (X) axis and represents an elevational gradient. Those species on the left side of gradient are more affiliated with streams of higher elevation and those to the right lowland streams. The 2nd (Y) axis represents a strong stream size gradient with upper species associated more with larger streams. When examined by quadrants, the lowland species such as mudminnows, and many of the native sunfishes represent a low-gradient, low elevation guild (lower right), while redhorse suckers and some of the cyprinid insectivores comprise a moderate stream order and higher elevation guild (upper left). (Figure 7). Further data analysis was divided into two groups of sites representing those below (131 sites) and above (104 sites) 150 feet in elevation. In addition, sites representing streams of 4th or higher stream order were removed from further analysis. Aside from stream size and elevation, only Colonizing Link (representing the size of the next largest stream downstream of the sampled site) exhibited notable influence on the species composition ordination. The remaining watershed metrics were not considered further.

The first run of the Principal Components Analysis (PCA) included all fish community and categorized habitat metrics (Table 1) and resulted in significant correlation among many of the metrics. For example, the metric of overall tolerance to degradation (Tolerant) showed similar direction and gradient influence as metrics of sedimentation tolerance and chemical tolerance (Sed-T, Chem-Tl Figures 7 & 8). We retained only one (Tolerance) in further analyses. A second PCA was performed after correlated variables were removed. Metrics exhibiting little descriptive potential were then removed from further analyses to reduce variables further. The series of ordination resulted in a final set of variables and a clustering/ordination of sites produced from the raw data (Figure 7).

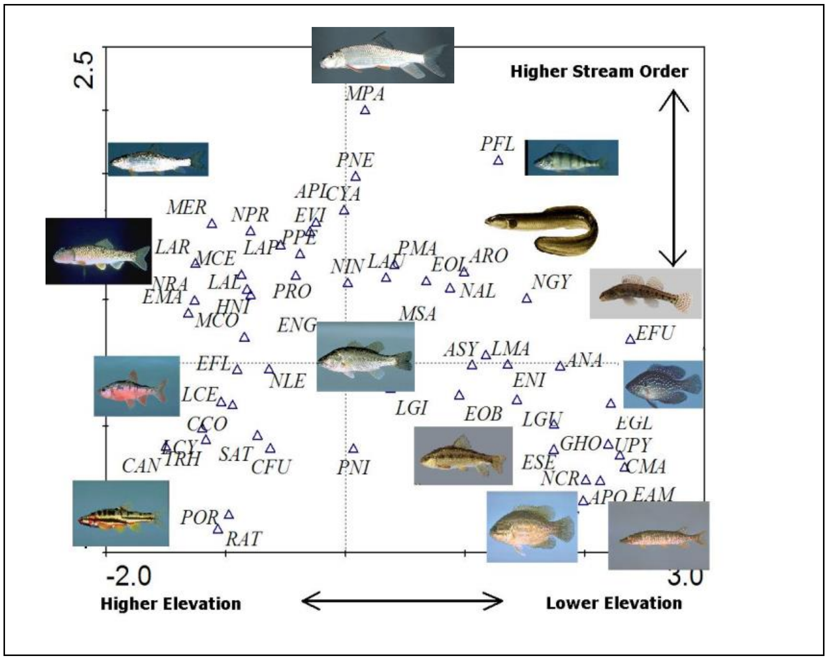


Figure 7. Ordination of fish metric associations for Chowan River basin streams based on INSTAR assessment. Arrow length represents the relative importance of the metric; metrics that are closely associated spatially on the plot are highly correlated A complete list of metrics analyzed is presented in Table 1. Taxonomic codes are explained in Appendix II.

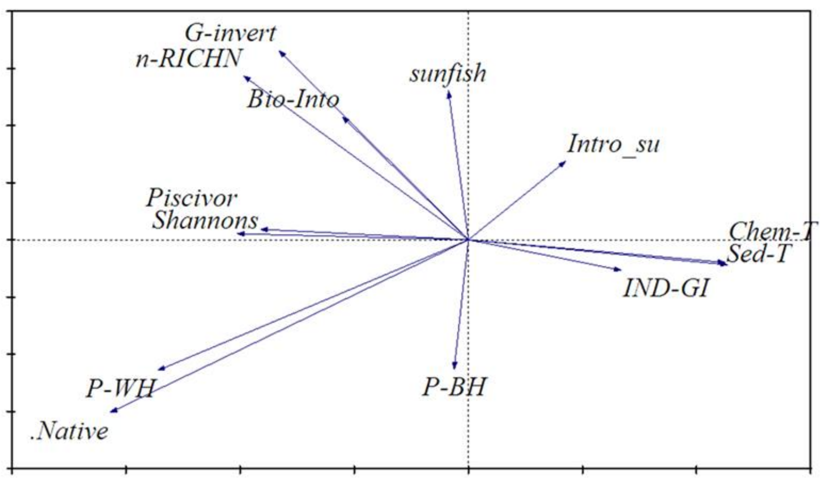


Figure 8. Ordination plot of stream habitat and landscape metrics generated by INSTAR data collection for sampled stream reaches in the Chowan River Basin. Arrow length represents the relative importance of the metric; metrics that are closely associated spatially on the plot are highly correlated. The axis scores (1st axis) of species data ordination were used as the dependent variable.

In the final iteration we utilized both species data and fish metric data (separately) and ordinate with watershed position metrics (link metrics) while partially out known variation due to stream order and elevation. The resulting ordination did not show a strong gradient associated with any of watershed parameters. There was a moderate gradient associated with Colonizing link, indicating a probably influence of the downstream colonizing pool on community structure.

The eight metrics exhibiting the most variation in the final PCA were used as explanatory variables in a multiple linear regression to further assess the ability to assess stream placement on a gradient. The first axis scores from the final species data ordination were used as the dependent variable. Two stepwise linear regression models (one for each elevational group) resulted in the final three variables listed below in the order that the model accepted them. These represent the variables that have the highest probability of setting a condition gradient based on the extant biota. As represented in Figure 7, 150 ft. or greater Elevation: Native species Richness, Proportion of native sunfishes, number of darters. Whereas, <150 ft Elevation = Native species Richness, Proportion of native sunfishes, and Number of Coastal Plain specialist species. Other variables included in the analysis were not found to significantly benefit the model.

We implemented different scoring criteria (i.e., submodels) based on stream order for all metrics included in the final model. Variable scores from the sampled sites were compared with expected/referenced scores based on their stream orders. The three variable scores were then averaged (nonweighted) and percent similarity reported as the stream health (ecological integrity) index for each stream evaluated.

Provisional ecological integrity scores, represented as percent comparability (range: 91-23%) to the appropriate regional reference condition model (described above) and applied both new (2012 & 2013) and scrubbed archival data for Chowan streams, were used to place streams into one of four categories, including ‘outstanding’ and ‘healthy’ (Figure 9). The distribution of stream ecological health categories between Chowan basin (this study) and Chesapeake basin (Garman et al. 2010) streams also assessed by INSTAR protocols in 2011 are presented in Figure 10. A greater percentage of Chowan streams were Healthy or Outstanding (49% combined) compared to Chesapeake streams (29% combined). Conversely, almost twice as many Chowan streams were ecologically compromised (33%) compared to Chesapeake streams (18%).

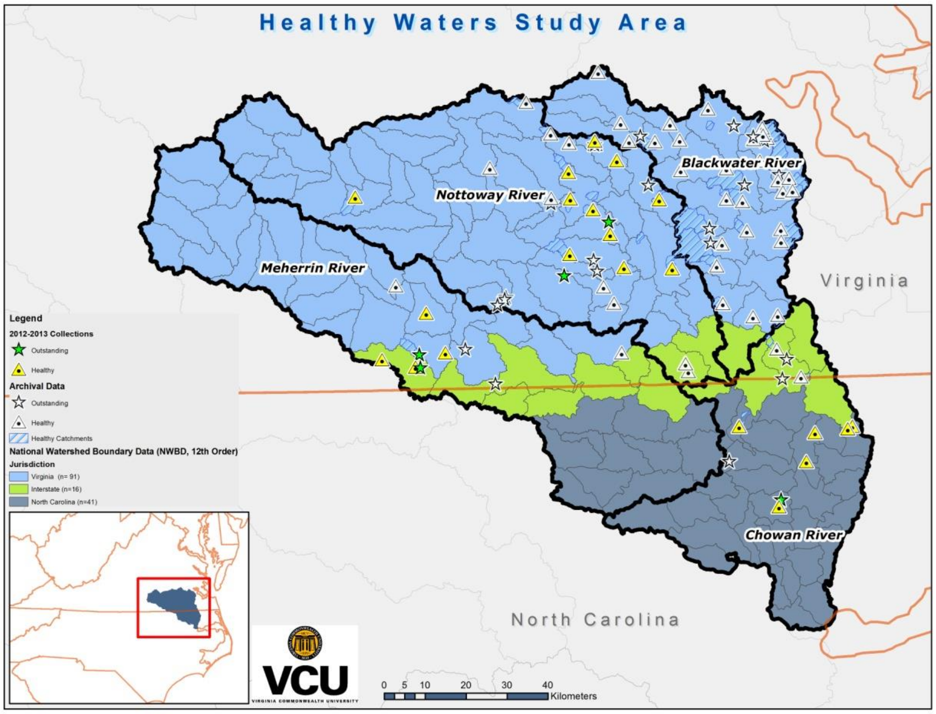


Figure 9. Final identification of new and archival Healthy and Outstanding stream sites in the Chowan River Basin, North Carolina.

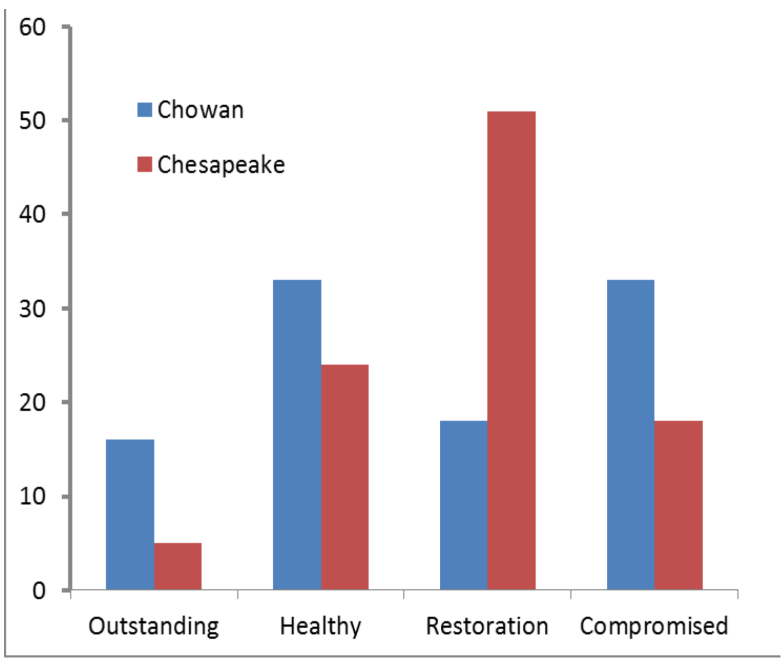


Figure 10. Distribution (percentage) of stream ecological health categories among Chowan (this study) and Chesapeake basin (Garman et al. 2010) streams assessed by INSTAR protocols. Chowan streams in this study had a distinct bi-modal distribution.

Conserving the Chowan Basin

The Section 319 Scope of Work for the project committed to developing three discreet watershed implementation plans. As the project advanced, the opportunity to target additional areas arose, however, the final project deliverable focused on a detailed Conservation Plan for the Raccoon Creek and includes four watersheds where conservation plans could be developed utilizing plan elements adapted to conservation based planning framework. The focus of the planning activities are in the Upper Nottoway River, Raccoon Creek but also identified, the Upper Nottaway River, Lower Nottaway River, Meherrin River and mainstem Chowan River. The opportunity to partner with the US Department of Defense and affect the Integrated Base Management Plan was one that needed to be capitalized upon. Significant terrestrial Natural Heritage Resources have been identified on Ft Pickett due to the unique land management strategy that replicates a consistent pattern of applying a burn strategy to the landscape. Additionally, Ft Pickett has encouraged the development of native plants and forest cover. Supplementing the terrestrial data with additional aquatic resources for their purposes of landscape scale conservation was a high priority. Specifically, the four additional locations are: Upper Nottaway: Wildcat Creek, Blackstone, VA; Lower Nottaway River: Joseph Swamp, near Waverly, VA; Meherrin River: White Oak and Rattlesnake Creeks, Valentines, VA; Chowan River: Beasley Branch and Bennett's Creek, Gatesville, NC. The example watershed plan is focused on the Upper Nottoway, Raccoon Creek.

As previously indicated, an outcome of the Project was the development of a suggested criterion for the protection of resources based on aquatic health. The VA DCR led meetings between the VDCR, VDEQ and VCU, to develop the following suggested approach to create a criteria for protection of natural resources based on aquatic conditions, habitat and species. The process utilized the USEPA Criteria for Watershed Restoration consistent with the VA DEQ watershed restoration planning process to create protection criteria that could be combined with restoration. The typical, the *A-I Criteria* is used as part of a watershed restoration strategy identifying the following points:

A. Identify and quantify causes and sources of impairments

B. Estimate expected load reductions

C. Identify BMPs and critical areas to achieve load reductions

D. Estimate needed technical and financial resources

E. Provide information, education and public participation component

F. Include schedule for implementing NPS management measures

G. Identify interim measurable milestones for implementation

H. Establish criteria to determine if load reductions are achieved

I. Provide a monitoring component to evaluate effectiveness

This iterative approach resulted in the following A-I Elements that where applied in developing the watershed based plans in the Chowan Basin, referred to as the A-I Criteria for Ecologically Healthy Watershed Conservation:

A. Quantify and verify the empirical basis for aquatic communities identified with high ecological integrity

B. Identify conditions needed to maintain existing ecological integrity

C. Identify best management practices and other preventative actions to achieve and maintain the system with high ecological integrity

D. Estimate needed technical and financial resources

E. Provide information, education and public participation component

F. Include schedule for implementing best management measures

G. Identify interim measurable milestones for implementation

H. Establish criteria to determine high ecological integrity is maintained at baseline assessments

I. Provide a monitoring component to evaluate effectiveness

The following section briefly outlines four identified watersheds in the Chowan Basin the protection strategies for that could be fully developed into protection strategies. They are organized: two from Virginia, one shared resource site, and one North Carolina site. However, the refocus of the effort was on the development of ONE watershed in the Chowan basin with detailed steps toward conservation. This site focused on the Raccoon Creek of the Nottaway River in Sussex County, near the town of Jarrat.

1. Nottaway River, Wildcat Creek Ecological Healthy Watershed Conservation Plan

Location: Wildcat Creek in the Nottaway River Basin was identified through an aquatic health assessment as having *Outstanding* ecological integrity. This watershed is located within and adjacent to the Fort Pickett US Army National Guard Military Reservation (Fort Pickett). Significant VA Division of Natural Heritage data is known about the location. It is also proximal to an existing DCR, Division of Natural Heritage Stream Conservation Unit (SCU), designated based on a rare species occurrence. Additionally, the site supports rare terrestrial and aquatic communities, rare vertebrate and invertebrate animal species and rate vascular plants.

Relevance: In addition to its high ecological integrity, proximity to an Natural Heritage Stream Conservation Unit (SCU) and identified important terrestrial Natural Heritage Resources, the watershed offers a number of strategic advantages including the opportunity to partner with Fort Pickett, the Virginia Department of Forestry, the Ward Burton Wildlife Foundation, the Nature Conservancy, the North Carolina Department of Natural Resources and the Albemarle-Pamlico National Estuary Program. These forest resources within the watershed and surrounding areas are located within wood fiber resource identified by Enviva for sustainable forest product harvesting. Moreover, the watershed is partially located within Fort Pickett. Fort Pickett is committed to integrated natural resources management and staffs have been an invaluable partner is this planning effort. This area is also been targeted by APNEP and NCDENR as a priority for land conservation. Adjacent to Ft Pickett are the counties of Brunswick, Nottoway, and Dinwiddie with opportunities to work with those that have comprehensive plans as part of their county.

2. Nottaway River: Joseph Swamp (Higgens Ck, Parker Br, Parker Ck, Gosee Swamp, Anderson Br) Source Water Protection

Location: The lower Nottaway River, Joseph Swamp area has been identified as containing several sites identified as having *Outstanding* ecological health. The Joseph Swamp drains into the lower Nottoway directly above a source water intake location for Norfolk Water. Additionally, the site is relative to several VDCR Division of Natural Heritage Conservation Sites that contain rare vascular plants, and vertebrate animal species.

Relevance: In addition to the rating of Outstanding based on the INSTAR assessment, the site lies within the overlapping Venn diagram of 75mi concentric fiber baskets. The site is in the upper headwaters of Norfolk Water withdrawal sites. The Norfolk Water reservoirs have maintained buffers but extraction sites do not, therefore there are significant economic incentives to protect the adjacent resources as opposed to an increased treatment prior to distribution to the public. This site resides in the counties of Sussex, Dinwiddie and Prince George Counties where opportunities to integrate the protection of significant Heritage data may be incorporated into local planning and land conservation efforts. Significant relationships were developed with the Nature Conservancy to advance the protection in this area including working through the Conservancy to assist with Norfolk Water.

3. Meherrin River, White Oak Creel Ecological Healthy Watershed Conservation Plan

Location: The lower Meherrin River watershed has been identified as containing several sites identified as having *Outstanding* ecological health. The White Oak Creek and Rattlesnake Creek drains into the lower Meherrin through an area that is heavily used for forest products. The site is in close proximity to several VDCR Division of Natural Heritage Conservation Sites that contain significant natural communities, rare vascular plants, and vertebrate animal species.

Relevance: In addition to the rating of Outstanding based on the INSTAR assessment, the site lies within the overlapping Venn diagram of 75mi concentric fiber baskets. This is relevant due to the location is heavily used for forest product development. The site is adjacent to fall line providing for a unique natural community. The site is also a historic restoration potential for Longleaf pine, adjacent to Triplet East Habitat Conservation area (BRANK B4) as an occurrence was documented in 1942. Since the region is under heavy timbering pressure with a manufacturer, Enviva, working closely with the VDOF and TNC to ensure improved best management practices are employed at point of extraction and Sustainable Forestry Initiative (SFI) practices are employed. Currently, the sale of Enviva product has resulted in the buyer requesting the manufacturer to increase and improve green practices including source extraction practices. This site resides in the counties of Brunswick, Greenville, Lunenburg, Mecklenburg and Southampton where opportunities to integrate the protection of significant Heritage data may be incorporated into local planning and land conservation efforts.

4. Chowan River, Beasley Branch and Bennett's Creek Ecological Healthy Watershed Conservation Plan

Location: The mainstem of the Chowan lies almost completely within the State of North Carolina and has been identified as containing several sites with a rating of *Outstanding* from the recent INSTAR assessment. Included in these and the focus of the North Carolina site is Beasley Branch and Bennett's Creek. The site is relative to both the VA DCR Division of Natural Heritage and several North Carolina DENR Heritage resource sites. For Virginia, this site contains rare vascular plants, terrestrial communities, and vertebrate animal species. For North Carolina, the site contains vascular plant and animal communities, the Chowan Sand Banks and Dedicated Nature Preserve Areas.

Relevance: In addition to the rating of Outstanding based on the INSTAR assessment, the site lies within the overlapping Venn diagram of 75mi concentric fiber baskets. This is relevant due to the location is heavily used for forest product development and is proximal to the protected area referred to as Merchants Mill Pond. The site is adjacent to the fall line providing for a unique natural communities and other unique natural features such as the Chowan Sand Outcrop, areas of high wildlife diversity based on the NCDENR assessments. These data developed by the VDCR and VCU for the Healthy Waters Program supports NCDENR land protection strategies.

Watershed-Based
Ecological Health Conservation Plan
for
Raccoon Creek
Nottoway River
Chowan Basin

Nottaway River: Raccoon Creek Source Water Protection

Overall, the project develops a Ecologically Healthy Watershed Conservation Plan that will be used to identify critical areas for protection and be used as the basis for the healthy watershed protection goals of the Albemarle-Pamlico National Estuary Partnership's Comprehensive Conservation and Management Plan and local planning efforts. It assures these ecologically healthy streams are incorporated into the Department of Conservation and Recreation's Natural Heritage Biotics Database and integrated into land conservation and land planning projects in Virginia. It expands Virginia's Healthy Waters Program by expanding into a basin that has limited data and will include an assessment of stream ecological health using the existing protocol that integrates fish, aquatic life as well as habitat indicators to determine condition. To facilitate the success of this project, the Virginia partnership will include the Virginia Department of Conservation and Recreation, the Virginia Department of Environmental Quality, Virginia Commonwealth University North Carolina Department of Environment and Natural Resources, the Albemarle-Pamlico National Estuary Partnership, US Environmental Protection Agency, The Nature Conservancy, local governments and other interested stakeholders.

The role of Virginia's Department of Conservation and Recreation, Division of Natural Heritage is the identification and protection of aquatic and terrestrial communities and rare plant and animal species that contribute important ecosystem services or represent significant ecological resources. Virginia is a member of the NatureServe Natural Heritage Network and draws upon resources throughout the Western Hemisphere to advance biodiversity conservation and shares Virginia conservation information and successes throughout the Hemisphere. Virginia has a well established record of identifying and achieving protection for rare species and terrestrial communities; the Healthy Waters Program, in strong collaboration with Virginia Commonwealth University (VCU), is finally able to identify the most biologically diverse streams in the state. In Virginia, the challenges associated with these important efforts, specifically as they relate to aquatic communities, include: 1) development and application of objective, quantitative, and diagnostic stream assessment protocols and 2) defining a set of measurable and appropriate stream conditions, based on empirical data, as goals for protection efforts. Both of these challenges are dependent on an understanding of, and comparison to, relevant reference conditions that describe accurately and quantitatively the ecological potential of streams and rivers within a specific region. In Virginia, the scarcity of relatively undisturbed streams to serve as reference systems is problematic in many ecoregions. In early 2000, in response to national US Environmental Protection Agency (US EPA) Region III initiatives, Virginia created the *Healthy Waters Program*, with the goal of identifying and protecting ecologically intact streams, riparian habitats, and stream-dependent living resources. Identification of healthy streams is a prerequisite for any resource protection program; however, current state agency-based stream monitoring and assessment activities focus primarily on water quality impairments and target degraded streams for rehabilitation.

Traditionally, water quality based programs have emphasized the assessment of streams to determine if water bodies meet water quality standards with a subsequent restoration plan to improve degraded surface waters. While this is a critical activity to provide the Commonwealth a healthy ecosystem it is equally as important to seek viable opportunities for best management practices to protect streams that are already considered healthy/biologically diverse. It is economically and ecologically preferable to conserve and protect healthy ecosystems than to restore them after they have been damaged. Agricultural BMPs may serve as a key role in the protection of healthy waters and healthy watersheds. The integrity (health) of aquatic ecosystems (streams) is tightly linked to the watersheds of which they are a part. There is a direct relationship between land cover, key watershed processes and the ecological health of streams.

The lower Nottaway River, Raccoon Creek area has been identified as containing several sites characterized as having *Outstanding* and *Healthy* ecological health. The Raccoon Creek drains into the lower Nottoway directly above a source water intake location for regional water districts and wellhead protection areas. Additionally, the site is relative to several VDCR Division of Natural Heritage Conservation Sites that contains rare vascular plants, and vertebrate animal species and is associated with High or Very High Ecological Health as identified by the VDCR DNH Natural Landscape Assessment. The drainage encompasses 126,984 acres that is dominated by evergreen and hardwood forests. Half of the area identified as hardwood is bottomland hardwood swamp, areas critical to maintaining high aquatic integrity.

Relevance: In addition to the rating of Outstanding based on the INSTAR assessment, the site lies within the overlapping Venn diagram of 75mi concentric fiber baskets. The site is in the upper headwaters of surface and groundwater withdrawal sites. Regional drinking water reservoirs have maintained buffers but extraction sites do not, therefore there are significant economic incentives to protect the adjacent resources as opposed to an increased treatment prior to distribution to the public. This site resides in the county of Sussex where opportunities to integrate the protection of significant Heritage data may be incorporated into local planning and land conservation efforts. Significant relationships were developed with the Nature Conservancy to advance the protection in this area including working through the Conservancy to assist with local drinking water organizations.

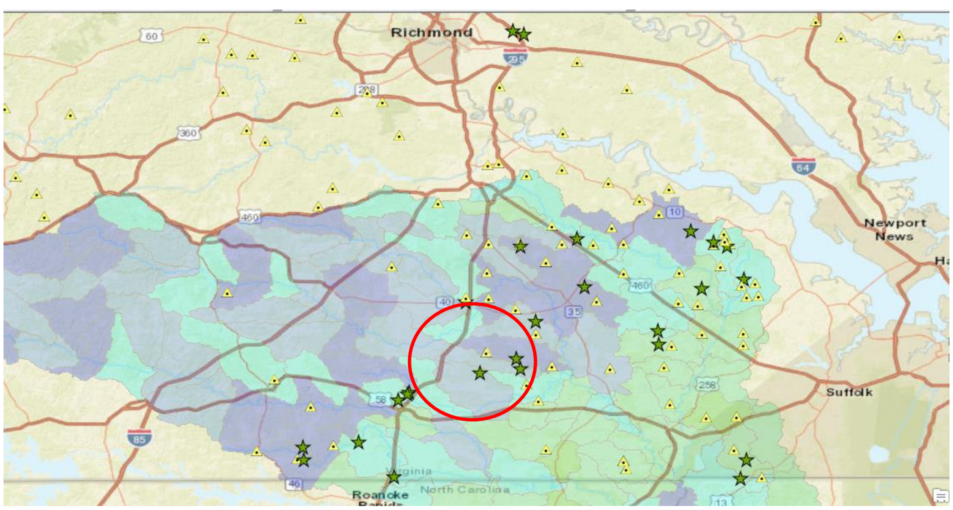


Figure 11. Raccoon Creek, Nottoway River

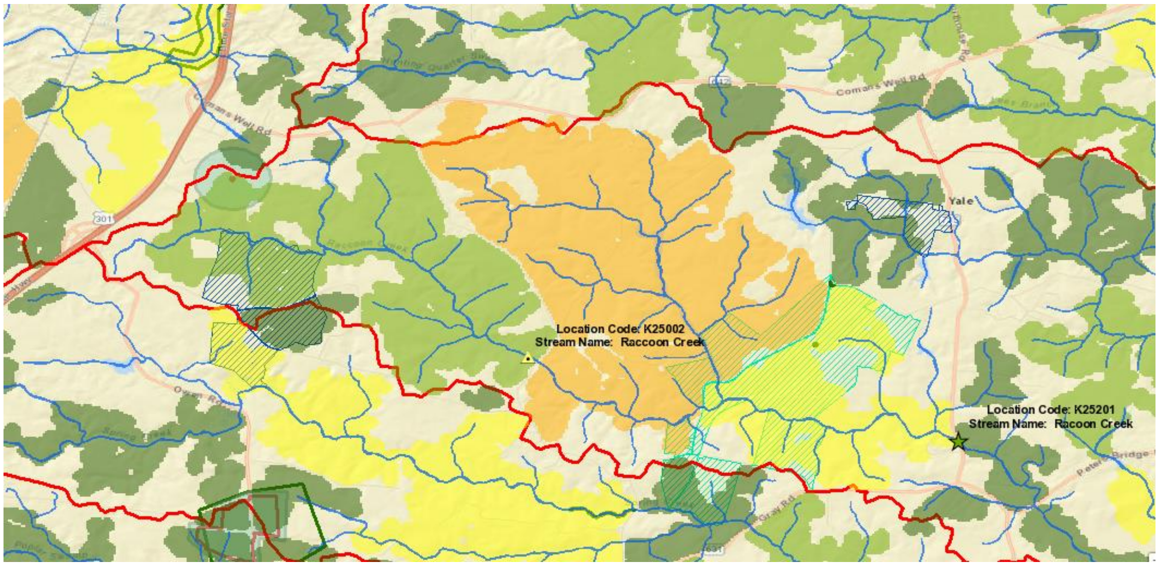


Figure 12. Nottaway River, Raccoon Creek near Sussex, VA, illustrating VDCR DNH natural features and VA Department of Health Drinking Water Intakes

Legend Raccoon Creek

Healthy Waters Category

- Outstanding
- Healthy

VaNLA_Cores_Lite

Ecological Integrity

- C1: Outstanding
- C2: Very High
- C3: High
- C4: Moderate
- C5: General
- Cave Site
- Conservation Site
- SCU

eorep83

GROUPNAME

- Animal Assemblage
- Aquatic Natural Community
- Geologic Feature
- Invertebrate Animal
- Nonvascular Plant
- Terrestrial Natural Community
- Vascular Plant
- Vertebrate Animal
- VOF
- Federal
- Local
- Private
- State

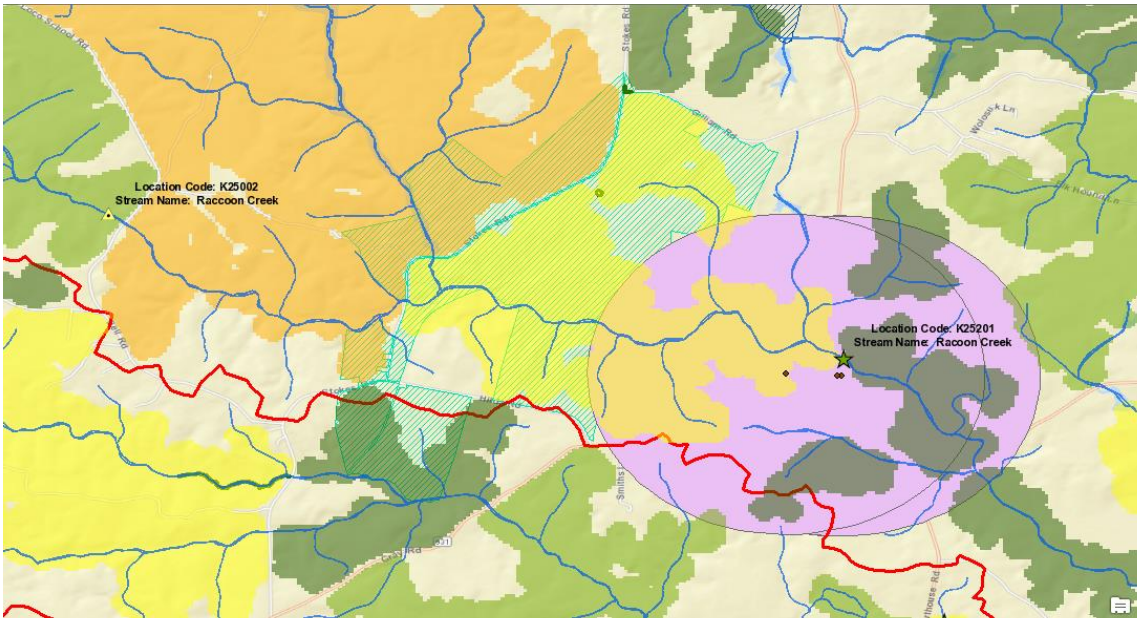
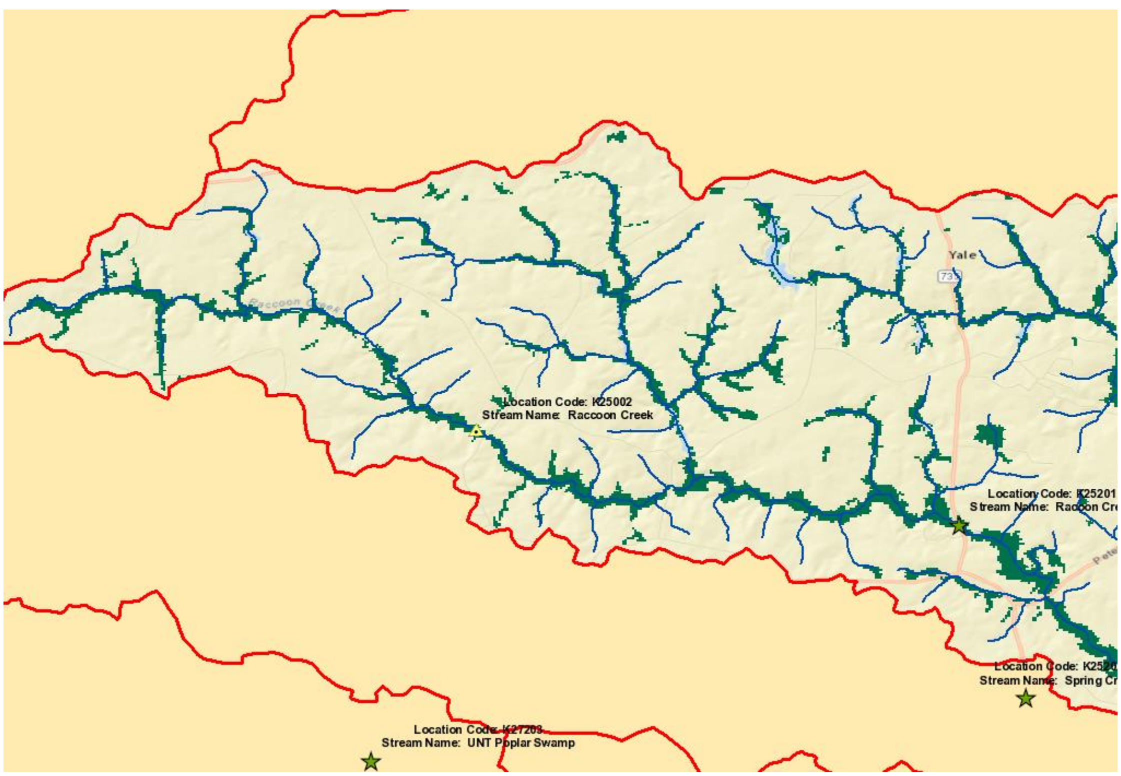


Figure 13. Purple areas designated at Well-head Protection areas



A-I Criteria for Lower Nottoway, Raccoon Creek Conservation

A. Quantify and verify the empirical basis for aquatic communities identified with high ecological integrity. The following outline conditions at time of survey that serves as a baseline to ensure the site remains in the current designation ecological condition.

1. Site 25201 Raccoon Creek is identified as an Ecologically *Exceptional* Healthy Water, the highest characterization of the VA Healthy Waters Program
2. These catchments epitomize historical conditions in low-gradient stream systems of Virginia's lower Coastal Plain physiography, particularly within the James and Chowan river basins. Water quality is dominated by high concentrations of natural organic acids (i.e., 'blackwater systems'), which are diagnostic for relatively undisturbed watersheds characterized by braided and undefined channels, low pH (4-6 units), seasonal hypoxia, unstable sand substrates, and heavily vegetated riparian zones. These natural but unusual physico-chemical stream conditions are increasingly rare in our region, as a consequence of agricultural conditioning, ditching, and other land-use practices that change the natural structure and function of Coastal Plain 'blackwater' streams. Unique aquatic communities that are adapted to the challenges of low dissolved oxygen and high natural acidity are characteristic of the highlighted streams. Fish assemblages in both systems support populations of rare or uncommon 'acid-endemic' species, including Swampfish, Mud Sunfish, Blackbanded Sunfish, and Sawcheek Darter, with limited (and declining) distributions in their native ranges. Most other fishes here are native habitat generalists (e.g. Pirate Perch, Bluespotted Sunfish) that are able to tolerate the unique physio-chemical conditions. Only a single nonindigenous fish species-Bluegill Sunfish-was represented in fish community collections at these sites, and it was not numerically dominant. All collections were characterized by high species richness and diversity values for the region. In summary, in comparison to data for other streams in the INSTAR database, both locations are characteristic of relatively undisturbed streams that exhibit high ecological integrity (i.e., are 'healthy') and should be protected by appropriate tools for land conservation.
3. The Raccoon Creek site has a total of three individual Natural Heritage Element Occurrences with both Global and State Rankings, specific to two vascular plant occurrences). Identified are two G4 S1 Vascular Plants and one G3 T3 S2 Vertebrate Animal. Where **S1** - Critically imperiled in the state because of extreme rarity or because of some factor(s) making it especially vulnerable to extirpation from the state. Typically 5 or fewer populations or occurrences, or very few remaining individuals (<1000). **S2** - Imperiled in the state because of rarity or because of some factor(s) making it very vulnerable to extirpation from the state. Typically 6 to 20 populations or occurrences or few remaining individuals (1,000 to 3,000).

   Natural Heritage Global Ranks are similar, but refer to a species' rarity throughout its total range. Global ranks are denoted with a "G" followed by a character. Note GX means the element is presumed extinct throughout its range. A "Q" in a rank indicates that a taxonomic question concerning that species exists. Ranks for subspecies are denoted with a "**T**". The global and state ranks combined (e.g. G2/S1) give an instant grasp of a species' known rarity.
4. The sites contain two core areas identified by the Virginia Natural Landscape Assessment as **B3**-High and **B2**-Very High Values, at approximately 1408ac and 4322ac, respectively. C-rank is a rating of the significance of the conservation site based on presence and number of natural heritage resources; on a scale of 1-5, 1

being most significant. Sites are also coded to reflect the presence/absence of federally/state listed species

5. The site contains a Nature Conservancy conservation easement of 1406ac that encompasses much of the B3-High Value Core
6. Upper reaches of Nottoway providing source water protection for groundwater serving the Tidewater Christian Service Area, including three identified well-heads and a source water drinking locations
7. Headwaters for regional drinking water intake from surface and ground water
8. A National Land Cover Database landuse and land cover analysis shows the current active categories, acreage and percentages for Raccoon Creek can be seen as:

Raccoon Creek			
Land Use		**Acres**	**Percentage**
Open Water		18.45	0.15
Open Space		373.24	2.94
Developed- Low Intensity		18.23	0.14
Developed- Medium Intensity		1.32	0.01
Barren Land		19.11	0.15
Deciduous Forest		1047.66	8.25
Evergreen Forest		3622.53	28.54
Mixed Forest		387.08	3.05
Shrub/Scrub		2167.37	17.07
Grassland/Herbaceous		1835.65	14.46
Pasture/Hay		574.68	4.53
Cultivated Crops		1178.37	9.28
Forested Wetlands		1365.53	10.76
Emergent Herbaceous Wetlands		84.80	0.67
Total		**12694.03**	**100.00**

B. Identify conditions needed to maintain existing ecological integrity.
   1. A maintained forested riparian habitat (31.3mi), hydrology and instream habitat and protection of High Ecological Value areas and forested wetlands to ensure the baseline ecological health remains in the current Exceptional condition

C. Identify best management practices, preventative and protective actions to achieve and maintain the system with high ecological integrity
   1. Ensure protection of 1365ac of Forested Wetlands per NLCD, 31.4 miles of stream corridor
      i. Direct acquisition of those areas to include the 1365ac (10% of total area)
      ii. Create conservation easements that include language and criteria to protect aquatic integrity ensuring Ecologically Healthy Waters to be held by TNC, VOF, SWCDs or water districts

iii. Apply 100% of SFI Water Quality standards and practices, for forestry operations standards at point of extraction
iv. Prioritization will be given to those areas directly associated with the protection of lands in the 1408ac B3-High Value Core, inclusive of the Nature Conservancy conservation easement and 4322ac B2-Very High Value Core

2. Create conservation easements to protect areas associated with the VA Department of Natural Heritage Element Occurrences for two Vascular Plants and one Vertebrate Animal
3. Coordinate with regional water districts to encourage application of riparian protection measures that would minimize impacts to source-water and headwater areas
4. Maintained forested buffers with minimal impacts
5. Implementation of DCR DNH recommendations to protect critical habitats and resources utilizing Stream Conservation Unit protection language
6. Integration with other regional planning efforts

D. Estimate needed technical and financial resources (includes effort allocation)

1. Technical assistance to be rendered by DCR, DEQ, DOF, TNC, SWCD
   i. The DCR DNH overseeing both conservation actions and the Healthy Waters Program would incur the following expenses:
      1. The average time for developing protective actions for a parcel of land to vary depending on local interests, local value of resources, value of property, etc. Therefore, the following is an estimate of time required for to apply those identified actions to conserve those areas in the Raccoon Creek. For this purpose, it will be assumed 18mo to implement protective actions on each parcel of property at a rate of $125,000/annually (including overhead) for a 20 year period totaling $2.5M, for protection.
      2. The DCR DNH Healthy Waters Program Manager would oversee all aspects of project coordination and development of strategies and implementation at an annual rate of $125,000 (including overhead) at 50% time allocated for 20 yrs totaling $1.25M
   ii. The VDOF would oversee the implementation of forestry-based conservation actions including the delivery of technical assistance for implementing SFI actions. Annually, an average cost may be $90,000 (including overhead) for a 20 year period at $1.8M
   iii. The VDEQ Nonpoint Source Protection field personnel implementing conservation actions and nonpoint source actions over a 20yr period in the watershed might incur $90,000 annually (including overhead), totaling $1.8M
   iv. The Nature Conservancy oversees the development of conservation actions and strategies at a similar estimated rate as the DCR DNH with average time for developing protective actions for a parcel of land to vary depending on local interests, local value of resources, value of property, etc. Therefore, the following is an estimate of time required for to apply

those identified actions to conserve those areas in the Raccoon Creek. For this purpose, it will be assumed 18mo to implement protective actions on each parcel of property at a rate of $125,000/annually (including overhead) for a 20 year period totaling $2.5M, for protection.

2. An assessment and valuation of those lands identified for protection should be conducted to develop a clear funding plan
3. Source water protection should consider an evaluation of the ecosystems services provided by headwater area protection Easements that include language for habitat and aquatic community protection
4. Evaluate funding options
    - i. State
        1. VA Agricultural BMP Practices Cost-Share
        2. VA Agricultural BMP Tax Credit Program
        3. VA Agricultural BMP Loan
        4. VA Water Quality Improvement Fund
    - ii. Federal
        1. Conservation Reserve Program
        2. Conservation Reserve Enhancement Program
        3. Environmental Quality Incentives Program
        4. Army Compatible Use Buffer (ACUB)—corridors for low level flights to protect stream buffers, acquisition of adjacent lands
        5. Forestry Reserve Act funding to meet multiple conservation goals within the watershed and adjacent areas
    - iii. Other
        1. South East Rural Community Assistance Project
        2. National Fish and Wildlife Foundation
        3. Clean Water State Revolving Fund

E. Provide info, education and public participation component

1. The role of the Virginia Department of Conservation and Recreation is to provide tangible and lasting improvements to the quality of Virginia's resource lands and waters; serving as a trusted steward of the outdoor recreational and natural resources placed under its care; promoting the conservation and enjoyment of Virginia's diverse and unique environment; protecting public safety through regulatory programs and conservation law enforcement. The VDCR includes the Division of Natural Heritage on science-based conservation to protect Virginia's native plant and animal life and the ecosystems upon which they depend to assess and prioritize those natural features for the Commonwealth of Virginia. As part of the VDCR DNH, the Healthy Waters Program identifies those areas with high aquatic integrity for the purpose of long-term protection. The HWP will:
    - i. Establish a Project Team to implement those protection measures identified within this plan.
    - ii. Coordinate all aspects of education, coordination and outreach to promote the area and protection of valuable resources

iii. Work in conjunction with partners (DEQ, DOF, TNC, SWCDs, etc, to create and deliver pertinent training on HWP priorities, applicability and goals.
iv. Coordinate with the DEQ, DOF, TNC and SWCDs on their local planning efforts to integrate HWP goals and priorities
v. Coordinate with the DOF to ensure Sustainable Forestry Initiative (SFI) standards are applied at timber extraction sites to minimize impacts to the aquatic integrity and develop presentation materials and training to SFI Board
vi. Coordinate with DOF, VOF, and TNC to develop incentive-based program for landowners in source water protection areas to ensure water quality protection aspects of the SFI standards are applied to protect aquatic integrity
vii. Coordinate with regional water districts to ensure the source water protection goals are achieved by developing outreach and education materials in coordination with Nature Conservancy to deliver information on aquatic health and ecological integrity

2. The role of the Virginia Department of Forestry is to work with local landowners that intend to implement forest management activities. This includes technical assistance to protect natural features and water quality. The DOF will be a critical partner in the protection of valuable habitats associated with maintaining the baseline aquatic integrity. The DOF will
   i. Coordinate with the VDCR HWP to work with timber lot owners to implement additional measures to ensure the water quality protection standards are applied for SFI and to apply the fullest SFI standards possible
   ii. Apply HWP recommendations to have SFI certification applied at point of extraction
3. The role of the VA Department of Environmental Quality is that of the lead agency on water quality regulations, specifically for point and nonpoint source. Applicable to this, are the planning efforts to develop and implement Watershed Implementation Plans for the purpose of restoring water bodies not meeting water quality standards. The VDEQ will:
   i. Coordinate with the HWP to integrate nonpoint source restoration best management practices to eliminate sources of pollutants associated with those waters not meeting water quality standards and implement Watershed Implementation Plans associated with TMDLs in the Chowan basin. Coordinated watershed planning will ensure community support and long-term success
4. The role of the Nature Conservancy in Virginia is to work regionally and locally to identify and protect valuable natural areas and features in the Commonwealth. For this region, the regional manager is specifically focused on the area that includes the Chowan basin. The Nature Conservancy has a long history of successful partnerships to implement long-term protection measures. The TNC will:

    i. Coordinate with the HWP to work with regional water districts to implement protection measures that include buffering riparian areas, protecting bottom-land hardwood areas and forested wetlands to ensure baseline aquatic integrity is maintained

5. The SWCDs work locally with respective landowners to apply conservation measures to restore and protect water quality and aquatic integrity. The SWCDs will
    i. Coordinate with the HWP to implement collaborative education and outreach materials tailored for their region and end users.
    ii. Integrate HWP protection measures into their local strategies to protect water quality and ensure aquatic integrity
6. The role of the VA Department of Health is to maintain safe drinking water, measured by standards set by the EPA. The VDH will:
    i. Coordinate with the HWP to ensure standards and enforceable actions to correct or eliminate impacts from OSDS and threats to drinking water systems

F. Include schedule for implementing best management measures
    1. Year 1 will include the major activities to ensure overall coordination and educational development, these include
        a. Development of Raccoon Creek Strategic Plan following Milestones and overall approach identified in this plan
        b. Coordination of Project Team by DCR DNH
        c. Development of educational programs and initiatives targeting VDEQ, VDOF, SWCDs and TNC
    2. Year 2 will include the implementation of those actions identified under the strategic planning efforts in year 1 and include:
        a. Delivery of education for DOF SFI Board
        b. Delivery of technical assistance by VDEQ, VDOF, SWCDs and TNC to possible landowners with the expected outcome of implemented conservation actions
            i. VDEQ to target nutrient and nps actions
            ii. VDOF to target forestry based actions to address WQ and SFI including forest buffers, improved stream crossings and SFI standards applied at point of extraction
            iii. SWCDs to provide direct technical assistance in the implementation of conservation actions
            iv. TNC to target those actions to directly conserve areas identified under section C.
    3. Years 3-5, conservation actions will be applied for conservation including land protection focused on those areas identified with bottomland hardwood wetlands, or forested wetlands
    4. Years 6-10, conservation actions will be applied for conservation including land protection focused on those areas identified with bottomland hardwood wetlands, or forested wetlands

5. Years 11-15, conservation actions will be applied for conservation including land protection focused on those areas identified with bottomland hardwood wetlands, or forested wetlands
6. Year s 16-20, conservation actions will be applied for conservation including land protection focused on those areas identified with bottomland hardwood wetlands, or forested wetlands

G. ID interim measurable milestones for implementation
   1. Protection of 1365ac of NLCD "woody wetlands"
      i. In year 1, outreach will be initiated to implement programs and objectives identified above
      ii. Year 1 will include the development of language for conservation easements that include specific mention of, "protection of aquatic integrity" as a maintained criteria
      iii. At year 5, 100 acres of the 1365ac will be under conservation easement or other natural area protections that include the specifics for maintaining aquatic integrity
      iv. At year 10, 700 acres of the 1365ac will be under conservation easement or other natural area protections
      v. At year 15, all 1000ac will be under conservation actions that ensure aquatic integrity is maintained at the baseline condition
      vi. At year 20, all 1365ac will be under conservation actions that ensure aquatic integrity is maintained at the baseline condition

H. Establish criteria which define conditions necessary to ensure high ecological integrity is maintained at initial baseline assessments
   1. 1365ac of Forested Wetlands conserved to ensure those lands are left in a natural condition
      i. Direct acquisition of those areas to include the 1365ac (10% of total area) and;
      ii. Conservation easements that include language and criteria to protect aquatic integrity ensuring Ecologically Healthy Waters to be held by TNC, VOF, SWCDs or water districts and;
      iii. 100% of SFI Water Quality standards and practices, for forestry operations standards at point of extraction
   2. Streamside Management Zones are established and maintained to a minimum of 100' with preference toward 150' per side, based on slope increasing and;
   3. VDCR DNH Vascular Plant and Vertebrate Animals are protected and maintained and;
   4. VDCR DNH Healthy Waters Program characterization of Exceptional Ecological Health is maintained and;

I. Provide an assessment component to evaluate effectiveness
   1. Conduct a re-assessment of the Chowan basin to ensure ITI accuracy as a means to validate criteria as identified in B, above at 5, 7 and 10 yr intervals

2. Conduct a re-assessment of the focal area (Raccoon Creek) to quantify aquatic conditions meet baseline conditions ensuring aquatic habitat and integrity maintained 1, 2, 3, 5, 7 and 10 yr intervals
3. Conduct a Land Use, Land Cover Analysis to determine if assessed conditions remain in baseline status 1, 2, 3, 5, 7 and 10 yr intervals

J. Other Considerations
    1. Integration of other plans or planning processes
        i. The Chowan Basin resides in the Albemarle-Pamlico National Estuary Partnership (APNEP) region and is applicable to guidance and implementation projects under the Comprehensive Conservation Management Plan (CCMP) for the region
    2. Coordination, identification of roles and responsibilities of stakeholders and other entities
        i. Federal Government
        ii. State
            1. DC's role is to provide tangible and lasting improvements to the quality of Virginia's resource lands and waters; serving as a trusted steward of the outdoor recreational and natural resources placed under its care; promoting the conservation and enjoyment of Virginia's diverse and unique environment and rich cultural legacy for future generations; protecting public safety through regulatory programs and conservation law enforcement
            2. DEQ's role is to protect and enhance Virginia's environment, and promotes the health and well-being of the citizens of the Commonwealth; and is the lead agency for Water Quality (NPS and PS) regulations
            3. DOF role is Protecting Virginia's Forests from Wildfire; Managing the Forest Resource; Protecting Virginia's Waters; Conservation of Virginia's Forests; Manage the State Lands and Nurseries; Regulated Incentive Programs for Forest Landowners
            4. VDH's role is to promote and protect the health of all Virginians
        iii. Regional and Local Government
            1. Sussex County Government
            2. SWCDs
        iv. Businesses and Community Groups
            1. Timber and Forest Products Industry
            2. Nature Conservancy
            3. APNEP
    3. Explore new partnerships
        i. Local nongovernmental organizations

References Cited

Barbour, M. T., J. Gerritsen, B. D. Snyder, and J. B. Stribling. 1999. Rapid bioassessment protocols for use in streams and wadeable rivers: periphyton, benthic macroinvertebrates and fish. Second edition. U.S. Environmental Protection Agency. Office of Water, Washington, D.C.

Garman, G. S. McIninch, D. Hopler, and W. Shuart. 2010. Stream Health Ecological Assessment for the Rivanna River Basin, Virginia. Final Report to the Rivanna River Basin Commission. Virginia Commonwealth University, Richmond, Virginia. 27 pages.

Hughes, R. M., and T. Oberdorff. 1999. Applications of IBI concepts and metrics to waters outside the United States and Canada. Pages 79-93 in T. P. Simon, editor. Assessing the sustainability and biological integrity of water resources using fish communities. CRC Press, Boca Raton, Florida.

Karr, J.R. 1981. Assessment of Biotic Integrity Using Fish Communities. Fisheries 6:21-27

Tiner, R. W. 2004. Remotely-sensed indicators for monitoring the general condition of natural habitat in watersheds: an application for Delaware’s Nanticoke River watershed. Ecological Indicators 4: 227 – 243.

APPENDIX I

MEETING AGENDAS

Healthy Waters Initiative
Internal Chowan Kick-off
Agenda
January 25, 2012
930--11am
DCR Admin Conference Room

930—Background

945—Roles and responsibilities

1000—Project tasks and timing

1030—Deliverables and expected outputs

1055—Next Steps

Healthy Waters Initiative
Chowan Project Team Kick-off
Agenda
January 30, 2012
1030a—1230p
Halifax County Center

1030—Background

1045—Partnership Opportunities and Basin Activities

1115—Project roles, responsibilities and coordination

1130—Project tasks and timing

1155—Deliverables and expected outputs

1225—Next Steps

Project Timeline:

December 2011 Contact Initial Partners and Key Participants
January 2012 Kickoff meeting with Partners
Dec 2011-Feb 2012 Conduct Coarse Scale remote assessment of Chowan
Jan-Feb 2012 Develop Stakeholder group to provide input to suggest three watersheds in the Chowan Basin (possible, APNEP STAC): VA, NC and one shared
Jan-Feb, 2012 QAPP revision
Mar-Nov 2012 In-field data collection, in those above listed watersheds
Apr-2012 Begin quarterly Project Team meetings
Apr-May 2012 Begin stakeholder engagement and outreach (possible, APNEP CAC) Commence development of local workgroups to begin data evaluation and options consideration
Aug 2012-Mar 2013 Data assessment, model development, entry, and QA assessment
Mar-May 2013 Final data collection and begin data integration and QA assessment
Mar 2013 Continued community and stakeholder outreach/ engagement
Mar-Nov 2013 Development of watershed protection plan for each watershed, including recommendations for modifying the USEPA Implementation Plan for the purpose of protection

Oct 2013	Draft Plans completed
Dec 2013	Development and submission of final deliverables

Healthy Waters Initiative
Chowan Project Mid-Project Update
Agenda
December 11, 2012
1030a—1230p
Halifax County Center
359 Ferrell Lane
Halifax, NC 27839

1030—Welcome, re-introductions, re-cap of project goals and brief updates

1050—Summary of 2012 Field Season
Overview of season
Can these new data refine the preliminary Watershed Integrity Model?
Do these new data and conclusions permit us to focus of our upcoming outreach efforts?

1115—Challenges of the 2012 Season
Dry conditions, how will this affect the next steps?
How do we integrate the large riverine (non-wadeable) data with the wadeable stream data?
Should we add spring data to incorporate presence of herring?
How do we integrate the "naturally impaired streams"?
Staffing changes

1150—Spring Sampling plan and timing of model development

1205—Timing of outreach
Identify Possible Locations
Staffing

1225—Next Steps

1230—Adjourn

Chowan Healthy Waters Project Timeline:

December 2011	Contact Initial Partners and Key Participants
January 2012	Kickoff meeting with Partners
Dec 2011-Feb 2012	Conduct Coarse Scale remote assessment of Chowan
Jan-Feb 2012	Develop Stakeholder group to provide input to suggest three watersheds in the Chowan Basin (possible, APNEP STAC): VA, NC and one shared
Jan-Feb, 2012	QAPP revision
Mar-Nov 2012	In-field data collection, in those above listed watersheds
Apr-2012	Begin quarterly Project Team meetings
Apr-May 2012	Begin stakeholder engagement and outreach (possible, APNEP CAC) Commence development of local workgroups to begin data evaluation and options consideration
Aug 2012-Mar 2013	Data assessment, model development, entry, and QA assessment
Mar-May 2013	Final data collection and begin data integration and QA assessment
Mar 2013	Continued community and stakeholder outreach/ engagement
Mar-Nov 2013	Development of watershed protection plan for each watershed, including recommendations for modifying the USEPA Implementation Plan for the purpose of protection
Oct 2013	Draft Plans completed
Dec 2013	Development and submission of final deliverables

APNEP Scientific and Technical Advisory Committee
Quarterly Meeting Agenda
January 31, 2012

Auditorium, Pitt County Office Complex, 403 Government Circle
Greenville, North Carolina 27834

10:00 a.m. **Call to Order and APNEP Update**...*Spruill*
Tim Spruill, STAC Co-Chair, will call the meeting to order.
- Welcome
- Approval of summer meeting minutes
- APNEP Update

10:15 a.m. **APNEP Update** ....*Carpenter*
Dean Carpenter, APNEP Program Scientist, will update members on APNEP activities since the APNEP State of the Sounds Symposium.

10:30 a.m. **Habitat Quality for River Herring in the Chowan River**......................................*Ensign*
Dr. Scott Ensign, Research Ecologist at the USGS National Research Center in Reston, Virginia, will share results of his investigation of river herring-related water quality studies on the Chowan River.

11:15 a.m. **Facilitating Ecosystem Approaches to Management**.......................................*Kellison*
Todd Kellison, Chief of the Fisheries Ecosystem Branch of the National Marine Fisheries Service at the NOAA Laboratory in Beaufort, will provide examples of research outcomes involving NMFS-Beaufort scientists that have facilitated ecosystem-based approaches by natural resource managers.

12:00 p.m. **Working Lunch: APNEP Ecosystem Assessment Discussion**.......................*Carpenter*
Dean Carpenter will brief STAC members on progress in developing APNEP's Ecosystem Assessment, followed by a discussion on the draft provided to the Committee prior to the meeting.

1:15 p.m. **Chowan Healthy Waters Project Plan**..*Janeski & Garman*
Todd Janeski, Virginia Healthy Waters Initiative and Non-Point Source Manager at the Virginia Department of Conservation & Recreation, and Dr. Greg Garman, Director of the Center for Environmental Studies at Virginia Commonwealth University, will brief STAC members on the draft plan of the Chowan Healthy Waters Project and seek committee feedback.

2:00 p.m. **STAC Support Letters for Revisions to NC Water Quality Standards**
....*Laney & Spruill*
Co-Chairs Laney and Spruill will brief STAC members on the process of creating draft text to support revisions to North Carolina water quality standards for metals and nutrients, respectively, followed by a discussion of the draft text provided to the Committee prior to the meeting.

2:45 p.m. **Action Items**.. *Spruill*
Co-Chair Spruill will confirm Committee action items to be completed by the Spring meeting (April 25).

3:00 p.m. **Adjourn**

Note: The scheduled times for issue topics are estimates and may vary during the meeting.

APPENDIX II

LIST OF TAXA COLLECTED BY VCU BIOLOGISTS FROM THE CHOWAN RIVER BASIN DURING THE STUDY PERIOD (2012-2013)

(List of fish species, including binomial, common name, and VCU taxonomic code. Fishes listed by family in phylogenetic order)

VCU Code	Genus	Family/Species	Common Name
		Petromyzontidae	
PMA	Petromyzon	marinus	Sea Lamprey
LAP	Lampetra	appendix	American Brook Lamprey
		Lepisosteidae	
LOS	Lepisosteus	osseus	Longnose Gar
		Amiidae	
ACA	Amia	calva	Bowfin
		Anguillidae	
ARO	Anguilla	rostrata	American Eel
		Clupeidae	
DCE	Dorosoma	cepedianum	Gizzard Shad
		Esocidae	
ENI	Esox	niger	Chain Pickerel
EAM	Esox	americanus	Redfin Pickerel
		Umbridae	
UPY	Umbra	pygmaea	Eastern Mudminnow
		Cyprinidae	
CCA	Cyprinus	carpio	Common Carp
NCR	Notemigonus	crysoleucas	Golden Shiner
POR	Chrosomus	oreas	Mountain Redbelly Dace
CFU	Clinostomus	funduloides	Rosyside Dace
RAT	Rhinichthys	atratulus	Eastern Blacknose Dace
CAN	Campostoma	anomalum	Central Stoneroller
SAT	Semotilus	atromaculatus	Creek Chub
VCU Code	**Genus**	**Family**/Species	**Common Name**
EMA	Exoglossum	maxillingua	Cutlips Minnow
NRA	Nocomis	raneyi	Bull Chub
NLE	Nocomis	leptocephalus	Bluehead Chub
CYA	Cyprinella	analostana	Satinfin Shiner
LCE	Luxilus	cerasinus	Crescent Shiner
LAL	Luxilus	albeolus	White Shiner
LAR	Lythrurus	ardens	Rosefin Shiner
NAM	Notropis	amoenus	Comely Shiner
NHU	Notropis	hudsonius	Spottail Shiner
NVO	Notropis	volucellus	Mimic Shiner
NPR	Notropis	procne	Swallowtail Shiner
NAB	Notropis	alborus	Whitemouth Shiner
NCH	Notropis	chalybaeus	Ironcolor Shiner
NAL	Notropis	altipinnis	Highfin Shiner
HRE	Hybognathus	regius	Eastern Silvery Minnow
		Catostomidae	
CCY	Carpiodes	cyprinus	Quillback
ESU	Erimyzon	sucetta	Lake Chubsucker
EOB	Erimyzon	oblongus	Creek Chubsucker

HNI	Hypentelium	nigricans	Northern Hogsucker
TRH	Thoburnia	rhothoeca	Torrent Sucker
MCE	Moxostoma	cervinum	Blacktip Jumprock
MMA	Moxostoma	macrolepidotum	Shorthead Redhorse
MER	Moxostoma	erythrurum	Golden Redhorse
MCO	Moxostoma	collapsum	Notchlip Redhorse
MPA	Moxostoma	pappillosum	V-lip Redhorse
CCO	Catostomus	commersonii	White Sucker
VCU Code	**Genus**	**Family**/Species	**Common Name**
		Ictaluridae	
IFU	Ictalurus	furcatus	Blue Catfish
IPU	Ictalurus	punctatus	Channel Catfish
ACT	Ameiurus	catus	White Catfish
APL	Ameiurus	platycephalus	Flat Bullhead
ANA	Ameiurus	natalis	Yellow Bullhead
ANE	Ameiurus	nebulosus	Brown Bullhead
NIN	Noturus	insignis	Margined Madtom
NGY	Noturus	gyrinus	Tadpole Madtom
		Aphredoderidae	
ASY	Aphredoderus	sayanus	Pirate Perch
		Ambylopsidae	
CHC	Chologaster	cormuta	Swampfish
		Fundulidae	
FLI	Fundulus	lineolatus	Lined Topminnow
		Poeciliidae	
GHO	Gambusia	holbrooki	Eastern Mosquitofish
		Centrarchidae	
ARU	Ambloplites	rupestris	Rock Bass
ACV	Ambloplites	cavifrons	Roanoke Bass
APO	Acantharchus	pomotis	Mud Sunfish
CMA	Centrarchus	macropterus	Flier
PNI	Pomoxis	nigromaculatus	Black Crappie
PAN	Pomoxis	annularis	White Crappie
EBB	Enneacanthus	obesus	Banded Sunfish
EGL	Enneacanthus	gloriosus	Bluespotted Sunfish
ECH	Enneacanthus	chaetodon	Blackbanded Sunfish
MDO	Micropterus	dolomieu	Smallmouth Bass
VCU Code	**Genus**	**Family**/Species	**Common Name**
MSA	Micropterus	salmoides	Largemouth Bass
LGU	Lepomis	gulosus	Warmouth
LCY	Lepomis	cyanellus	Green Sunfish
LAU	Lepomis	auritus	Redbreast Sunfish
LMA	Lepomis	macrochirus	Bluegill
LGI	Lepomis	gibbosus	Pumpkinseed
LMI	Lepomis	microlophus	Redear Sunfish
LHY	Lepomis	hybrid	Hybrid Sunfish

		Percidae	
PFL	Perca	flavescens	Yellow Perch
PRE	Percina	rex	Roanoke Logperch
PNE	Percina	nevisense	Chainback Darter
PRO	Percina	roanoka	Roanoke Darter
ENI	Etheostoma	nigrum	Johnny Darter
EOL	Etheostoma	olmstedi	Tessellated Darter
EVI	Etheostoma	vitreum	Glassy Darter
EFL	Etheostoma	flabellare	Fantail Darter
ESE	Etheostoma	serrifer	Sawcheek Darter
EFU	Etheostoma	fusiforme	Swamp Darter

APPENDIX III

CLASSIFICATION AND LOCATION OF CHOWAN BASIN STREAMS EVALUATED FOR THIS PROJECT, INCLUDING NEW (2012-2013) AND FILTERED ARCHIVAL COLLECTIONS. DATA FROM VCU's INSTAR DATABASE.

Location Code	Location Information	Stream Name	DRAINAGE	Category
K23018	Above Rte 627	Joseph Swamp	Chowan	Outstanding
K11001	Along Rte 95	Fountains Creek	Chowan	Outstanding
K34501	Below Rte 621	Pouches Swamp	Chowan	Outstanding
K29200	Higgens, VA	Higgens Creek	Chowan	Outstanding
K35006	Above Rte 626	Round Hill Swamp	Chowan	Outstanding
K35202	Below Rte 601	Seacock Swamp	Chowan	Outstanding
K21001	Co Route 657	Stony Creek	Chowan	Outstanding
K38005	Above Rte 660	Jones Swamp trib	Chowan	Outstanding
K38009	Above Rte 669	Mill Swamp	Chowan	Outstanding
K33005	Above Rte 618	Terrapin Swamp	Chowan	Outstanding
K42032	Above Rt. # 45	Deep Creek	Chowan	Outstanding
K31011	At Rte 613	Warwick Swamp	Chowan	Outstanding
K34202	Off Rte 626	Mill Swamp	Chowan	Outstanding
K11200	At Rte 633	Fountians Creek	Chowan	Outstanding
K25201	At Rte 735	Racoon Creek	Chowan	Outstanding
K32206	Below Rte 618	Pigeonroost Swamp	Chowan	Outstanding
K26201	At Rte 617	Three Creek	Chowan	Outstanding
K26202	At Rte 610	Maclins Creek	Chowan	Outstanding
K26203	At Rte 619	Maclins Creek	Chowan	Outstanding
K25202	Below Rte 735	Spring Creek	Chowan	Outstanding
K34205	Below Rte 631	Mill Swamp	Chowan	Outstanding

K31020	At Rte 613	UNT Blackwater Swamp	Chowan	Healthy
K23007	Below Rte 606	Jones Hole Swamp	Chowan	Healthy
K32204	At Rte 601	Buzzards Branch	Chowan	Healthy
K32001	Below Rte 621	Coppahaunk Swamp	Chowan	Healthy
K34502	Below Rte 623	Pouches Swamp	Chowan	Healthy
K34504	At Rte 681	Rattlesnake Swamp	Chowan	Healthy
K07001	Above Rte 642	Rocky Run	Chowan	Healthy
K33008	Below Rte 616	Hickaneck Swamp	Chowan	Healthy
K33003	Off Rte 622	Tucker Swamp	Chowan	Healthy
K35001	Below Rte 614	Round Hill Swamp	Chowan	Healthy
K23002	Below Rte 670	Arthur Swamp	Chowan	Healthy
K34009	Above Rte 626	Mill Swamp trib	Chowan	Healthy
K34200	At Rte 618	Green Swamp	Chowan	Healthy
K34007	Below Rte 626	Golden Hill Swamp	Chowan	Healthy
K34505	Below Rte 680	Stallings Creek	Chowan	Healthy
K34506	At Rte 682	Rattlesnake Swamp	Chowan	Healthy
K33201	Below Rte 644	Pope Swamp	Chowan	Healthy
K32007	Below Rte 613	Blackwater River trib	Chowan	Healthy
K36200	Below Rte 603	Black Creek	Chowan	Healthy
K36013	Above Rte 706	UNT Blackwater River	Chowan	Healthy
K38008	Above Rte 616	Chapel Swamp trib	Chowan	Healthy
K38001	Off Rte 670	Summerton Creek trib	Chowan	Healthy
K36018	Above Rte 653	Kingsale Swamp	Chowan	Healthy
K33011	Above Rte 646	Burnt Mills Swamp	Chowan	Healthy
K35004	Off Rte 618	Seacock Swamp trib	Chowan	Healthy
K23004	Above Rte 618	Galley Swamp	Chowan	Healthy
K23200	Below Rte 662	UNT Joseph Swamp	Chowan	Healthy
K30200	At Rte 682	UNT Mill Creek	Chowan	Healthy
K13200	Below Rte 665	Tarrara Creek	Chowan	Healthy
K31200	Above Rte 624	Warwick Swamp	Chowan	Healthy
K27204	At Rte 652	Angelico Creek	Chowan	Healthy
K32207	At Rte 615	Coppahaunk Swamp	Chowan	Healthy
K36201	At Rte 615	Kingsale Swamp	Chowan	Healthy
K34203	Below Rte 616	Golden Hill Branch	Chowan	Healthy
K27205	At Rte 735	Hornet Swamp	Chowan	Healthy
K34204	At Rte 616	Green Swamp	Chowan	Healthy
K34206	At Rte 617	Mill Swamp	Chowan	Healthy
K30201	Above Rte 684	Mill Creek	Chowan	Healthy
K30202	At Rte 684	UNT Darden Mill Run	Chowan	Healthy
K32208	At Rte 647	Cypress Swamp	Chowan	Healthy
K21201	Rtes 619 and 734	Hawkins Run	Chowan	Healthy
K31201	Above Rte 710	NF Blackwater River	Chowan	Healthy
K23201	Near Rte 668	Jones Hole Swamp	Chowan	Healthy
K32209	Above Rte 607	Otterdam Swamp	Chowan	Healthy

K20001	Off Rte 642	Butterwood Creek	Chowan	Restoration Potential
K23008	Below Rte 638	Jones Hole Swamp	Chowan	Restoration Potential
K32220	At Rte 602	Otterdam Swamp	Chowan	Restoration Potential
K31010	Below Rte 301	Warwick Swamp	Chowan	Restoration Potential
K14500	At Rte 739	Modest Creek	Chowan	Restoration Potential
K32002	Above Rte 611	Johnchecohunk Swamp	Chowan	Restoration Potential
K32201	Rte 647	Cypress Swamp	Chowan	Restoration Potential
K32205	At Rte 647	Cypress Swamp	Chowan	Restoration Potential
K32202	Rte 602	Otterdam Swamp	Chowan	Restoration Potential
K34503	Below Rte 621	Mill Swamp	Chowan	Restoration Potential
K32006	Above Rte 621	Coppahaunk Swamp	Chowan	Restoration Potential
K35009	Above Rte 621	Seacock Swamp trib	Chowan	Restoration Potential
K33200	Near Rte 646	Blackwater River	Chowan	Restoration Potential
K35200	Below Rte 616	Round Hill Swamp	Chowan	Restoration Potential
K35203	Above Rte 616	Seacock Swamp	Chowan	Restoration Potential
K28001	Off Rte 58	Buckhorn Swamp	Chowan	Restoration Potential
K23006	Below Rte 670	Hatcher Run	Chowan	Restoration Potential
K32203	At Rte 616	Hazel Swamp	Chowan	Restoration Potential
K36008	Above Rte 630	Lees Millpond	Chowan	Restoration Potential
K31005	Above Rte 624	Warwick Swamp	Chowan	Restoration Potential
K25001	Along Rte 645	UNT Spring Creek	Chowan	Restoration Potential
K36017	Above Rte 619	Cattail Swamp	Chowan	Restoration Potential
K36003	Below Rte 641	Kingsdale Swamp trib	Chowan	Restoration Potential
K38007	Below Rte 653	Jones Swamp trib	Chowan	Restoration Potential
K21200	At Rte 609	UNT Mortar Branch	Chowan	Restoration Potential

K02001	Upstream of Rte 628	North Meherrin River	Chowan	Compromised
K10001	Above Rte 601	Little Creek	Chowan	Compromised
K14002	Downstream of Rte 625	Nottoway River	Chowan	Compromised
K34001	Bracketing Rte 626	Passenger Swamp	Chowan	Compromised
K34008	Below Rte 626	Stallings Creek	Chowan	Compromised
K38006	Off Rte 666	Chapel Swamp	Chowan	Compromised
K38002	Above Rte 668	Spivey Swamp	Chowan	Compromised
K31001	Above Rte 629	Blackwater Swamp trib	Chowan	Compromised
K31007	Above Rte 686	Blackwater Swamp	Chowan	Compromised
K31004	Below Rte 649	Seconds Swamp	Chowan	Compromised
K31003	Below Rte 608	Warwick Swamp trib	Chowan	Compromised
K23003	Above Rte 301	Jones Hole Swamp	Chowan	Compromised
K31002	Above Rte 608	Seconds Swamp	Chowan	Compromised
K31008	Above Rte 460	Seconds Swamp trib	Chowan	Compromised
K32005	Below Rte 615	Coppahaunk Swamp	Chowan	Compromised
K32004	Below Rte 630	Cypress Swamp	Chowan	Compromised
K32008	Above Rte 601	Blackwater River trib	Chowan	Compromised
K33001	Below Rte 604	Terrapin Swamp trib	Chowan	Compromised
K34003	Below Rte 646	Rattlesnake Swamp trib	Chowan	Compromised
K35201	Below Rte 626	Round Hill Swamp	Chowan	Compromised
K34010	Above Rte 622	Moores Swamp	Chowan	Compromised
K34004	Above Rte 626	Passenger Swamp trib	Chowan	Compromised
K34006	Below Rte 682	Stallings Creek trib	Chowan	Compromised
K33004	Above Rte 637	Vellines Swamp	Chowan	Compromised
K33006	Off Rte 638	Antioch Swamp	Chowan	Compromised
K36005	Above Rte 612	Corrowaugh Swamp	Chowan	Compromised
K33202	Above Rte 646	Pope Swamp	Chowan	Compromised
K36016	Below Rte 648	Ducks Swamp	Chowan	Compromised
K36015	Above Rte 603	UNT Blackwater River	Chowan	Compromised
K36014	Above Rte 630	UNT Blackwater River	Chowan	Compromised
K33009	Below Rte 635	Pig Swamp	Chowan	Compromised
K36001	Below Rte 630	Blackwater River trib	Chowan	Compromised
K36006	Below Rte 635	Cypress Swamp	Chowan	Compromised
K36007	At Rte 616	Unnamed tributary	Chowan	Compromised
K36009	Above Rte 260	Blackwater River trib	Chowan	Compromised
K38004	Above Rte 661	Chapel Swamp trib	Chowan	Compromised
K38011	Below Rte 647	Quake Swamp	Chowan	Compromised
K38010	Above Rte 666	March Swamp	Chowan	Compromised
K36010	Below Rte 671	Blackwater River trib	Chowan	Compromised
K36012	Below Rte 258	UNT Blackwater River	Chowan	Compromised
K32009	Above Rte 460	Spring Branch	Chowan	Compromised

K36020	Blackwater River	Blackwater River	Chowan	Not Assessed
K36019	At Rte 611	Blackwater River	Chowan	Not Assessed
K03001	Rtes 636 and 637	Meherrin River	Chowan	Not Assessed
K23009	Near Rte 626	Nottoway River	Chowan	Not Assessed
K21002	Off Rte 40	Stony Creek	Chowan	Not Assessed
K22001	At Rte 40	Sappony Creek	Chowan	Not Assessed
K14001	Off Road	Nottoway River	Chowan	Not Assessed
K31008	Below Rte 618	Blackwater Swamp	Chowan	Not Assessed
K02202	Forest Road	Ledbetter Creek trib	Chowan	Not Assessed
K02204	Rte 758	Swedish Creek	Chowan	Not Assessed
K06501	At Rte 603	Great Creek trib	Chowan	Not Assessed
K38012	Above Rte 672	Goodman Swamp	Chowan	Not Assessed
K02200	Rte 700	Spring Creek	Chowan	Not Assessed
K02201	Forest Road	Ledbetter Creek	Chowan	Not Assessed
K02205	Rte 682	Tussekiah Creek	Chowan	Not Assessed
K01500	Rte 662	Kits Creek	Chowan	Not Assessed
K14200	Rte 624	Nottoway River	Chowan	Not Assessed
K02203	Forest Road	Ledbetter Creek trib	Chowan	Not Assessed
K32200	At Rte 601	Buzzards Branch	Chowan	Not Assessed
K34500	At Rte 637	Rattlesnake Swamp trib	Chowan	Not Assessed
K06500	At Rte 617	Great Creek	Chowan	Not Assessed
K29201	Rte 604	Assamoosick Swamp	Chowan	Not Assessed
K29500	At Rte 606	Parkers Branch	Chowan	Not Assessed
K24200	Rte 641	Hunting Quarter	Chowan	Not Assessed
K25200	Rte 635	Raccoon Creek	Chowan	Not Assessed
K35204	Near Rte 628	Lightwood Swamp	Chowan	Not Assessed
K19200	Rte 607	Masons Branch	Chowan	Not Assessed
K26200	Rte 607	Tryall Creek	Chowan	Not Assessed
K27200	Rte 612	Applewhite Swamp	Chowan	Not Assessed
K27201	Rte 612	Chatman Branch	Chowan	Not Assessed
K27202	Rte 612	Browns Branch	Chowan	Not Assessed
K27500	Rte 655	Three Creek	Chowan	Not Assessed
K33203	Below Rte 614	Blackwater River	Chowan	Not Assessed
K19500	At Rte 648	Nottoway River trib	Chowan	Not Assessed
K18200	Rte 631	Beaver Branch	Chowan	Not Assessed
K18500	At Rte 609	Sturgeon Creek	Chowan	Not Assessed
K33204	Below Rte 614	Blackwater River	Chowan	Not Assessed
K36011	Along Road	Blackwater River	Chowan	Not Assessed

APPENDIX IV

VIRGINIA COMMONWEALTH UNIVERSITY
INSTAR BIOLOGICAL MONITORING PROGRAM
QUALITY ASSURANCE PROJECT PLAN (QAPP) FOR
WADEABLE STREAMS AND RIVERS

Chowan River Basin

Prepared By: Stephen P. McIninch, PhD.
Center for Environmental Studies
Virginia Commonwealth University
1000 West Cary Street
P.O. Box 843050
Richmond, VA 23284-3050

Date: July 1, 2012

Group A: Project Management

A1 – Title and Approval Sheet

Virginia Commonwealth University
INSTAR Biological Monitoring Program
Quality Assurance Project Plan for
Wadeable Streams and Rivers

____

Richard Batuik Date:
Quality Assurance Officer
EPA Chesapeake Bay Program Office

____

Kyle Zeiba Date:
EPA Project Officer
EPA Chesapeake Bay Program Office

____

Greg Garman, Ph.D. Date:
Center for Environmental Studies
Virginia Commonwealth University
Phone: (804) 828-7202
Co-Director

Len Smock, Ph.D. Date:
Department of Biology
Virginia Commonwealth University
Phone: (804) 828-1562
Co-Director

Stephen P. McIninch, Ph.D. Date:
Center for Environmental Studies
Virginia Commonwealth University
Phone: (804) 827-0090
Principal Investigator and Quality Assurance Officer

David Hopler, M.S. Date:
Center for Environmental Studies
Virginia Commonwealth University
Phone: (804) 827-0236
Aquatic Monitoring Coordinator

William Shuart, M.S. Date:
Center for Environmental Studies
Virginia Commonwealth University
Phone: (804) 828-7202
Data Manager

A2 – Table of Contents

APPENDICES

A3 – Distribution List

Name	Organization
Louis Reynolds	U. S. Environmental Protection Agency
Frank Borsuk	U. S. Environmental Protection Agency

Richard Batuik	U.S. Environmental Protection Agency
Kyle Zeiba	U. S. Environmental Protection Agency
Susan Block	Virginia Department of Conservation and Recreation
Greg Garman	Virginia Commonwealth University
Len Smock	Virginia Commonwealth University
Stephen McIninch	Virginia Commonwealth University

A4 – Background and Goals

INSTAR (INteractive STream Assessment Resource; http://instar.vcu.edu) is a dynamic and interactive internet application built on ESRI's ArcIMS platform and supported by dedicated servers at Virginia Commonwealth University's Center for Environmental Studies. INSTAR allows users to access and manipulate a comprehensive (and growing) database representing over 2,000 stream and river collections statewide. Accessible data represent fish and macroinvertebrate assemblages, instream habitat, and stream geomorphology. The application supports user-driven database queries, mapping functions, and quantitative biological assessments of stream reaches and watersheds, using algorithms and ecological models that compare user-selected sites to appropriate regional reference conditions. INSTAR is accessible from most computers via the internet and navigation throughout the application is relatively easy.

The INSTAR program began in 2003 as a collaboration between the Center for Environmental Studies at VCU and several agencies, including the Virginia Department of Conservation and Recreation and the Virginia Coastal Zone Management Program. The program goal is to develop and promote statistically sound analytical and decision-support tools for blue infrastructure assessment statewide. Specifically, INSTAR supports detailed geospatial analyses of aquatic living resources, in-stream and riparian habitat, and measures of the ecological integrity of streams and watersheds (i.e., Virtual Stream Assessment, VSA; Modified Index of Biotic Integrity, mIBI). INSTAR, and the extensive aquatic resources database on which it runs, were developed to support a variety of stream assessment, management, and planning activities aimed at restoring and protecting water quality and aquatic living resources throughout the Commonwealth. Currently, over 2,000 stream locations across Virginia are represented within the INSTAR database and most of these sites are accessible through the INSTAR online interface.

The database that VCU will develop is expected to complement and enhance the limited available information on stream ecological health in many parts of the state, including the Coastal Plain Macroinvertebrate Index (CPMT; USEPA 1997, Maxted et al. 2000) for low-gradient streams and rivers of the Coastal Plain physiographic province, and other indices based on the EPA's Rapid Bioassessment Protocols for streams and rivers (Barbour et al. 1999). In addition, the fish community data are expected to be particularly useful for the assessment of larger, nonwadeable streams and rivers, which are not amenable to macroinvertebrate sampling. Because of the complementary nature of the purpose and research design, much of the project management, assessment and oversight follows the protocols of VADEQ Biological Monitoring of Virginia Quality Assurance Project Plan for Wadeable Streams and Rivers (2006). The current project through Virginia Department of Conservation and Recreation will expand significantly the geographic scope of the existing INSTAR database.

The goal of this project is to expand INSTAR (Integrated Stream Assessment Resource) coverage into the Chowan Basin of Virginia and North Carolina. Currently, the INSTAR program includes most of the Chesapeake Bay basin within Virginia. Following the completion of this proposed study, data for a substantial number of Chowan streams will also be accessible through the INSTAR program (http://instar.vcu).

A5 – Project Description

Project Approach

Probabilistic study reaches for INSTAR sampling are selected through a statistically powerful stratified (by stream order) random design. Within each geo-referenced reach (150-200 m), fishes are sampled quantitatively using electrofishing equipment (backpacks, tote barge units, boats) and standard methods. Backpack and tote barge sampling is performed throughout the entire reach in a single pass. Boat electrofishing may include additional sampling effort depending on stream width and habitat variability. All fishes are identified to species in the field, checked for anomalies, and released. Macroinvertebrates are collected using modified EPA Rapid Bioassessment Protocols (RBP III) for single habitat collections using D-frame dipnets. Each major stream habitat type is sampled separately and collections are returned to the VCU lab for identification to the lowest practical taxon and enumeration. Data are compiled into SQL databases and application macros within INSTAR calculate over 50 separate metrics and ecological variables, including those typically generated with the Index of Biotic Integrity (IBI) and Rapid Bioassessment Protocol (RBP). INSTAR assesses the ecological health of streams within watersheds based on percent comparability to the appropriate (e.g. basin, stream order) reference condition (i.e., virtual stream).

Stream Ichthyofauna Sampling

Virginia Commonwealth University, Center for Environmental Studies (CES), uses various quantitative sampling gears and procedures for freshwater fish assemblages depending on the size and geomorphology of the stream, water quality characteristics, and flow conditions. The large majority of wadeable streams (typically 1st through 3rd order) are sampled using a single backpack electrofishing unit (Smith-Root LR-20). Larger streams may warrant the concurrent use of two backpack units and crews in order to effectively sample a wider or more complex channel. Larger streams and rivers (4th or 5th order) that are wadeable but have sufficient width and depth to decrease substantially the efficiency of backpack units are sampled with a tote boat unit (Smith-Root SR-6). Non-wadeable streams and rivers (5th order or greater) are sampled using electrofishing boats (Smith-Root SR-16H) units. Selection of appropriate gears and protocols is based on the best professional judgment of an experienced regional fish biologist.

Sampling will be conducted during the period 2012-2013 and at water temperatures above 5°C and water conductivities above 30 μmhos. Fishes at each location will be sampled quantitatively using well-maintained electrofishing equipment (pulsed direct current; Smith-Root backpack units, tote barge units, and boats) and standard methods (Garman and Smock 2004, McCormick and Hughes 1998). Electrofisher settings (e.g. output voltage, waveform, etc.) for each sampling event will optimize sampling efficiency and minimize fish mortality, based on ambient conditions and operator experience. Sites that can be sampled effectively by wading will be sampled by backpack electrofisher; comparatively high-order streams and rivers will be sampled by electrofishing boat. Transitional sites (e.g. deep pools and wide, but wadeable, channel) will be sampled by tote barge. Sampling will be performed throughout the entire stream channel in a single pass and in a manner that incorporates all major aquatic habitat types. Blocking nets will be deployed where deemed both necessary and feasible. Boat electrofishing may include multiple sampling passes (e.g. channel versus margin), depending on stream conditions, channel width, and habitat variability. Electrofishing settings and total effort (seconds of generator output) will be recorded for each sampling event, along with any other relevant information. Proper precautions (e.g. use of insulated gloves, etc.) will be taken to ensure the safety of field personnel at all times.

For all gear types, a minimum crew of three experienced field biologists will be employed for gear operation and netting. In very small streams, the crew may be reduced to two individuals. During electrofishing, dippers will collect stunned fish and place into a livewell (boat) or bucket (backpacking) for later processing. Sampling may be interrupted temporarily to process special (e.g. listed) specimens or if high water temperatures are likely to cause substantial mortality. Sample processing in the field will involve enumeration and identification to species for all specimens, as well as documentation of specific external anomalies (e.g. lesions, parasites). Fish species will be identified by standardized taxonomic codes created by VCU and based on recent and accepted nomenclature (American Fisheries Society 2005). Species-level IDs will be made on-site by trained, regional ichthyologists (McIninch, Hopler, and Garman). Small voucher collections (or images, for species of conservation concern) of those species not already represented in the VCU Fish Collection (1000 W. Cary Street, Richmond, Virginia) will be prepared using standard, IACUC-approved procedures. Field reference keys for Virginia fishes (e.g. McIninch and Garman, unpublished) will be used for problematic field IDs. Only non-juvenile fish will be included in field collections. Occurrences of other aquatic and semi-aquatic vertebrates (e.g. salamanders) will be noted for each collection. All relevant data will be recorded on a VCU fish collection form, which will also include all relevant location information for the collection reach. Following processing, all fish will be released alive to the sampling reach. All field procedures will be comparable to those developed for EPA surface water monitoring programs (e.g. EMAP; Lazorchak, et al. 1998) and specifically for assessment of fish assemblage composition, relative abundance, and external indicators of individual fish health. VCU will hold all necessary research permits (e.g. VDGIF, USFWS) to conduct the work.

Site Selection

Probabilistic sampling locations (stream reaches) will be determined by VCU using GIS methods described elsewhere in this report. The length of the sampling reach for each event will be based on both time and distance criteria. Specifically, in small (i.e., channel width <= 4 m), wadeable streams (backpack or tote barge unit), sampling will represent 500 seconds of shock time or 150 m of stream channel. Collections in larger rivers and streams (i.e., > 4 m channel width) based on boat electrofishing or tote barge will represent 1,600 seconds of shock time or a reach length corresponding to 40 times the mean channel width (cumulative, if multiple passes). Sampling will always proceed upstream from the downstream end of the reach.

Selection of probabilistic study sites is based on a stratified (by stream order), probabilistic design to be representative of stream conditions within the watershed. The number of sites sampled is based on the results of a statistical power analysis, the amount of available resources, and the quantity and quality of archival data for the basin. ESRI software is used to generate points (study site locations) in 12 digit watersheds, using a probabilistic site selection program. Points represent the center points of study reaches. Each probabilistic location will be sampled once during the study period.

Stream Habitat Assessment

An evaluation of habitat quality is critical to any assessment of ecological integrity and will be performed at each site at the time of the biological sampling. In general, instream habitat and biological diversity in streams and rivers are closely linked. This project will employ EPA's standard Rapid Habitat Assessment protocols for low-gradient streams. Qualitative habitat assessment is conducted at each bioassessment site by trained and experienced individuals. Both in-stream and riparian habitat are important determinants of the composition, structure, and function of biotic communities. Habitat quality also often is an indicator of water quality stressors in streams. In addition, poor habitat quality can obscure the effects of specific pollutants. A systematic assessment of in-stream and riparian habitat quality thus is necessary to fully assess water quality conditions in streams and rivers. Habitat assessment is considered an important tool for the final evaluation of impairment. Habitat parameters that are evaluated are related to the overall aquatic life use and are a potential source of limitation to the aquatic biota. Both the quality and quantity of available habitat can affect the resident biological community structure and composition. The final conclusion of a bioassessment should take into consideration the habitat quality of a water body and whether the health of aquatic biological communities is limited by habitat conditions. Procedures for habitat assessments follow that of the EPA Rapid Bioassessment Protocols (Barbour et al. 1999). No water quality parameters will be measured.

Data Analysis

Compiled empirical data (i.e., variables and metrics) will be analyzed with multivariate techniques (e.g. correspondence analysis (CA), detrended correspondence analysis (DCA), canonical correspondence analysis (CCA), principal components analysis (PCA), and multiple regression). The site scores (i.e., coefficients from the final response model) are entered as the response variable and significant ($P<0.05$) biotic and abiotic variables and metrics are entered as explanatory variables. Finally, a series of reference stream models (i.e., virtual reference streams) are created for each ecoregion and stream order. We will use Gower's similarity index to compare empirical scores obtained from sampled stream sites and reaches to the appropriate regional reference stream, generating an index of stream health (i.e., Virtual Stream Assessment, VSA, score; range 0-100%) as a measure of percent comparability to the appropriate (virtual) reference condition model. Current reference stream models for coastal streams include variables representing fish assemblage structure, instream habitat, and geomorphology, and have substantial explanatory power (R2 up to 0.74). This integrative approach eliminates many of the limitations typically associated with traditional bioassessment methods (e.g. RBP, IBI), including lack of appropriate reference sites and stream classifications that are based on a single ecological component (e.g. biotic versus abiotic, fishes versus macroinvertebrates) that may not be diagnostic under many conditions.

A6 – Data Quality

High quality data is imperative to a biological monitoring programs ability to accurately assess the condition of Virginia's streams and rivers. The specific data quality objectives as discussed below include accuracy and precision, representativeness, and comparability.

Accuracy and Precision

Data quality objectives for this program emphasize accuracy and precision of fish identification at the species level of taxonomy, and macroinvertebrate identification at the genus level (typically) will be maintained by following appropriate SOP and QA/QC procedures. All personnel involved in the field identification of collected fishes will have successfully completed a graduate level course in Ichthyology and/or Fish Biology with a strong taxonomic identification component and will also complete a training period with an experienced fish biologist. Specimens requiring laboratory identification or that represent significant range extensions will be identified by a regional expert in fish identification. All personnel involved in laboratory identification of macroinvertebrates will have successfully completed a graduate level course in stream ecology with a strong taxonomic identification component and will also complete a training period with an experienced aquatic biologist.

Representativeness

Experimental design, sampling techniques, sample preservation and sample handling are interactive factors that directly affect achievement of representativeness of biological sampling. Standard Operating Procedures are utilized by VCU-CES personnel that address sample site selection, sampling techniques, collection, preservation, handling, and processing to maintain standards of representativeness in the surveys.

Comparability

Comparability of biomonitoring data is a summation of quality products at each phase of the data gathering process. It includes representative sampling, sample handling procedures and procedures for reporting of biological data. Following SOPs based on published methodology and uniform sampling procedures ensure that biologists make accurate assessments of biotic integrity statewide. Biologists from VCU (Garman, McIninch, Hopler, and others), Virginia DEQ (Jason Hill), and U.S. EPA (Lou Reynolds) have held joint field operations on at least two occasions since 2006 to coordinate sampling protocols and thereby ensure comparability of INSTAR data with these agencies.

A7 – Documentation and Records

The QAPP for this project was written and reviewed by VCU faculty and staff and will be reviewed by appropriate agency personnel. The current and approved version of this QAPP will be available from the VCU biological monitoring program coordinator.

All field data (locations, habitat assessments, field observations, and assemblage information) are entered on standardized paper forms that are completed and reviewed at the time of sampling or sample processing (see Appendix B). Data from the original field sheets are entered into INSTAR SQL databases, which are supported by VCU Academic Computing and are automatically backed-up daily. Data entry activities will be conducted under the supervision of the Center's geospatial data manager (W. Shuart). Quality Control procedures will be based on a double-entry protocol and will be consistent with EPA QA and Chain-of-Custody standards.

Originals of all field data sheets, taxonomic records, quality control records, instrument calibration records, and miscellaneous correspondence and notes related to the specific sampling stations will be maintained by the Principal Investigator in the appropriate dedicated storage locations (VCU Trani Center, 1000 W. Cary Street, Richmond, Virginia). Original data sheets and logs will be retained by VCU for a period of at least five years after the project end date. Raw data (i.e., species occurrences, relative abundance, location, etc.) will be available through the INSTAR website at the completion of the project.

Group B: Measurement/ Data Acquisition

B1 – Sampling/Experimental Design

The probabilistic monitoring network is a set of randomly chosen stations used to make statistically based assessments of Virginia's streams. This approach differs from targeted monitoring, which may incorporate biases based on ease of access or specific program needs. Data from randomly selected stations represents an unbiased distribution of statewide conditions and allows a measure of accuracy of these data. Selection of probabilistic study sites is based on a stratified (by stream order), probabilistic design to be representative of stream conditions within the watershed. The number of sites sampled is based on the results of a statistical power analysis, the amount of available resources, and the quantity and quality of archival data for the basin. ArcGIS software is used to generate points (study site locations) in 12 digit watersheds, using a probabilistic site selection program.

B2 - Sampling Methods

The sampling methods for the biological monitoring program are presented in the SOPs, above.

B3 – Sample Handling and Custody Requirements

Each biologist will be responsible for the appropriate preservation, labeling, transport and storage of samples. No special custody requirements of samples are required in the current program.

B4 – Quality Control

Comparability- VCU field personnel will re-sample 10% of fish community sample sites from the previous year to assess interannual variability in the data as an element of Quality Control. In addition, VCU personnel will re-sample 10% of fish community sample sites within each sampling season to assess intra-annual variability. Because the majority of fishes captured are released unharmed back into their habitat, it is expected that re-sampling within the same season will result in comparable results. Significant deviation (less than 70% agreement in assemblage composition) will be assessed as a potential quality control (methodology) issue.

Accuracy and Precision- Identification to species of captured fishes on-site is accomplished by at least two competent biologists. VCU-CES monitoring personnel expect 100% agreement in those fishes identified on site. If there is any disagreement among site biologists, the specimen is preserved and positively identified in the laboratory using appropriate taxonomic keys. Macroinvertebrate identifications will be assessed annually from a randomly selected subset of collections and will be considered successful based on 95% or greater agreement between two aquatic ecologists. The QC officer will be responsible for conducting annual field audits to ensure appropriate SOPs are being followed in the field and lab.

B5 – Inspection/ Acceptance Requirements for Supplies and Consumables

Inspections should be made before each sampling event on dip net to ensure that there are no tears in the mesh. Sample containers should also be inspected for damage before use. Battery life and wear are monitored via an inboard computer on newer backpack electrofishing units. Quality Control measures of the electrofishing units assures a unit working to specifications with regard to battery life, voltage and amperage output.

B6 –Non-direct Measurements

GIS data may be used in the determination of appropriate reference stations and to facilitate interpretation of sampling results based on watershed characteristics.

B7 – Data Management

See A9 above.

Group C: Assessment/ Oversight

C1 – Assessment and Response Actions

Biotic assemblage composition, abundance, and health information will be used to assess the biotic integrity and health of sampled streams and rivers.

C2 – Reports to Management

VCU Biomonitoring program staff will discuss QA/QC issues at regularly scheduled meetings or as the need arises. Yearly reports will be developed by the program QC officer and distributed to the Director for the Center for Environmental Studies. A summary of QA/QC activities , including any conditions or situations affecting data completeness or quality, corrective actions, and outcomes of corrective actions will be prepared as part of the final report to the agency.

Group D: Data Validation and Usability

D1 – Data Review, Validation, and Verification Requirements

All field and laboratory data will be reviewed, verified, and validated to ensure they conform to program specifications. It will be the responsibility of the Principal Investigator(s) whether to accept or reject data.

D2 – Validation and Verification Methods

Data review, verification, and validation will be performed using self-assessment and peer and management review. Data will initially be validated by the Principal Investigator(s) when returning from the field and further validated following entry into the appropriate electronic database. Any errors detected will be rectified by editing incorrect database entries, re-sampling, or excluding questionable data.

D3 – Reconciliation with Data Quality Objectives

All data collected by the biological monitoring program will be reviewed on an ongoing basis for accuracy, precision, and completeness. If data quality does not meet the appropriate specifications, data will be discarded and re-sampling will occur, as necessary.

References

Barbour, M.T., J. Gerritsen, and B.D. Snyder and J.B. Stribling. 1999. Rapid bioassessment protocols for use in streams and rivers; periphyton, benthic macroinvertebrates, and fish 2nd edition. U.S. Environmental Protection Agency, Office of Water, Washington, D.C. EPA841-b-99-002

Maxted, J.R., M.T. Barbour, J. Gerritsen, V. Poretti, N. Primrose, A. Silvia, D. Penrose, and R. Renfrow. 2000. Assessment framework for mid-Atlantic coastal plain streams using benthic macroinvertebrates. J. N. Am. Benthol. Soc., 19(1):128-144

U.S. Environmental Protection Agency. 1997. Field and laboratory methods for macroinvertebrate and habitat assessment of low gradient nontidal streams. Mid-Atlantic Coastal Streams Workgroup, Environmental Services Division, Region 3, Wheeling, WV: 23 pages with appendices.

Virginia Department of Environmental Quality. 2006. Biological monitoring program. Quality assurance project plan for wadeable streams and rivers. Unpubl. Manuscript.

APPENDIX V

Definitions of Abbreviations Used on Natural Heritage Resource Lists of the Virginia Department of Conservation and Recreation

Natural Heritage State Ranks

The following ranks are used by the Virginia Department of Conservation and Recreation to set protection priorities for natural heritage resources. Natural Heritage Resources, or "NHR's," are rare plant and animal species, rare and exemplary natural communities, and significant geologic features. The criterion for ranking NHR's is the number of populations or occurrences, i.e. the number of known distinct localities; the number of individuals in existence at each locality or, if a highly mobile organism (e.g., sea turtles, many birds, and butterflies), the total number of individuals; the quality of the occurrences, the number of protected occurrences; and threats.

S1 - Critically imperiled in the state because of extreme rarity or because of some factor(s) making it especially vulnerable to extirpation from the state. Typically 5 or fewer populations or occurrences, or very few remaining individuals (<1000).

S2 - Imperiled in the state because of rarity or because of some factor(s) making it very vulnerable to extirpation from the state. Typically 6 to 20 populations or occurrences or few remaining individuals (1,000 to 3,000).

S3 - Vulnerable in the state either because rare and uncommon, or found only in a restricted range (even if abundant at some locations), or because of other factors making it vulnerable to extirpation. Typically having 21 to 100 populations or occurrences (1,000 to 3,000 individuals).

S4 - Apparently secure; Uncommon but not rare, and usually widespread in the state. Possible cause of long-term concern. Usually having >100 populations or occurrences and more than 10,000 individuals.

S5 - Secure; Common, widespread and abundant in the state. Essentially ineradicable under present conditions, typically having considerably more than 100 populations or occurrences and more than 10,000 individuals.

S#B - Breeding status of an animal within the state

S#N - Non-breeding status of animal within the state. Usually applied to winter resident species.
S#? - Inexact or uncertain numeric rank.

SH - Possibly extirpated (Historical). Historically known from the state, but not verified for an extended period, usually > 15 years; this rank is used primarily when inventory has been attempted recently.

S#S# - Range rank; A numeric range rank, (e.g. S2S3) is used to indicate the range of uncertainty about the exact status of the element. Ranges cannot skip more than one rank.

SU - Unrankable; Currently unrankable due to lack of information or due to substantially conflicting information about status or trends.

SNR -
- Unranked; state rank not yet assessed.

SX - Presumed extirpated from the state. Not located despite intensive searches of historical sites and other appropriate habitat, and virtually no likelihood that it will be rediscovered.

SNA - A conservation status rank is not applicable because the element is not a suitable target for conservation activities.

Natural Heritage Global Ranks are similar, but refer to a species' rarity throughout its total range. Global ranks are denoted with a "G" followed by a character. Note GX means the element is presumed extinct throughout its range. A "Q" in a rank indicates that a taxonomic question concerning that species exists. Ranks for subspecies are denoted with a "T". The global and state ranks combined (e.g. G2/S1) give an instant grasp of a species' known rarity. **These ranks should not be interpreted as legal designations.**

FEDERAL LEGAL STATUS

The Division of Natural Heritage uses the standard abbreviations for Federal endangerment developed by the U.S. Fish and Wildlife Service, Division of Endangered Species and Habitat Conservation.

LE - Listed Endangered
LT - Listed Threatened
PE - Proposed Endangered
PT - Proposed Threatened
C - Candidate (formerly C1 - Candidate category 1)
E(S/A) - treat as endangered because of similarity of appearance
T(S/A) - treat as threatened because of similarity of appearance
SOC - Species of Concern species that merit special concern (**not a regulatory category**)
NL – no federal legal status

STATE LEGAL STATUS

The Division of Natural Heritage uses similar abbreviations for State endangerment.

LE - Listed Endangered
PE - Proposed Endangered
SC - Special Concern - animals that merit special concern according to VDGIF (not a regulatory category)
LT - Listed Threatened
PT - Proposed Threatened
C - Candidate
NL - no state legal status

For information on the laws pertaining to threatened or endangered species, please contact:

U.S. Fish and Wildlife Service for all **FEDERALLY** listed species;
Department of Agriculture and Consumer Services, Plant Protection Bureau for **STATE** listed plants and insects
Department of Game and Inland Fisheries for all other **STATE** listed animals

Conservation Sites Ranking

Brank is a rating of the significance of the conservation site based on presence and number of natural heritage resources; on a scale of 1-5, 1 being most significant. Sites are also coded to reflect the presence/absence of federally/state listed species:

Conservation Site Ranks	**Legal Status of Site**
B1 – Outstanding significance	**FL** – Federally listed species present
B2 – Very High significance	**SL** – State listed species present
B3 – High significance	**NL** – No listed species present
B4 – Moderate significance	
B5 - Of general Biodiversity significance	

APPENDIX VI

North Carolina Department of Environment and Natural Resources Natural Heritage Element Occurrences (October 2014)

Download Link: **ftp://ftp.nconemap.com/outgoing/vector/nheo.zip**

Abstract: The North Carolina Natural Heritage Program's Natural Heritage Element Occurrences (or NHEO) identify occurrences of rare plants and animals, exemplary or unique natural communities, and important animal assemblages (e.g., heronries and colonial waterbird nesting sites). Collectively, these plants, animals, natural communities, and animal assemblages are referred to as "elements of natural diversity" or simply as "elements". Specific occurrences of these elements are referred to as "element occurrences" or simply "EOs". Records for the Blue Ridge Parkway are not included in the shapefile. You must contact the Blue Ridge Parkway if you need information for this area.

Purpose: This data was created to assist governmental agencies and others in making resource management decisions through use of a Geographic Information System (GIS).

Supplemental Information: An extensive tabular database is maintained by the Natural Heritage Program. Other data that can be accessed include element occurrence identification number. Supplemental materials are also available that indicate the state, national, and global status of the rare plants and animals of North Carolina. These publications are available from the NHP and are helpful in understanding each natural heritage record. (SEE CROSS REFERENCES) NATURAL HERITAGE PROGRAM DATA The North Carolina Natural Heritage Program is the state's most comprehensive source of information on rare and endangered animals and plants, and exemplary natural communities, known collectively as "elements of natural diversity." Since 1976, the program has systematically gathered information on the occurrence and the status of the state's ecological resources. The inventory consists of information compiled from a broad range of sources including herbarium and museum collections, published and unpublished literature, and field surveys by volunteers, contracted workers, and staff. Information from and interpretation of this database for specific sites is available from the North Carolina Natural Heritage Program. This is generally the preferred method of getting information on elements of natural diversity. The geographic content of the Natural Heritage Program element occurrence database has also been incorporated into the NC OneMap database where it can be combined with other geographic data for planning and analysis. Users of the data must, however, be aware of the nature and limitations of the data. LIMITATIONS OF DATA The element occurrence database contains data from a variety of sources, which vary in the quality of their locational information. Some centroid points may be as much as several miles off, though most are closer and many are exact to within one or two seconds of latitude or longitude. The precision of record is indicated in the Natural Heritage Program databases. Because of uncertainty about the precision and accuracy of source data, and because the aerial extent of occurrences is not indicated on CGIA maps, occurrences anywhere within several miles of a site of interest should be regarded as indicating the need for more information. Probability of effects by a project depends on the actual location and extent of the element occurrence, on the nature of the species or community, and on the nature of the action being considered. Interpretation of potential effects should be done only by biologists familiar with the element, with the best locational information available. LIMITATIONS OF ABSENCE OF DATA Although the North Carolina Natural Heritage Program has conducted numerous biological inventories and has assembled as

much of the secondary source data as possible, the majority of the state has never been systematically surveyed for rare species or natural communities. In addition, negative surveys are seldom reported to the Natural Heritage Program and are not recorded. The database reflects only locations where an element was once known to occur. It does not distinguish between areas known to have no elements and those that have not been checked. The absence of element location cannot be taken as an indication of absence of elements or of ecological concerns. Natural Heritage Program biologists are often able to give indications of the potential for concern in unsurveyed areas. DATA CURRENCY The Natural Heritage Program databases are continually updated as new information is acquired. The locational database at CGIA is updated as needed for applications. Users should determine the date of the last update and, if necessary, see that an update is done prior to their application being run. All printed maps from the GIS should be dated. Depending on activity in a given area, a map may quickly become outdated, or may remain current for several years. It is not possible to set a specific expiration date on maps; however, data more than six months old should not be depended on without checking with the Natural Heritage Program. Only a small portion of the rare species and community locations are monitored on a regular basis. Information in the Natural Heritage Program database represents the occurrence at the last time it was observed. The date of last observation is given in the Natural Heritage Program database but is not included in the NC OneMap datalayer. Records are kept in the database until the destruction of an occurrence is confirmed. Thus, some of the records are likely to represent locations where an element has not been seen in many years and may no longer be present. ADDITIONAL INFORMATION Additional information about databases, elements of natural diversity, and user services is available from the Natural Heritage Program. The basic data are "public records" and are available for inspection on request for reasonable purposes. Beginning with the May 16, 2008 version quite a few low precision, county-level element occurrences were replaced with more precise locations. There was a large drop in acreage from the previous version, but loss of acreage in the NHEO layer should not be interpreted as loss of habitat. The relatively few low precision records in the coverage will dominate the acreage total, and any changes in these will obscure any acreage trends. The trend of replacing low precision records with higher precision will continue in future versions. That doesn't guarantee that the number of low precision records will continually go down, though, since NHP may start tracking a new species which has only poor data initially.
Publication Date: 20141001
Originator: North Carolina Natural Heritage Program, Department of Environment and Natural Resources
Publisher: North Carolina Natural Heritage Program, Department of Environment and Natural Resources
Online Linkage: **http://www.ncnhp.org**
Time Period of Content:
Time Period Information:
Range of Dates/Times:
Beginning Date: 1990
Ending Date: 20141001
Currentness Reference: Original release and last revision dates
Status:
Progress: Complete
Maintenance and Update Frequency: As needed

Spatial Domain:
Bounding Coordinates:
West Bounding Coordinate: -84.205
East Bounding Coordinate: -75.417
North Bounding Coordinate: 36.559
South Bounding Coordinate: 33.728
Contact Electronic Mail Address: john.finnegan@ncdenr.gov
Contact Voice Telephone: 919-707-8630
Grid Coordinate System Name: State Plane Coordinate System 1983
Horizontal Datum Name: North American Datum of 1983
Planar Distance Units: meters
Ellipsoid Name: Geodetic Reference System 1980
Attribute:
Attribute Label: EO_ID
Attribute Definition: Element Occurrence Identifier (A number uniquely identifies the element occurrence.)
Attribute Definition Source: Natural Heritage Program
Attribute Domain Values:
Unrepresentable Domain: Identifier varies.
Attribute Measurement Frequency: As needed
Attribute:
Attribute Label: ACCURACY
Attribute Definition: Estimated Representational Accuracy (The estimated representational accuracy is the approximate percentage of the element occurence - as represented by its digitized features buffered by their uncertainty distance - that is believed to be occupied by the element.)
Attribute Definition Source: Natural Heritage Program
Attribute Domain Values:
Enumerated Domain:
Enumerated Domain Value: 1 - Very High
Enumerated Domain Value Definition: Greater than 95% of the polygon is occupied by the element.
Enumerated Domain Value Definition Source: Natural Heritage Program
Attribute Domain Values:
Enumerated Domain:
Enumerated Domain Value: 2 - High
Enumerated Domain Value Definition: Between 80% and 95% of the polygon is occupied by the element.
Enumerated Domain Value Definition Source: Natural Heritage Program
Attribute Domain Values:
Enumerated Domain:
Enumerated Domain Value: 3 - Medium
Enumerated Domain Value Definition: Between 20% and 80% of the polygon is occupied by the element.
Enumerated Domain Value Definition Source: Natural Heritage Program
Attribute Domain Values:
Enumerated Domain:

Enumerated Domain Value: 4 - Low
Enumerated Domain Value Definition: Between 5% and 20% of the polygon is occupied by the element.
Enumerated Domain Value Definition Source: Natural Heritage Program
Attribute Domain Values:
Enumerated Domain:
Enumerated Domain Value: 5 - Very Low
Enumerated Domain Value Definition: Less than 5% of the polygon is occupied by the element.
Enumerated Domain Value Definition Source: Natural Heritage Program
Attribute Domain Values:
Enumerated Domain:
Enumerated Domain Value: 6 - Unknown
Enumerated Domain Value Definition: Percentage of the polygon occupied by the element is unknown.
Enumerated Domain Value Definition Source: Natural Heritage Program
Attribute Domain Values:
Enumerated Domain:
Enumerated Domain Value: <blank>
Enumerated Domain Value Definition: An accuracy estimate has not been assigned to record.
Enumerated Domain Value Definition Source: Natural Heritage Program
Attribute:
Attribute Label: EO_STATUS
Attribute Definition: Element occurrence status
Attribute Definition Source: Natural Heritage Program
Attribute Domain Values:
Enumerated Domain:
Enumerated Domain Value: Current
Enumerated Domain Value Definition: The occurrence was observed recently.
Enumerated Domain Value Definition Source: Natural Heritage Program
Attribute Domain Values:
Enumerated Domain:
Enumerated Domain Value: Historical
Enumerated Domain Value Definition: Either the element has not been found in recent surveys; or it has not been surveyed recently enough to be confident they are still present; or the occurrence is thought to be destroyed.
Enumerated Domain Value Definition Source: Natural Heritage Program
Attribute Domain Values:
Enumerated Domain:
Enumerated Domain Value: Obscure
Enumerated Domain Value Definition: The date the element was last observed is uncertain.
Enumerated Domain Value Definition Source: Natural Heritage Program
Attribute Measurement Frequency: As needed
Attribute:
Attribute Label: EO_RANK

Attribute Definition: Element Occurrence Rank. Indicates the estimated viability of the element occurrenc e.
Attribute Definition Source: Natural Heritage Program
Attribute Domain Values:
Enumerated Domain:
Enumerated Domain Value: A
Enumerated Domain Value Definition: The EO has excellent estimated viability/ecological integrity.
Enumerated Domain Value Definition Source: Natural Heritage Program
Attribute Domain Values:
Enumerated Domain:
Enumerated Domain Value: B
Enumerated Domain Value Definition: The EO has good estimated viability/ecological integrity.
Enumerated Domain Value Definition Source: Natural Heritage Program
Attribute Domain Values:
Enumerated Domain:
Enumerated Domain Value: C
Enumerated Domain Value Definition: The EO has fair estimated viability/ecological integrity.
Enumerated Domain Value Definition Source: Natural Heritage Program
Attribute Domain Values:
Enumerated Domain:
Enumerated Domain Value: D
Enumerated Domain Value Definition: The EO has poor estimated viability/ecological integrity.
Enumerated Domain Value Definition Source: Natural Heritage Program
Attribute Domain Values:
Enumerated Domain:
Enumerated Domain Value: E
Enumerated Domain Value Definition: The EO has recently been verified to still exist, but there is insufficient information t o estimate its viability/ecological integrity.
Enumerated Domain Value Definition Source: Natural Heritage Program
Attribute Domain Values:
Enumerated Domain:
Enumerated Domain Value: F
Enumerated Domain Value Definition: Recent surveys failed to relocate an EO previously reported, but there is no evidence the EO has been destroyed.
Enumerated Domain Value Definition Source: Natural Heritage Program
Attribute Domain Values:
Enumerated Domain:
Enumerated Domain Value: H

Enumerated Domain Value Definition:The EO is old, and if surveyed recently, surveys failed to find it, but there is no evide nce it is destroyed.
Enumerated Domain Value Definition Source: Natural Heritage Program
Attribute Domain Values:
Enumerated Domain:
Enumerated Domain Value: NR
Enumerated Domain Value Definition: The EO has not yet been assigned a rank.
Enumerated Domain Value Definition Source: Natural Heritage Program
Attribute Domain Values:
Enumerated Domain:
Enumerated Domain Value: U
Enumerated Domain Value Definition: The EO cannot be assigned a rank because of insufficient information.
Enumerated Domain Value Definition Source: Natural Heritage Program
Attribute Domain Values:
Enumerated Domain:
Enumerated Domain Value: X
Enumerated Domain Value Definition: The EO has been destroyed.
Enumerated Domain Value Definition Source: Natural Heritage Program
Attribute Domain Values:
Enumerated Domain:
Enumerated Domain Value: i
Enumerated Domain Value Definition: The EO was introduced. (Used as a qualifier of the above ranks.)
Enumerated Domain Value Definition Source: Natural Heritage Program
Attribute Domain Values:
Enumerated Domain:
Enumerated Domain Value: r
Enumerated Domain Value Definition: The EO was reintroduced or restored. (Used as a qualifier of the above ranks.)
Enumerated Domain Value Definition Source: Natural Heritage Program
Attribute Domain Values:
Enumerated Domain:
Enumerated Domain Value: ?
Enumerated Domain Value Definition: There is uncertainty about the rank. (Used as a qualifier of the above ranks.)
Enumerated Domain Value Definition Source: Natural Heritage Program
Attribute:
Attribute Label: LAST_OBS
Attribute Definition: Last Observed Date. The date on which the element occurrence was most recently observed. Format of the dates is: yyyy-mm-dd. When the date is not precisely known, estimates are given.
Attribute Definition Source: Natural Heritage Program
Attribute Domain Values:
Unrepresentable Domain: Dates vary by feature.

Attribute:
Attribute Label: NAME_CATGY
Attribute Definition: categorizes the occurrences into broad taxonomic groups.
Attribute Definition Source: Natural Heritage Program
Attribute Domain Values:
Unrepresentable Domain: Categories vary by feature.
Distribution Liability: NCCGIA is charged with the development and maintenance of NC OneMap and, in cooperation with other mapping organizations, is committed to offering its users accurate, useful, and current information. Although every effort has been made to ensure the accuracy of information, errors and conditions originating from physical sources used to develop this dataset may be reflected in the data supplied. The user must be aware of possible conditions and bear responsibility for the appropriate use of the information with respect to possible errors, original map scale, collection methodology, currency of data, and other conditions specific to certain data. NCCGIA does not support secondary distribution of this dataset without its current, compliant metadata record. The use of trade names or commercial products does not constitute their endorsement by NCCGIA or North Carolina State Government.