

Stream Steward Campaign: Targeting Two Threatened Creeks in Chatham County

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Executive Summary

Rapid development in northeast Chatham County is stressing the Haw River and many of its tributaries. Two tributaries of the Haw River, Pokeberry Creek and Dry Creek are particularly threatened by the new mega developments, Briar Chapel and Chapel Ridge, that are using on-site spray application of wastewater. Before any new development, these two creeks were already showing signs of stressed aquatic life. Dry Creek has been on the 303(d) list of impaired waters for aquatic habitat since 2006. DWQ monitoring in 2003 measured a decline in the benthic macroinvertebrate communities in Pokeberry Creek.

The Two Threatened Creeks project aimed to investigate the decline in aquatic life in Dry Creek and Pokeberry Creek and to measure the impact of new development using benthic macroinvertebrate sampling, stormwater monitoring, and visual stream assessments. From spring 2007 to the spring of 2009, 46 benthic macroinvertebrates samples were collected, approximately 23 storm events were studied, and 84 stream assessment surveys were completed.

Over the two year sampling period, macroinvertebrate communities appeared to be improving in Pokeberry Creek. Macroinvertebrate scores on Dry Creek were shown to have a strong seasonal component. Due to drought conditions in 2007, it was difficult to determine whether the decline in macroinvertebrate communities that was measured on Dry Creek was due to poor aquatic habitats or just a response to drought conditions.

The hydrology of Pokeberry Creek is quite complicated which made interpretation of the stormwater data for this watershed difficult. Also the slow in the housing market resulted in no use of onsite spray application of wastewater in this watershed until after the sampling period. The hydrology on Dry Creek appeared to be more straightforward. There was a clear increase in all pollutant loading from upstream to downstream monitoring sites, except for inorganic nitrogen. The increase in ammonium nitrogen concentrations between the upstream and downstream monitors indicated there is a potential organic waste problem that possibly may be due to wastewater application or biosolid applications on nearby farm fields. Turbidity was shown to be a problem both in Dry and Pokeberry Creeks.

Pokeberry Creek flows through a string of wetlands and beaver ponds that are providing amazing wildlife habitat in the midst of a developed landscape of residential neighborhoods. The wetlands are also acting as filters cleaning up much of the sediment laden stormwaters that are washing into Pokeberry from construction. Without additional protection these wetlands will start to decline. Implementation of some stormwater best management practices in the the riparian area of the wetland in the new Briar Chapel subdivision would be good first step to protecting Pokeberry Creek.

Dry Creek has been impacted by a long history of farming that shaped the stream channel well before the agricultural BMPs we advocate today were developed. Streambank and channel erosion were continually noted during the assessment of Dry Creek. Potential sites for agricultural and stormwater best management practices were identified.

Introduction/Background

The piedmont of North Carolina is undergoing very rapid development with significant impacts on the upper Cape Fear watershed. North Carolina is one of the ten fastest growing states in the United States, and Chatham is one of the ten fastest growing counties in the state (Chatham News 2006). In particular, the Haw River and its tributaries are experiencing some of the most rapid changes from rural farming and timber land to residential subdivisions in Chatham County. Monitoring Dry Creek and Pokeberry Creek provides some important data about the water quality in these streams, and indicates impacts that will soon affect more Haw River tributaries as Chatham develops.

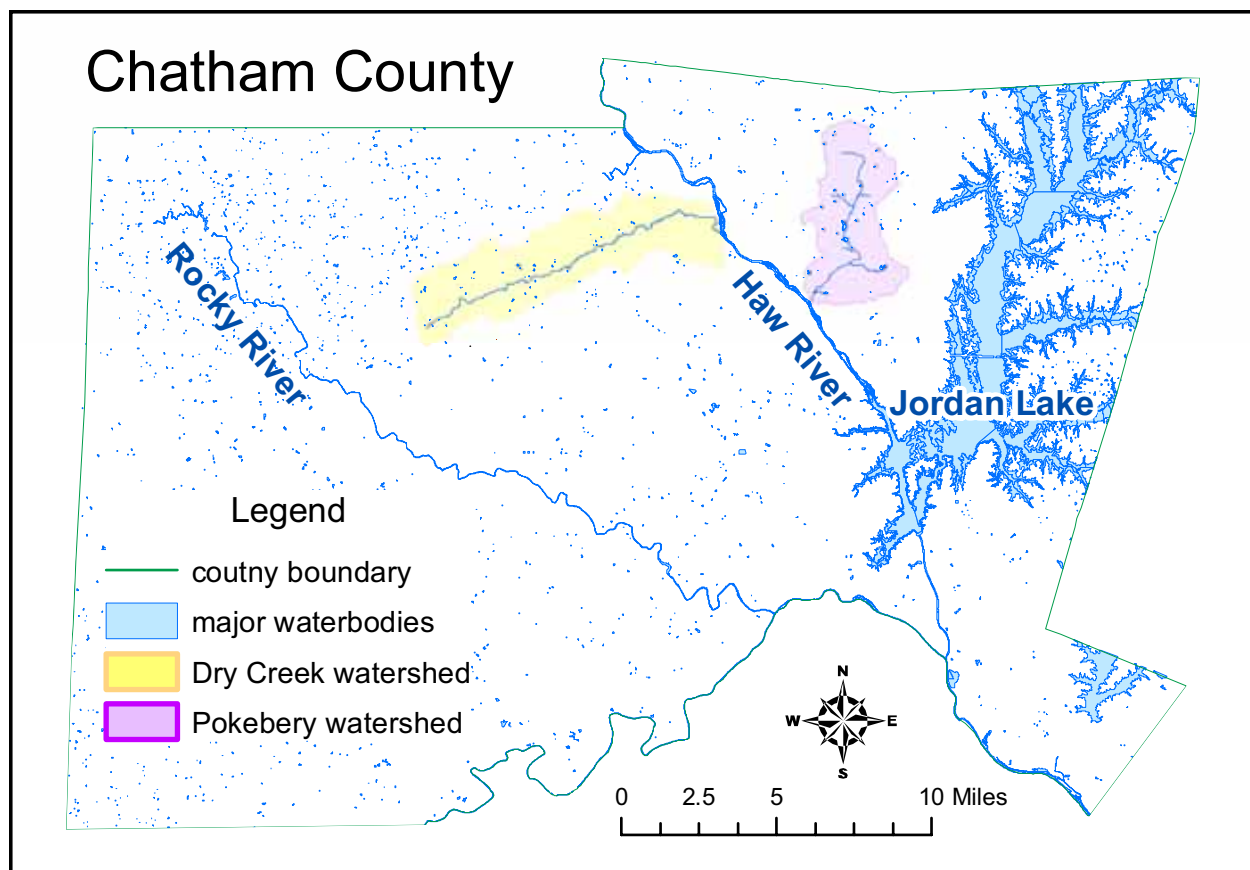


Figure 1. Location of Dry Creek and Pokeberry Creek watersheds

Dry Creek flows into the Haw River (Cape Fear 02) in northern Chatham County. Its drainage area is approximately 24 square miles. With its headwaters in the West near the Silk Hope area, Dry Creek has historically been one of the cleaner creeks draining into the Haw River arm of Jordan Lake. Dry Creek was Fully Supporting in the 2000 Basinwide Plan. The 2005 Cape Fear River Basinwide Plan states that Dry Creek is currently Impaired for aquatic life due to a Poor benthic community rating. The stressors listed are turbidity and habitat degradation. The potential source listed for the turbidity is land clearing. Dry Creek was again listed on the State's 303(d) list of Impaired waters in 2008 as Non-supporting for aquatic life for the 0.3 miles

downstream of SR 1506 (White Smith Road) to the Haw River (10.1 miles). The 2003 Cape Fear Assessment Plan states that “Dry Creek had been rated Poor, Good, and Good-Fair. In 2003 this site declined slightly to Fair which maybe the result of the effects of the 2002 drought and the increased nonpoint pollution inputs from the wet year observed in 2003.” No ambient monitoring data has been collected on Dry Creek before the Two Threatened Creeks project.

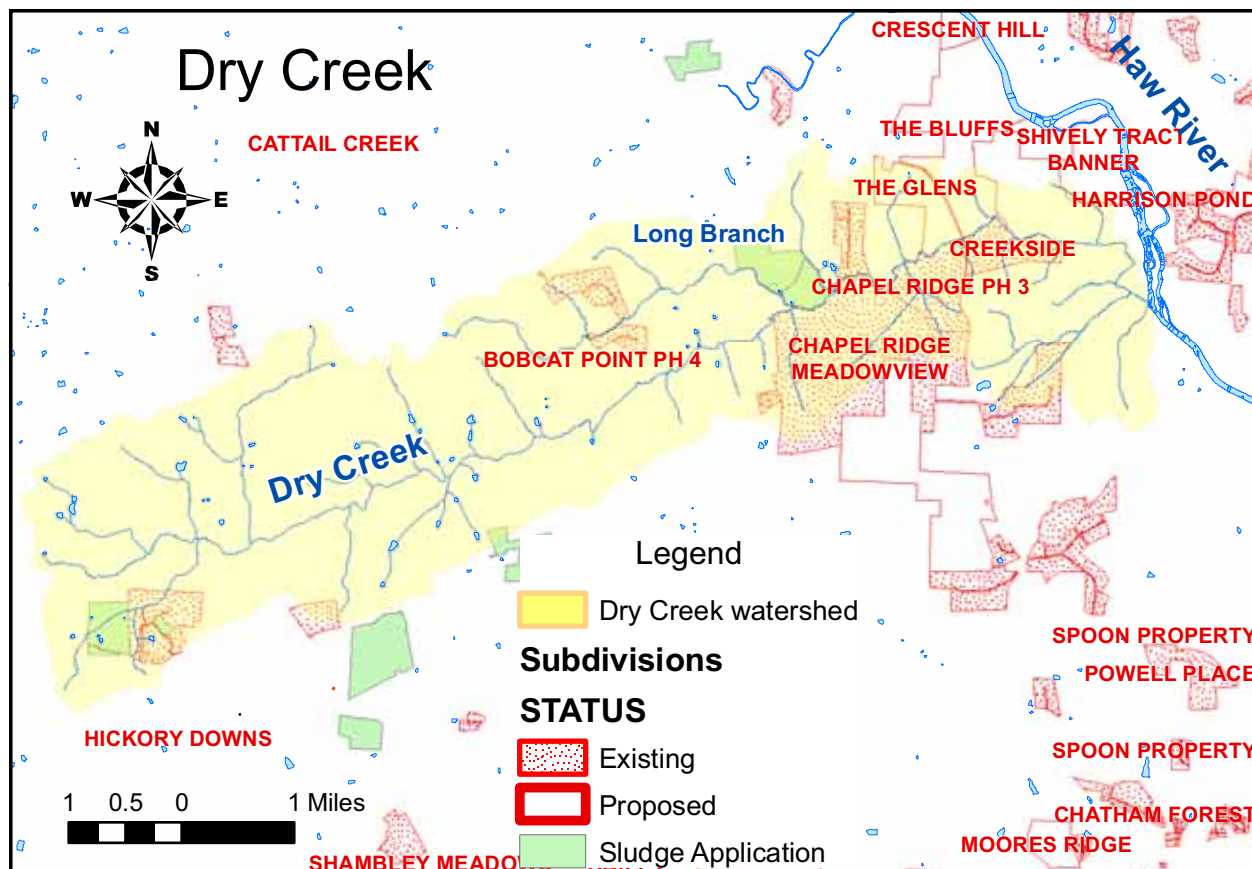


Figure 2. Proposed and Existing Subdivision in and around the Dry Creek watershed

Continued agriculture, sludge application, and an increased number of housing and golf course developments in the watershed are having the cumulative effect of rapidly changing the health of Dry Creek. Just prior to the beginning of the *Two Threatened Creeks project*, Chapel Ridge a large golf course community that relies a waste water spray irrigation system began construction. Since the project began many additional communities have begun construction. Aqua North Carolina operates a 500,000 gallon per day wastewater treatment and spray irrigation system at Chapel Ridge subdivision that serves the new subdivisions: Chapel Ridge, Meadowview, Woodlands, Bluffs, Creekside and McBane. The wastewater treatment plant began operations in 2007.

Pokeberry Creek enters the Haw on the eastern side, into the new Lower Haw River State Natural Area. Its headwaters rise in the area of Briar Chapel which will soon become the biggest Chatham "compact community" development with almost 2500 new houses. Pokeberry Creek

differs from Dry Creek and many of the surrounding watershed in that it has a very sandy streambed. The drainage area for Pokeberry is just over 13 square miles.

Pokeberry Creek is currently considered to be Supporting, but the 2003 Cape Fear Assessment Plan suggests that there is evidence that “the benthic communities in Pokeberry Creek may be declining in this rapidly developing area.” Many new subdivisions: Briar Chapel, The Hamptons, Baldwin Peaks, and The Sanctuary of the Haw, began construction within the Pokeberry Creek watershed over the last few years. All of these new developments rely on septic systems except Briar Chapel which relies on reclaimed water system that irrigates the open space throughout the development. Due to the slow down in home sales over the last year, Briar Chapel did not begin using reclaimed water for irrigation until October 2009.

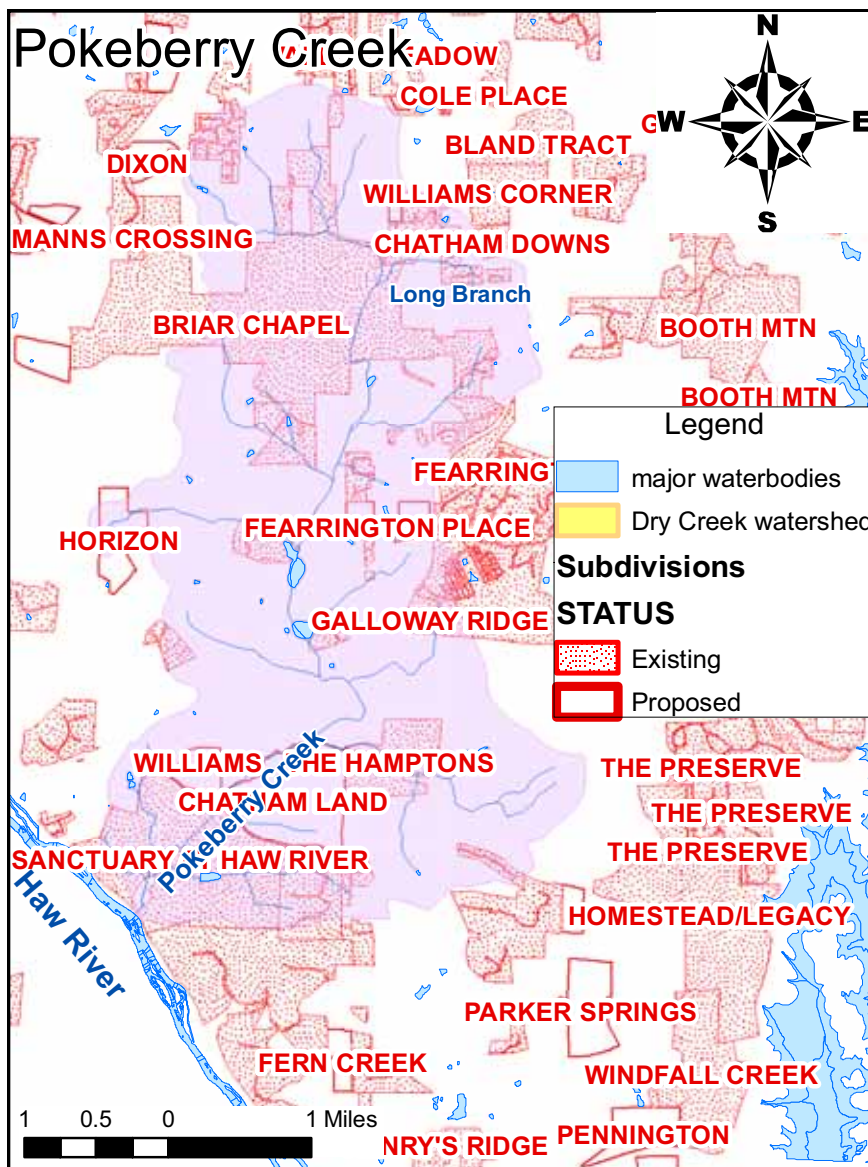


Figure 3. Proposed and Existing Subdivision in and around the Pokeberry Creek watershed

Dry Creek and Pokeberry Creek are part of the watershed of the Haw River Arm of Jordan Lake, and are included in the nutrient load reduction targets under the Jordan Lake Nutrient Management Strategy and TMDL. The reductions for loading to this part of the Lake are 5% for phosphorus and 8% for nitrogen. The non-point source plan includes strategies for reducing nutrient loading to streams from agricultural lands; better management of fertilizers and biosolid applications; reducing stormwater run-off from new and redevelopment, as well as retrofitting existing development; riparian buffer protection; and improving wastewater land application and on-site wastewater systems to reduce nitrogen and phosphorus loading. All of these land use strategies apply to the Pokeberry Creek and Dry Creek watersheds.

Purpose and Goals

The three primary Goals for the Two Threatened Creeks project were the following:

1. Conduct visual stream assessments with as many landowners as possible along Dry Creek and Pokeberry Creek. Assessments will be used to provide an opportunity for landowner education in stream stewardship and in the land-use strategies developed for the Jordan Lake Nutrient Management Strategy. Also data collected from assessments and conversations with landowners will be used to identify potential sites for stream restoration, installation of BMPs, and conservation.
2. Conduct macroinvertebrate counts along Dry Creek and Pokeberry Creeks to identify possible causes for impairment.
3. Conduct water quality monitoring for storm events for Pokeberry Creek and Dry Creek to evaluate the potential runoff from onsite community spray irrigation fields to local creeks. Monitoring also provides a measure for the effectiveness of the adoption of stream stewardship practices by landowners.

Deliverables

1. Hold Steering Committee meeting for project

- The Two Threatened Streams Project Steering Committee met approximately quarterly, and served as an advisory group for the entire Two Threatened Streams project. Its active members were:
 - i. Janet McFall, Elon University
 - ii. Betsy Kraus, HRA volunteer
 - iii. Glenn Woolard, NC Cooperative Extension
 - iv. John Wagner, HRA volunteer

- v. Sydney Miller, Triangle J Council of Government
 - vi. Dave Penrose, NCSU WQG
 - vii. Dan Line, NCSU-WQG
 - viii. Sharon and JC Garbutt, HRA volunteers
 - ix. Beverly Wiggins, HRA Riverwatchers on Pokeberry Creek
 - x. Jim Swenberg, landowner along Dry Creek
 - xi. Seth Reice, UNC Ecology professor
 - xii. Jason Sullivan, Chatham County Planning Office
 - xiii. Kathryn Gardner, Chatham County Soil and Water Conservation
2. **Write Quality Assurance Progress Plans (QAPP) for storm event monitoring program**
- The surface water monitoring on Dry Creek and Pokeberry Creek was contracted to Dan Line, NCSU Water Quality Group (WQG) in January 2007.
 - The *Dry and Pokeberry Creeks Monitoring Project* QAPP for stormwater monitoring was submitted to DENR in January 2007 (see Appendix A).
3. **Write QAPP for macroinvertebrate sampling**
- HRA staff with guidance from Dave Penrose wrote standard operating procedures (SOP), *Dry Creek and Pokeberry Creek Macroinvertebrate Protocol Two Stream Project*.
 - HRA staff expanded their SOP to include protocols for macroinvertebrate identification lab sessions.
 - The draft *Quality Assurance Project Plan for Macroinvertebrate Sampling, Two Threatened Creeks Project* was reviewed during the March 29, 2007, Steering Committee meeting.
 - *Quality Assurance Project Plan for Macroinvertebrate Sampling, Two Threatened Creeks Project* was submitted to DENR on March 30, 2007.
 - Revised QAPP and SOP for Macroinvertebrates based on comments received from Kim Nimmer, DENR (see Appendix B).
4. **Contact landowners**
- A series of letters were mailed to landowners adjacent to Dry and Pokeberry Creeks (see Appendix G)
 - i) Initial contact letter announcing the Two Threatened Streams project
 - ii) Invitation to *A Threatened Stream Pokeberry Creek Community Meeting*
 - iii) Postcard invitation to *Responsible Stream Stewardship Workshop*
 - iv) Dry Creek assessment letter
 - v) Invitations to *Discoveries from Studying a Threatened Stream: Dry Creek*
 - Contacted landowners about potential sites for the macroinvertebrate and stormwater monitoring.
 - Contacted landowners by phone in Pokeberry watershed to ask if they would like to participate in a visual stream assessment.
 - HRA Staff participated in quarterly community meetings with Briar Chapel from May 2007 to July 2009.

- HRA staff visited and corresponded by email with Tricia and Mike Burchette to plan a streamside planting along Dry Creek on the Burchette Farm.
5. **Submit QAPPs to DWQ for review and approval**
 - QAPP for surface water monitoring, *Dry and Pokeberry Creeks Monitoring Projects* was submitted to Kim Nimmer, DENR, on January 22, 2007.
 - QAPP for *Macroinvertebrate Sampling for the Two Threatened Creeks Project* was submitted to Kim Nimmer, DENR, on March 30, 2007.
 - Received notification on October 9, 2007 that the QAPPs for both the stormwater monitoring and macroinvertebrate monitoring were accepted with a few minor suggested changes.
 6. **Installation of monitoring stations for storm event sampling and start data collection needed to create flow rate curves for both creeks**
 - NCSU WQG staff installed upstream and downstream monitoring station on Dry Creek in May 2007 at bridge crossings.
 - NCSU WQG staff installed monitoring stations on Pokeberry Creek in July 2007 after HRA staff obtained landowner permission.
 - The monitoring stations were instrumented to continuously monitor discharge and collect flow-proportional samples during storm events.
 - Stage-discharge relationships were developed for each site.
 - Discharge measurements were conducted at each monitoring site during various stream visits to develop stage-discharge rating tables for each site.
 7. **Hold community meetings**
 - Held *A Threatened Stream - Pokeberry Creek Community Meeting* on January 26, 2008.
 - Held a *Responsible Streamside Stewardship Workshop* on September 13, 2008.
 - Held *Discoveries from Studying a Threatened Stream: Dry Creek* on September 24, 2009.
 - Presented summary of study of Dry Creek and Pokeberry Creek to Chatham County Environmental Review Board on March 19, 2009.
 - Presented results from visual stream assessments to the Chatham County Soil and Water Conservation Board on September 10, 2009.
 8. **Conduct stream assessments**
 - Completed visual stream assessment surveys at the 9 benthic macroinvertebrate monitoring sites.
 - Completed 21 visual stream assessment surveys along Pokeberry Creek.
 - Completed 63 visual stream assessment surveys along Dry Creek.
 9. **Conduct macroinvertebrate monitoring**
 - Established 9 benthic macroinvertebrate monitoring sites
 - i) Dry 1 - Daniel Graham (farm site and most upstream site)
 - ii) Dry 2 - upstream of Highway 87 Bridge

- iii) Dry 3 - upstream of Old Graham Road Bridge
- iv) Dry 4 - Swenburgs (upstream of confluence with the Haw)
- v) Poke 1 - Marvin Mecham (off of Dollar Road and most upstream site)
- vi) Poke 2 - Jesse Fearington (off of Morris Road and in the middle of a wetland)
- vii) Poke 3 - upstream of Bynum Ridge Road Bridge
- viii) Poke 4- State Natural Area (upstream of confluence with the Haw)
- ix) Terrells - upstream of Highway 87 Bridge
- Collected macroinvertebrates samples in April 2007, November 2007, April 2008, November 2008, and April 2009 at all 9 sites.
- Collected macroinvertebrates samples at Poke 4 and Dry 4 in September 2007 during drought conditions.

10. Storm event sampling

- Ambient monitoring at 4 sites between July 2007 and April 2009
 - i) Collected 22 samples at upstream Pokeberry Creek site (Poke 1).
 - ii) Collected 26 samples at downstream Pokeberry Creek site (Poke 2).
 - iii) Collected 23 samples at upstream Dry Creek site (Dry 2).
 - iv) Collected 25 samples at downstream Dry Creek site (Dry 3).
- Grab samples collected at 2 sites on Pokeberry between April to June 2008.
 - i) Collected 3 samples at upstream Pokeberry Creek site (Poke 1)
 - ii) Collected 1 sample at downstream Pokeberry Creek site (Poke 2)

11. Hold River Watch trainings

- Held training with Dave Penrose on February 3, 2007, on Terrells Creek, the project reference stream, for our Macroinvertebrate Site Leaders for Pokeberry and Dry Creek.
- Training on using the project macroinvertebrate monitoring method on Pokeberry Creek with River Watch volunteer, Sharon Garbutt, and Neville Handel to help with monitoring and benthic identifications.
- Public HRA River Watch training held on August 29, 2008, in Bynum.
- Cynthia Crossen, HRA River Watch Coordinator, developed a tutorial using voice threads for macroinvertebrate identification for the Two Streams web page (see hawriver.org, under –Projects, Two Streams Project (check out “Stoneflies” for a good sample).

12. Start new River Watch teams

- Established 9 new River Watch sites for macroinvertebrate monitoring for this project.
- On December 18, 2007 HRA staff reviewed the macroinvertebrate sampling methodology with Beverly and Jim Wiggins of the Pokeberry River Watch Team. They also visited the two monitoring sites that the Pokeberry River Watch Team have been monitoring.
- On April 4, 2007, Cynthia Crossen trained Patricia Tidwell and her son to be HRA River Watch Team on Dry Creek. Their new River Watch site is located on Dry Creek just downstream of the Silk Hope Gum Springs Road Bridge.

13. Compile and analyze data collected from assessments and macroinvertebrate counts

- Created a pictorial reference collection of macroinvertebrates collected and identified from sampling on Pokeberry, Dry, and Terrells Creeks. All identifications included in the reference collection were verified by Dave Penrose, NCSU. Reference library is included as a CD in Appendix K.
- HRA staff created a web page for the Two Streams project to make public the data collected from the project. The website is at hawriver.org, under Projects, Two Streams Project, and includes field notes and all lab notes for macroinvertebrate collections.
- Calculated family level EPT and Total Taxa Biotic Indexes, Richness, and Abundance values for macroinvertebrate samples collected in April 2007, September 2007, November 2007, April 2008, November 2008.

14. Identify potential sites for stream restoration, BMPs, or protection

- Potential BMPs along Dry Creek
 - i. Riparian enhancement at Burchette Farm (planted on October 12, 2009)
 - ii. 17 Riparian buffer plantings (scored less than 3 on Riparian Zone in visual assessment or noted during assessment that planting would be useful)
 - iii. 5 Pasture fences
 - iv. Stream restoration site within old cattle pasture
 - v. 7 Actively used farm or stream crossings that could be stabilized
 - vi. 3 Sites that could use stormwater BMPs (bioretention, level spreaders) in Chapel Ridge
 - vii. 3 Potential educational stream watch monitoring sites
 - viii. Educate new landowners in Chapel Ridge and the Estates about management of riparian areas.
 - ix. 9 Recommended areas for conservation easements
- Potential BMP sites along Pokeberry Creek
 - i. 13 Recommended areas for conservation easements
 - ii. 2 Riparian buffer plantings
 - iii. Streambank stabilization at Briar Chapel Parkway bridge over Pokeberry Creek wetland
 - iv. Stormwater BMPs (bioretention, level spreaders) along Pokeberry Creek wetland within Briar Chapel to protect wetland from runoff from spray irrigation and muddy runoff from power cut.
 - v. 2 Stabilization of 2 stream crossings by gas line and power cuts

15. Complete storm event sampling and analyze data

- NCSU completed stormwater sampling in April 2009
- Ambient samples were analyzed for Total Suspended Solids, TSS; Total Phosphorus, TP; Total Kjeldahl Nitrogen, TKN; Ammonium nitrogen, NH₄-N; Nitrate+nitrite nitrogen, NO_x-N; and Turbidity by state certified lab #522 (Center for Applied Aquatic Ecology).
- Grab samples collected on Pokeberry Creek were analyzed for e.Coli by the NCSU WQG which is not a state-certified lab.

- Summary statistics for discharge and sample concentration data were computed for each sample set and comparison made between upstream and downstream sites.
- Discharge, concentration, and drainage area were combine to calculate the storm event load rates.

16. Write Quarterly and Final Report

- 11 quarterly reports and final report completed.

Methodology/Execution

Quality Assurance Plans

The first task in the Stream Steward Campaign: Two Threatened Creeks in Chatham County project was to write the quality assurance project plans (QAPPs) for the stormwater sampling and the benthic macroinvertebrate sampling that was to be completed for this project.

Stormwater Monitoring: North Carolina State University Water Quality Group (NCSU WQG) was tasked with writing the QAPP for the stormwater monitoring. Dan Line, NCSU WQG, has conducted ambient monitoring on many streams throughout North Carolina, so he quickly completed and submitted the *Dry and Pokeberry Creeks Monitoring Project QAPP* for the stormwater monitoring (see Appendix A).

Macroinvertebrate Monitoring: The HRA staff and HRA River Watch Steering committee put an enormous amount of effort into developing a more rigorous protocol for The Two Streams project than the River Watch protocol that HRA has used with volunteers for over 15 years for macroinvertebrate monitoring. Working under the guidance of Dave Penrose, HRA staff drafted standard operating procedures (SOP) that included sampling from various stream habitats: riffle (traveling kick), streambank, leaf pack, and visuals (various microhabitats). Unlike the state protocol which combines collections from various habitats, this protocol requires collections to be kept separate so that the health of the various habitats could be evaluated. We tested our SOP with the help of Dave Penrose on February 3, 2007. We then drafted the *Quality Assurance Project Plan for Macroinvertebrate Sampling, Two Threatened Creeks Project* which we had reviewed by the Two Streams Steering Committee. The QAPP was completed and submitted to DENR by the end of March 2007.

After completing the first benthic macroinvertebrate sampling in April 2007, we decided it would be useful to document our procedures for macroinvertebrate identification as well as the sampling protocol. So we drafted an expansion to our Macroinvertebrate SOP to include protocols for our lab sessions. Dave Penrose suggested that we also request that the photo library of benthic macroinvertebrates created during our lab sessions be used as the project reference collection. We submitted the new lab protocol, along with a request to change from a physical reference collection to photo reference collection, to DENR who promptly approved them. These lab procedures are included with the QAPP in Appendix B.

Setting up Monitoring Sites

In November 2006, HRA staff visually inspected all the road crossings of Dry Creek and Pokeberry Creek to conduct an initial assessment of where to locate our monitoring sites. We needed to establish 9 macroinvertebrate monitoring sites: 4 on Pokeberry Creek, 4 on Dry Creek and 1 on Terrell Creek which we had chose to be our reference stream. We also needed to install 4 stormwater monitoring stations located just upstream and downstream of the new developments on Pokeberry and Dry Creeks.

Dry Creek: With the help of our GIS mapping, we were able to quickly ascertain where the stormwater stations on Dry Creek should be located. The upstream station was located just downstream of the Highway 87 bridge and the downstream station was located at the Old Graham Road bridge, since the new Chapel Ridge Subdivision spans the distance between these two major road corridors. NCSU WQG established these monitoring stations, installing stream staff gages, and automated samplers, surveying the cross section, making at least two discharge measurements, and estimating a stage-discharge rating table. The Dry Creek sites were operational and ready to collect flow-proportional storm samples starting in June 2007.

We established two of our Dry Creek macroinvertebrate monitoring sites approximately 200 feet upstream of the stormwater monitoring sites appromiately where NC DWQ monitors for macroinvertebrates on Dry Creek. We also wanted to establish two more macroinvertebrate sites, one closer to the headwaters of Dry Creek and another just before the confluence with the Haw River. Finding a site close to the headwaters was difficult. As its name suggests, Dry Creek is often dry and this condition is even more prevalent further upstream. We ended up locating our most upstream site at the Graham's Farm downstream of Silk Hope Springs Road. We located our most downstream site on the Swenburg's property approximately 200 feet upstream of the confluence with the Haw River.

Pokeberry Creek: Finding monitoring sites upstream and downstream of Briar Chapel on Pokeberry Creek was difficult. The ideal downstream site would have been located upstream of the bridge at Andrew Store Road, but the cattle farmer who owned the property was not willing to give us access to the creek. After flowing though the cattle farm, Pokeberry Creek entered a wetland. So we ended up locating the downstream monitoring station downstream of the wetland off of Morris Road on James Selkirk's property. We were able to locate the upstream stormwater monitoring site on the Mecham property that was primarily being used for hunting, but ended up being timbered in the winter of 2009. Catherine Deininger participated in the installation of the upstream sampler on Pokeberry Creek and wrote an article for the HRA Newsletter describing this (see Appendix H for the article).

Two of the macroinvertebrate sites were again located nearby the stormwater stations. At the upstream site the macroinvertebrate monitoring was conducted within 50 feet of the stormwater station. The macroinvertebrate site for downstream of Briar Chapel was located upstream of Morris Road within the wetland on the Fearington property. This ended up being one of our more interesting sites, since the substrate in stream channel was primarily sand. We located two

additional macroinvertebrate monitoring stations on Pokeberry Creek. One approximately 100 feet upstream of the Bynum Ridge Road bridge on Pace's hunting property (approximately the same location as DWQ monitors for macroinvertebrates). The fourth site was located approximately 300 feet upstream of the confluence with the Haw River in the Lower Haw River Natural Area.

We also located one macroinvertebrate monitoring site on Terrells Creek upstream of Highway 87 bridge to use as our reference stream at approximately the same location DWQ monitors. The Terrells Creek watershed is next to the Dry Creek watershed and with an approximately 20 acre drainage area which is similar size to the Dry Creek watershed. Terrells Creek watershed is primarily rural and is currently not being impacted by new development.

Macroinvertebrate Monitoring

Expanded Goals: The goal identified for macroinvertebrate monitoring for this project was to identify possible causes for impairment on Dry Creek. We expanded on this project goal in the *QAPP for Macroinvertebrate Sampling*. These expanded project goals for macroinvertebrate sampling include:

1. Establish a baseline for macroinvertebrate communities in Pokeberry and Dry Creeks before further development takes place in these watersheds.
2. Measure changes in the macroinvertebrates over time in the two streams
3. Identify stream sections that may exhibit changes due to localized non-point impacts.
4. Provide information to the state about negative impacts that may be found and where possible additional investigations may be necessary.
5. Provide more detailed information at more sites in more frequent intervals than NCDENR is able to collect on two streams that may experience substantial and rapid changes.
6. Determine possible causes of impairment of aquatic habitat in Dry Creek.

Our hope was to accomplish the first 5 goals by selecting multiple sites on both streams and monitoring them for a three-year period, giving us baseline data that we could use to detect changes in benthic macroinvertebrate communities over time and determine approximate locations of any negative impacts. The sixth goal is the original project goal. The state's designation of aquatic habitat impairment on Dry Creek is based on the macroinvertebrate collections they have taken at Old Graham Road (SR 1520). We located the Dry 3 sampling site at approximately the same location at the state's monitoring site. Also we included two sites upstream of this site and one downstream so that we could determine if the decline in aquatics life was just a localized problem or if it expanded further. In addition, we decided to keep separate the collections that we made from the various habitats: riffle, streambank, leaf pack, visuals (micro habitats) for each sampling session so that we could evaluate the richness and abundance of the macroinvertebrates collected at each habitat.

Sampling: In the *QAPP for Macroinvertebrate Sampling*, we committed to collecting macroinvertebrate samples for all 9 sites for April 2007, April 2008, and April 2009. Dave Penrose suggested that if possible we collect an additional sample at a time during the year when the macroinvertebrate community would be more stressed, such as the summer or fall. When we tried sampling in September 2007, many of the sites were dry due to the drought; we ended up only being able to collect samples at the most downstream sites (Poke 4 and Dry 4). We then sampled again in November 2007 after the streams began to flow again (more due to reduced transpiration rates of the deciduous trees rather than any rainfall). We collected another sample the following November so that we ended up with a total of six sampling seasons rather than the planned three. In addition, we decided to collect in November 2008 three samples from our Terrells Creek reference stream to use to evaluate the reproducibility of our sampling protocol. In all we collected 48 macroinvertebrate samples. This rigorous sampling schedule was made possible by some very dedicated volunteers (Jeannie Ambrose, Neville Handel, Sharon Garbutt, Betsy Kraus, and John Wagner) who helped the HRA staff with the macroinvertebrate collections and identifications. We managed to complete the macroinvertebrate identifications and analysis for all but the April 2009 sample.

Documentation: After completing our first sample in April 2007, we decided to keep more rigorous notes both during the lab macroinvertebrate identification sessions and for our field sampling. The field notes helped to increase the communication between our sampling teams and to create a complete documentation of the sampling conditions. The lab notes were used to document any new identifications we learned so we could share them with the rest of the team, and they were used to aid communication with Dave Penrose. We posted all this documentation to our Two Streams webpage on the Haw River Assembly's website (www.hawriver.org). We met with Dave Penrose several times to have him verify our macroinvertebrate identifications. We also set Dave Penrose up to use VoiceThread, an internet tool for sharing documents and images which allows people to leave written discussions. Our VoiceThread discussion can also be viewed from the Two Streams webpage. The photo reference library that we created of macroinvertebrates we identified during this project are contained in Appendix K as a CD.

Data Analysis: There are many Biological Indices that can be used to summarize the raw data collected from macroinvertebrate samples. For this project we decided to start by calculating the indices used in the North Carolina Standard Operating Procedure: the taxa richness and abundance and the Ephemeroptera, Plecoptera, and Trichoptera (EPT) Biotic Index. The richness is the number of taxa families found in each sample. The abundance for the sample is a simple count of the number of organisms found in each sample. "The Biotic Index for a sample is a summary measure of the tolerance values of organisms found in the sample, relative to their abundance (SOP for Benthic Macroinvertebrates Biological Assessment Unit)". Because we did our identification to the family level rather than species level, we were not able to make judgements based on the richness criteria followed by the state.

The family level tolerance values used in the Biotic Index calculations were primarily derived by averaging all the tolerance values within a family (i.e. species and genus values) that were

obtained from *NC DWQ Standard Operating Procedures for Benthic Macroinvertebrates Biological Assessment Unit July 2006*. Tolerance values for six of the benthic macroinvertebrates (Ameletidae, Isonychiidae, Curculionidae, Sciridae, Ephemerellidae, and Bithyniidae) that could not be found in DWQ SOP were obtained from *A Guide to Freshwater Invertebrates of North America* by J. Reece Voshell and from the Water Resource Center for University of Minnesota website (wrc.umn.edu/Publications/supplyquantityandquality/guidetoaquaticinverts/) and from the Soil & Water Conservation Society of Metro Halifax website (www.chebucto.ns.ca/ccn/info/Science/SWCS/ZOOBENTH/BENTHOS/tolerance.html). These three resources had already assigned tolerance values for the family level.

In addition to completing the calculations for the EPT, we also calculated the richness and abundance values for all the taxa in each sample and in each habitat, and the Total Taxa Biotic Index for the whole sample.

Below is a summary of the formulas we are used in our analysis.

1. Richness = the number of benthic macroinvertebrates families
2. Abundance = the total number of benthic macroinvertebrate
3. Score (Biotic Index for all Taxa) = $\sum(TVi)(ni) / N$
 TVi = ith taxa's tolerance value
 ni = ith taxa's abundance value
 N = sum of all abundances
4. Adjusted Score = Score + seasonal correction
 Seasonal correction for spring (Mar to May) = +0.2
 Seasonal correction for fall (Oct to Nov) = +0.1

Terrells Creek Monitoring Study: A host of external factors are expected to influence the outcome of insect population sampling. Some of these factors are not reflective of watershed health such as site choice, seasonal effects, variations in flow level and water temperature, and natural fluctuations in aquatic insect populations. In order to assess the importance of the sampling location, three independent samples were collected from Terrell's creek. On November 13, 2008, we formed three teams with two to three people each. Each team was assigned a reach to sample that was within a 300 foot section of Terrells Creek. We received assistance from James McClure a doctoral candidate in the Department of Environmental Sciences and Engineering at UNC in looking at these additional samples from Terrells Creek.

Stormwater Monitoring

NCSU Water Quality Group was contracted to conduct the stormwater monitoring for the Two Threatened Creeks project. The complete report of their work is included in Appendix D. Water quality monitoring stations were installed upstream and downstream of recently completed or

still under construction residential developments on Dry and Pokeberry Creeks in Chatham County.

Dry Creek: The upstream station was located just downstream of the Highway 87 bridge while the downstream station was located about 3.1 miles downstream under the Old Graham Road bridge. Much of the land south of the creek between the monitoring sites is a large tract of land under development into residential subdivision(s). The subdivision has a package sewage treatment facility with on-site wastewater application onto a golf course and other land. Observation throughout the subdivision indicated few to no stormwater controls. The land north of the creek between the sites is mostly agricultural, with areas of low density residential land use. Soils in the watershed are of the Carolina Slate Belt system consisting mostly of the Nason series. Several small unnamed tributaries and one relatively large tributary, Long Branch, empty into Dry Creek between the monitoring stations. It appears that Long Branch provides significant discharge and possibly pollutant loading to Dry Creek, although the amount is unknown. In particular, we became aware after most of the sampling was completed for the project that biosolid applications are made on fields within the Long Branch watershed.

The monitoring stations were instrumented to continuously monitor discharge and collect flow-proportional samples during storm events. Stage-discharge relationships were developed for each site. Discharge measurements were conducted at each monitoring site during various stream visits to develop stage-discharge rating tables for each site. At least 4 discharge measurements were made for each site using standard stream gauging equipment and methods (Buchanan and Somers 1969). All sites, except the downstream station on Dry Creek at Old Graham Road, remained relatively stable and consistent, thereby providing consistent discharge data. For the downstream Dry Creek site, the rating changed during and following the installation of a pipeline across the creek just downstream of the monitoring station resulting in the need to conduct additional discharge measurements and update the rating table. Rainfall measurements were made with a continuously recording rain gage located near the upper end of the watershed.

Pokeberry Creek: The stations were located near the end of Dollar Road and downstream about 2.9 miles where the creek crosses under Morris Road (figure 1). There was a large residential development and several smaller developments under construction between the monitoring sites, as well as other land uses. The largest subdivision has a package sewage treatment facility with on-site wastewater application onto open land throughout the development, but application had not begun during the project period. This subdivision also has stormwater treatment features/ponds throughout. At least 5 significant (in appearance on a map) unnamed tributaries enter Pokeberry Creek between the monitoring sites. Soils in the watershed are in the Felsic-Crystalline system and are mostly of the Wedowee and Vance series. The hydrology/hydraulics of the creek is relatively complex with at least one large wetland and other sections of low gradient stream channel between the monitoring sites. Further, during the drought of 2007, there would often be discharge at the upstream site, but none at the downstream site. At the same time, there was almost continuous discharge observed in the stream channel downstream of the downstream monitoring station.

Visual Stream Assessments

The NRCS stream visual assessment protocol (SVAP) was used to conduct visual assessments along Dry Creek and Pokeberry Creek. This protocol includes 15 possible scoring categories: channel condition, hydrologic alteration, riparian zone, bank stability, water appearance, nutrient enrichment, barriers to fish movement, instream fish cover, pools, macroinvertebrate habitat, canopy cover, manure presence, salinity, riffle embeddedness, and macroinvertebrates observed. Salinity was not applicable to the creeks in this study. The protocol also suggests providing the landowner with assessment scores and recommendations on how to address problems noted by the assessment. Considering recommendations by the Two Stream Steering Committee, some basic revisions to the NRCS Stream Assessment Protocol (SVAP) were made to reflect expected conditions in Piedmont streams. In particular we made revisions in the scoring descriptions for channel condition, pools, and macroinvertebrates observed. The SVAP scoring sheet and the scoring descriptions used for this project are included in Appendix C.

One of our first steps in this project was to map all the land parcels within 100 feet of Pokeberry and Dry Creek. To facilitate record keeping we gave each parcel an identification number starting with the headwaters for each creek that we used to keep track of landowner contact information and to identify parcels for stream assessments.

Pokeberry Creek: The second year of the project we focused on conducting stream assessments along Pokeberry Creek. We followed the plan outlined in the grant proposal of contacting landowners by phone and asking them to participate in a stream assessment of their property. We ran into many problems with this approach such as not being able to reach landowners by phone, difficulty setting up an initial assessment, and often needing to reschedule due to weather or other circumstances. We managed to complete 21 stream assessments on Pokeberry Creek.



Neville Handel, HRA Volunteer surveys the Pokeberry Creek wetland at Briar Chapel

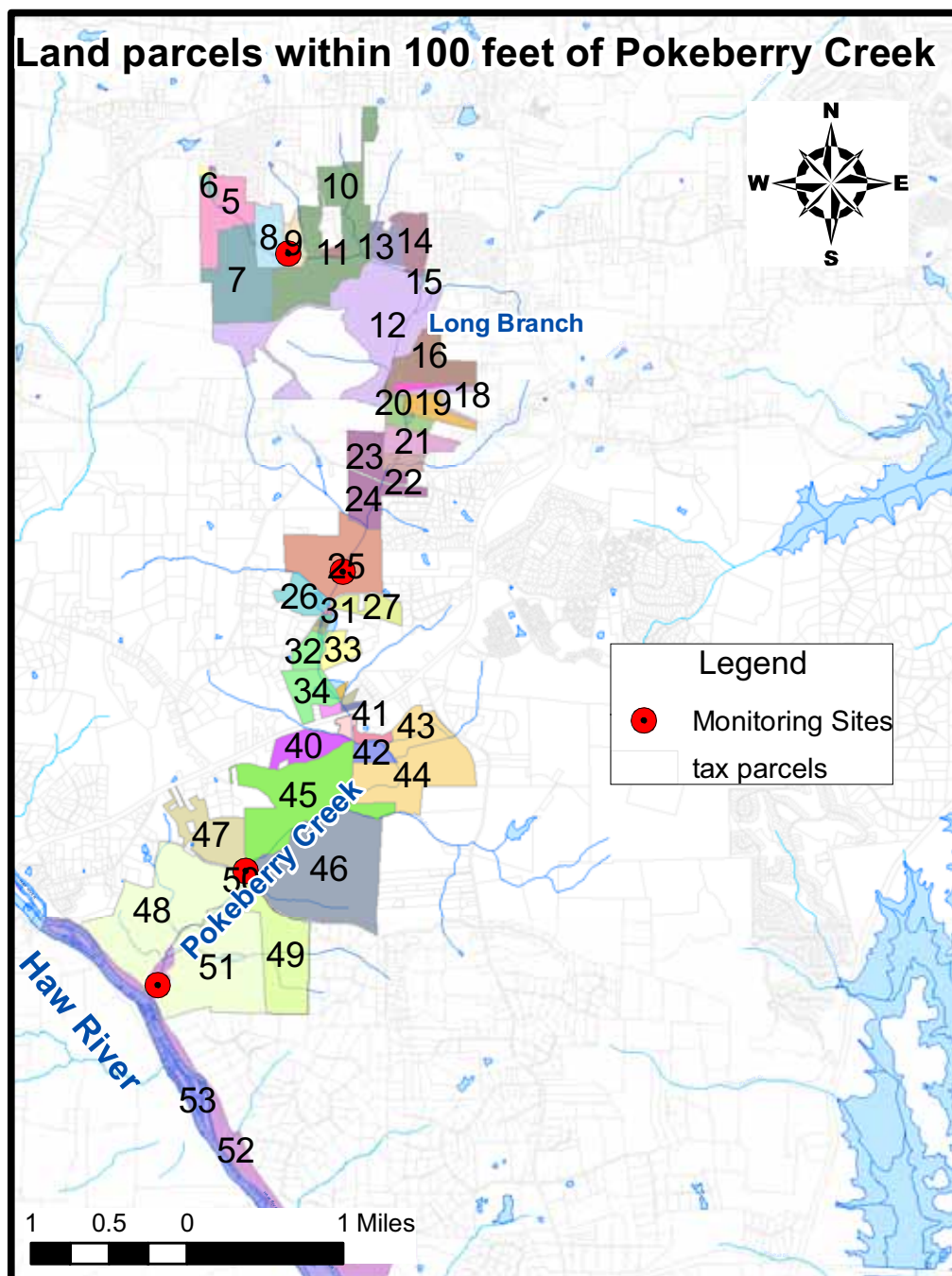


Figure 4. Monitoring Sites and Land Parcels within 100 feet of Pokeberry Creek

We discovered during our assessments that Pokeberry Creek is the home to numerous beavers that have helped create many large wetlands. These wetlands have done an excellent job at removing much of the sediment that has flowed into Pokeberry Creek from new development. Unfortunately many of the wetlands are filling in with muddy runoff. The stormwater sampling found that the turbidity in Pokeberry Creek is generally higher than it is in Dry Creek, but it also unexpectedly decreases as you go downstream, probably due to these wetland filters. Farms and

timberland are quickly phasing out in Pokeberry and being replaced by new development. Another potentially big concern for the headwaters of Pokeberry Creek is the number of small older lots with septic systems.



Monitoring site on Pokeberry Creek (Poke2). Downstream of Briar Chapel.

Dry Creek: Due to the difficulties experienced in scheduling assessments in Pokeberry Creek, we decided to take a different approach in completing the stream assessments for Dry Creek. We mailed a letter to all the landowners along Dry Creek in February 2009 letting them know we planned to conduct assessments along Dry Creek in March and April of 2009. We provided them with contact information and asked them to contact us if they had questions about the stream assessments, if they would like to participate in the assessment on their property, or if they did not want to allow an assessment of Dry Creek on their property. We had several landowners contact us to let us know that hunting would be occurring on their property in April. We had a couple of landowners that wanted to know exactly which days we'd be passing through their properties. We had only three landowners that asked us not to conduct assessments on their properties.

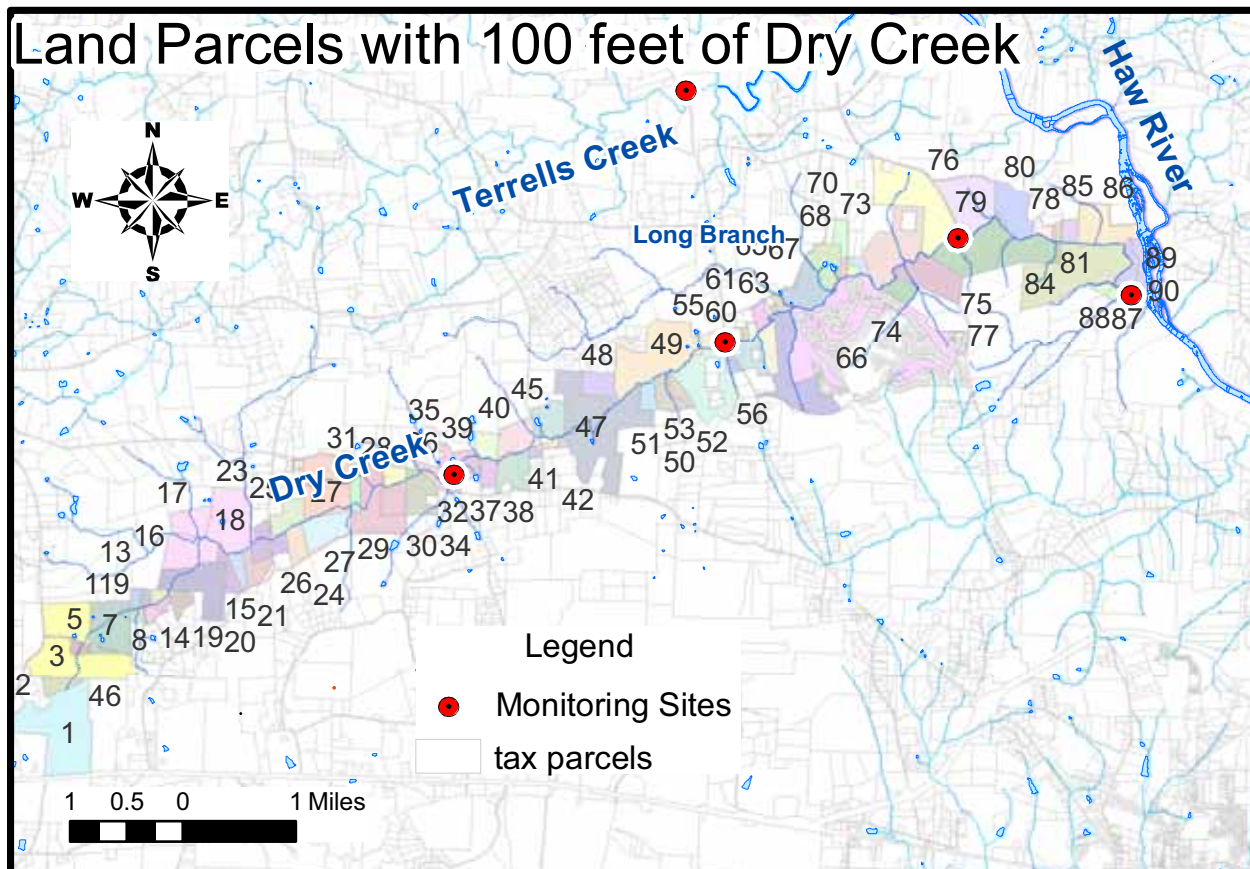


Figure 5. Monitoring Sites and Parcels within 100 feet of Dry Creek

Land parcels are colored so that adjacent parcels with the same landowner are the same color.

In March, HRA staff Catherine Deininger, walked approximately 11.3 of the 13 miles of Dry Creek and completed visual stream assessments for 63 reaches. Each assessment day she had another HRA staff member and/or volunteer with her to help. Getting to see Dry Creek expand from its headwaters to its confluence with the Haw was very helpful in the evaluation of the condition of the creek. After completing the GIS analysis on all the assessments conducted on Dry Creek, 61 letters were mailed to landowners containing the assessment scores for their section of Dry Creek. Along with the scores, each landowner was given specific recommendations on what they can do to protect Dry Creek and a copy of the HRA Stream Stewardship Handbook (handbooks are available for download from the HRA website www.hawriver.org under publications).

We found land along Dry Creek to be more rural compared to Pokeberry Creek with much timberland and farming. Deeply incised stream channels, divergent channels coupled with the numerous rock walls along the stream banks indicate that Dry Creek has a long history of being affected by rural living. Besides old rock walls we found what appeared to be the remains of old grist mills. The location of some of these remains corresponds to the location of Clarks Mill on Captain Ramsey's 1870 Map of Chatham. This old mill site and other stone crossings over Dry

Creek have created drops greater than foot deep that could be impeding fish movement along Dry Creek. The stream channel also invariably falls apart into braided channel or shows signs of significant erosion after flowing past these old rock walls which act as levees forcing the stormwater to flood on only one side of the creek or to serverly erode the stream channel.

Community meetings

As part of this project Catherine Deininger gave five presentation to various members of the Dry Creek and Pokeberry Creek communities. We found obtaining a good attendance at this meetings to be challenging. For the three meetings specifically aimed at landowners, the landowners with property adjacent to Dry and Pokeberry Creeks were mailed invitations. For the first presentation on Pokeberry Creek all the homeowner associations within the watershed were contacted and email invitations were also mailed to their memberships. Our best efforts seemed to be in reaching out to the Chatham County Environmental Review Board and the Soil and Water Conservation Board. Both boards were very impressed with the work done by the Haw River Assembly for this project and expressed interest in helping to see this work continued. A copy of each presentation is contained in Appendix I.

A Threatened Stream - Pokeberry Creek Community Meeting: Approximately 15 people from the neighborhoods in headwaters of Pokeberry Creek attended this meeting on January 26, 2008. Heather Boyettee from DWQ and Dave Penrose from NCSU attended as well. Some useful contacts were made with the Pokeberry Creek community though this meeting. Also some productive discussions were started about how septic systems in some of the older subdivisions were potentially effecting water quality in Pokeberry Creek.

Responsible Steamside Stewardship Workshop. Held on September 13, 2008, and hosted by Abundance Foundation at Piedmont Biofuels. Karen Hall, NCSU WQG, Bill Cure, Cure Nursery, and Catherine Deininger made presentations on stream stewardship, vegetation management in riparian areas, and riparian vegetation. We had 10 participants.

Two Threatened Creeks presentation for the Chatham County Environmental Review Board A presentation was given at their March 2009 meeting about the Two Streams project. An summary of the project was given with a focus on the results from the stormwater monitoring. Next steps for addressing the problems in the Dry Creek and Pokeberry Creek watershed were suggested, along with ideas on how Chatham County could participate. They asked to receive a copy of this final report and be kept informed of plans for future work in this watershed.

Dry Creek presentation for the Chatham Soil and Water Conservation A presentation was given to the Chatham SWCD board during their September 2009 meeting. The focus was on what potential sites for stormwater and agricultural best management practices had been identified while conducting the assessment of Dry Creek. The Chatham SWCD is considering applying for a 319 grant to implement some of these BMPs and to write a watershed restoration plan for Dry Creek.

Discoveries from Studying a Threatened Creeks: Dry Creek This last presentation was aimed primarily at landowners along Dry Creek. Unfortunately only a couple of people from the actual Dry Creek community attended. Some additional people from outside the Dry Creek community attended who were interested in the Two Threatened Creeks project. The chair of the Chatham County Planning Board attended and asked that a shortened version of this presentation be given to the Chatham County Planning Board.

Streamside Planting on Burchette Farm

After hearing about the Two Threatened Creeks project, the Burchette family contacted Catherine Deininger and asked for a stream assessment to be conducted on the section of Dry Creek on their farm. This property has been farmed by the Dorsett family since 1850 and is now owned by the Burchette family. Patricia Burchette is a descendant of the Dorsett family. The farm is located in the headwaters of Dry Creek. This section of Dry Creek has been highly affected by past farming and scored poor on the visual assessments. Cattle had access to the creek until May of 2008. Currently only a few horses are kept on the farm. Based on the assessment, recommendations were made for fencing farm animals away from the creek, streamside planting to enhance the riparian buffer, and the installation of a stream crossing. Catherine Deininger asked Kathryn Gardner, Chatham County SWCD, to visit the farm. Since that visit the Burchettes have applied for funding from the NC Conservation Reserve Enhancement Program (CREP) to help with building a fence and a stream crossing.

In May 2009, the funding needs for the Two Threatened Creeks project were reevaluated and a request was made to DENR for HRA to be allowed to use some of the funds for planting a riparian buffer along part of Dry Creek on the Burchette Farm. DENR gave permission for redistribution of funds, and on September 12, 2009, with the help of six boy scouts and seven adult volunteers, HRA staff planted a 150 by 30 foot buffer along some of the headwaters of Dry Creek.

Outputs and Results

The drought conditions in 2007 due to no significant rain events from May 2007 to October 2007 had to be taken into account in the analysis of the monitoring data collect for this project.

Macroinvertebrate Monitoring

The abundance, richness, and Biotic Index scores were calculated for each sample for both the Ephemeroptera, Plecoptera, and Tricoptera (EPT) families and for all the benthic macroinvertebrate (Total Taxa (TT)) families collected.

Biotic index scores are linearly proportional to the tolerance value each organism. The tolerance values range from 0 to 10. The more tolerant the organism is to pollution the higher the tolerance value. Therefore the lower the Biotic Index score the higher the water quality at that monitoring site. We found that in both Dry and Pokeberry Creeks that the two downstream sites tended to have higher Biotic Index scores each season compared to the two upstream sites.

Table 1. Benthic Macroinvertebrate Scores

Site	Season	Total Taxa			EPT		
		BI Score	Abundance	Richness	BI Score	Abundance	Richness
Dry 1	Apr-07	3.9	126	17	1.7	73	4
	Nov-07	monitoring site dry					
	Apr-08	6.1	555	24	2.0	167	8
	Nov-08	7.0	746	23	2.7	31	5
Dry 2	Apr-07	4.2	135	21	2.0	66	5
	Nov-07	6.3	468	24		4	2
	Apr-08	3.5	252	22	2.1	189	9
	Nov-08	6.6	346	28	2.7	80	11
Dry 3	Apr-07	4.3	163	22	2.2	80	7
	Nov-07	6.0	363	23		1	1
	Apr-08	4.6	129	21	2.4	65	6
	Nov-08	5.2	272	24	2.2	58	8
Dry 4	Apr-07	4.2	310	19	3.2	175	11
	Sept-08	4.0	92	12	2.9	64	2
	Nov-07	4.7	93	15	3.2	46	3
	Apr-08	3.5	276	18	2.6	210	7
	Nov-08	4.2	179	16	2.8	116	7
Poke 1	Apr-07	5.6	157	9		2	2
	Nov-07	5.2	94	19		5	4
	Apr-08	4.9	303	26	3.3	93	7
	Nov-08	3.6	477	21	2.1	275	8
Poke 2	Apr-07	4.9	223	24	3.2	136	9
	Nov-07	6.5	131	15		11	2
	Apr-08	5.4	151	14	2.6	96	6
	Nov-08	6.8	317	22	2.8	35	6
Poke 3	Apr-07	3.6	241	21	3.2	170	9
	Nov-07	3.9	74	19	3.2	42	8
	Apr-08	3.5	615	28	2.6	501	14
	Nov-08	2.2	1128	27	2.8	1006	13

Site	Season	Total Taxa			EPT		
		BI Score	Abundance	Richness	BI Score	Abundance	Richness
Poke 4	Apr-07	4.1	140	27	3.2	70	10
	Sept-07	3.1	62	8	2.9	35	4
	Nov-07	4.2	61	21		27	5
	Apr-08	5.0	270	31	2.6	97	10
	Nov-08	2.0	763	20	2.8	746	11
Terrells	Apr-07	3.2	249	27	3.2	180	12
	Nov-07	6.3	90	20		3	2
	Apr-08	4.7	140	19	2.6	76	7
	Nov-08 Team 1	4.5	1039	36	2.8	567	12
	Nov -08 Team 2	4.8	278	25	2.7	115	6
	Nov -08 Team 3	5.2	270	28	2.6	77	6

Summary tables were created for each sampling season that include the monitoring dates, monitoring teams, lab dates, EPT BI scores, TT BI Scores, stream flow, pH, Nitrate and Phosphorus values were completed for each sampling season. The summary tables for each season are contained in Appendix E.

In the discussion below for each creek, we look at the Total Taxa values which in general followed the same trends as the EPT values but had a larger spread in BI scores. Also there are a few holes in the EPT BI scores, since BI scores were not calculated when the abundance was less than 30. According to the *SOP for Benthic Macroinvertebrates (2006)* “BIEPT values have little meaning when EPT N (abundance) is very low (<30). In these cases, the EPT taxa could be mainly drift organisms from upstream, with no development of tolerant taxa at the stressed site.” Primarily because of the drought we had seven samples where the EPT abundance was less than 30. We had no samples where the total number of benthic macroinvertebrates was less than 30.

Pokeberry Creek: All the sites at Pokeberry Creek except for Poke 2 (which is the first site downstream of Briar Chapel) had continuous flow throughout the project period including the 2007 drought. Poke 2 is located at the end of one of Pokeberry Creeks many wetlands. The stream channel as it goes though the wetland is well defined, but the streambed differs from the other sites in that it consists primarily of sand.

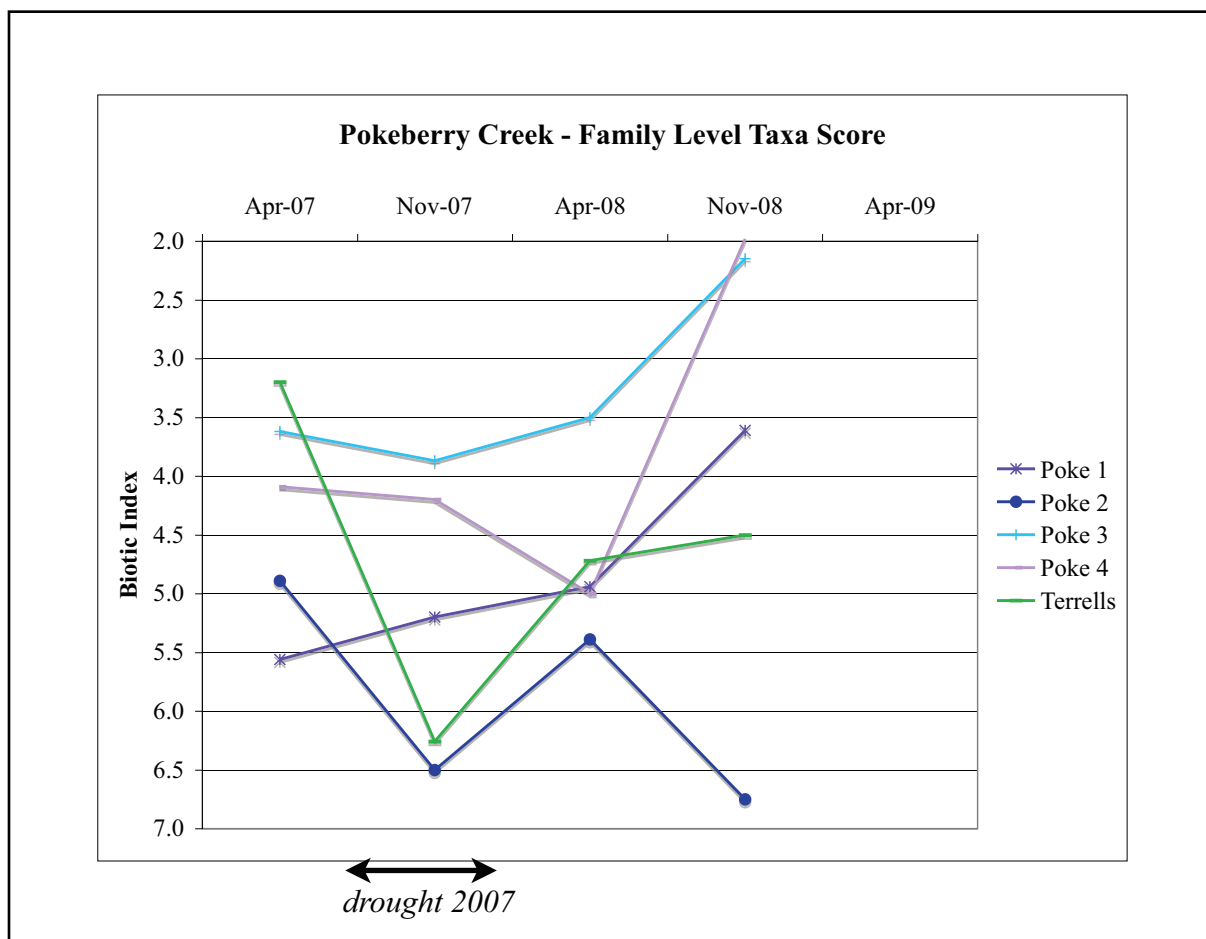


Figure 6. Total Taxa Biotic Index overtime for Pokeberry Creek

Note the y-axis on the graph is oriented such that lower water quality scores are lower on the graph.

- The Biotic Index Total Taxa (BI TT) scores for Pokeberry Creek ranged from 2.0 to 6.0 with a mean of 4.5.
- The BI TT scores appear to be improving over time except for Poke 2.
- The BI TT do not appear to be seasonally dependent except for Poke 2.
- The Poke 3 monitoring site which is located at the same site that DWQ monitors consistently had the best Biotic Index TT

Dry Creek: During the drought all the monitoring sites on Dry Creek except for the most downstream site went dry. For the collection in November 2007, the sites on Dry Creek were wet but they were more a series of pools than a flowing stream except for the most the most upstream site on Dry Creek which was still completely dry. We were amazed though at the abundance of benthic macroinvertebrates we found in those pools. The macroinvertebrates found for this sampling period were dominated by facultative species such as dragonflies and aquatic beetles that can survive low oxygen situations.

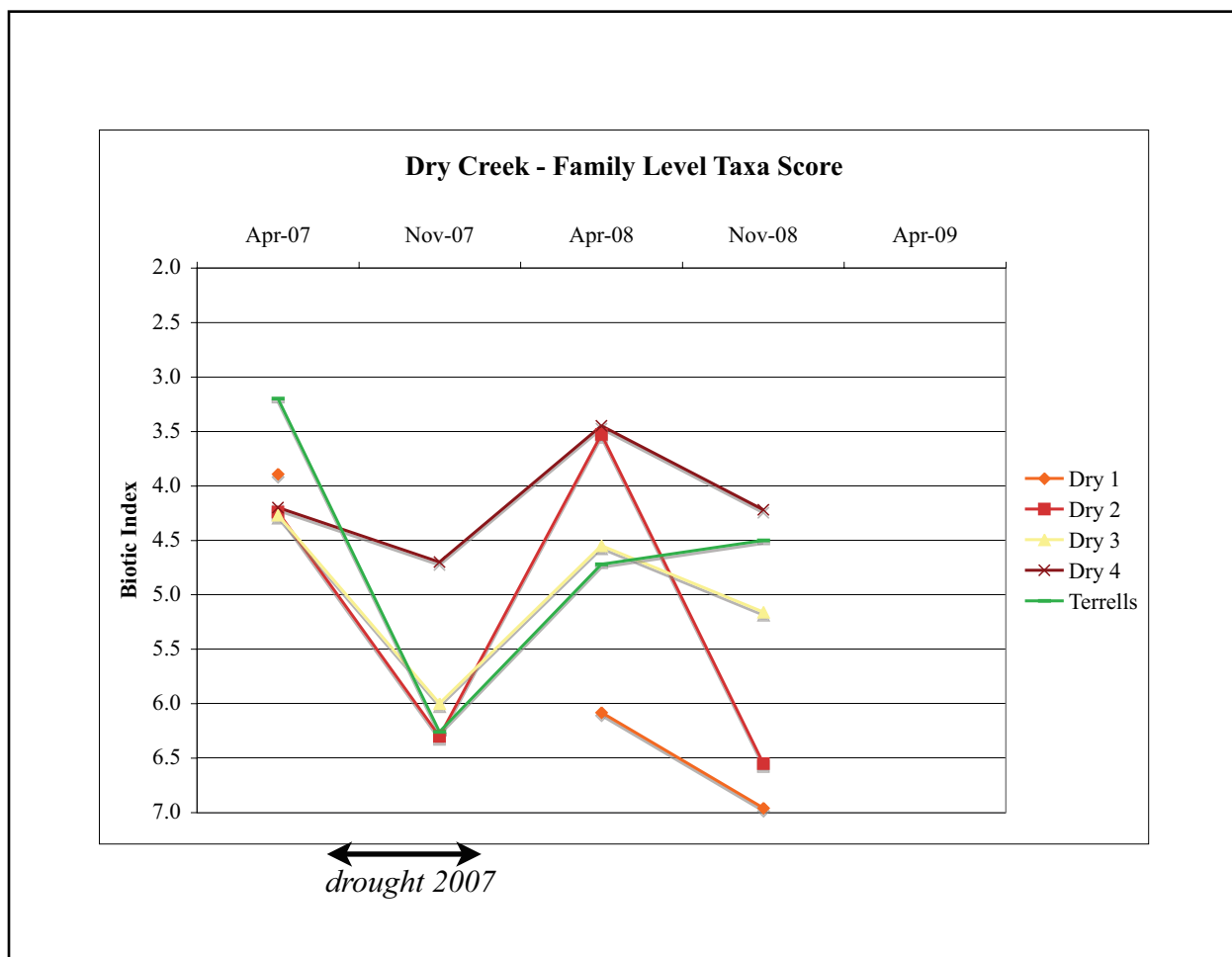


Figure 7. Total Taxa Biotic Index overtime for Pokeberry Creek

- The BI TT range for Dry Creek was 3.5 to 7.0 with a mean of 4.9, similar to the range and mean obtained for Pokeberry Creek.
- The improvement of the BI TT in the spring and its decline in the fall indicate that tolerance level of the macroinvertebrate communities in Dry Creek are somewhat seasonally dependent.
- There appears to be a slight decline in the BI TT scores over time for Dry 1 and Dry 2. This could be due to the macroinvertebrate communities in these upstream sites still recovering from the drought.
- The BI TT scores appear to be improving over time at the downstream sites, Dry 3 and Dry 4.

Terrells Creek Sampling Study: For this additional sampling study, we found the most abundant family from each order (Trichoptera, Ephemeroptera, Plecoptera) was independent of the sampling site. However, the location of the sampling site is shown to exhibit a strong influence on insect abundance, as shown in Figure 8. This indicates that even if factors such as season and flow level are not important, the current sampling procedure is not robust enough to provide

data for specific insect populations which is predictive, in a quantitative sense, with respect to stream water quality. By comparison, the overall richness scores show much less variability, indicating that this variable is likely to be a better predictor of stream health. Since diversity would be expected to decrease with a significant decrease in water quality, anomalous decreases in richness are potentially a cause for concern.

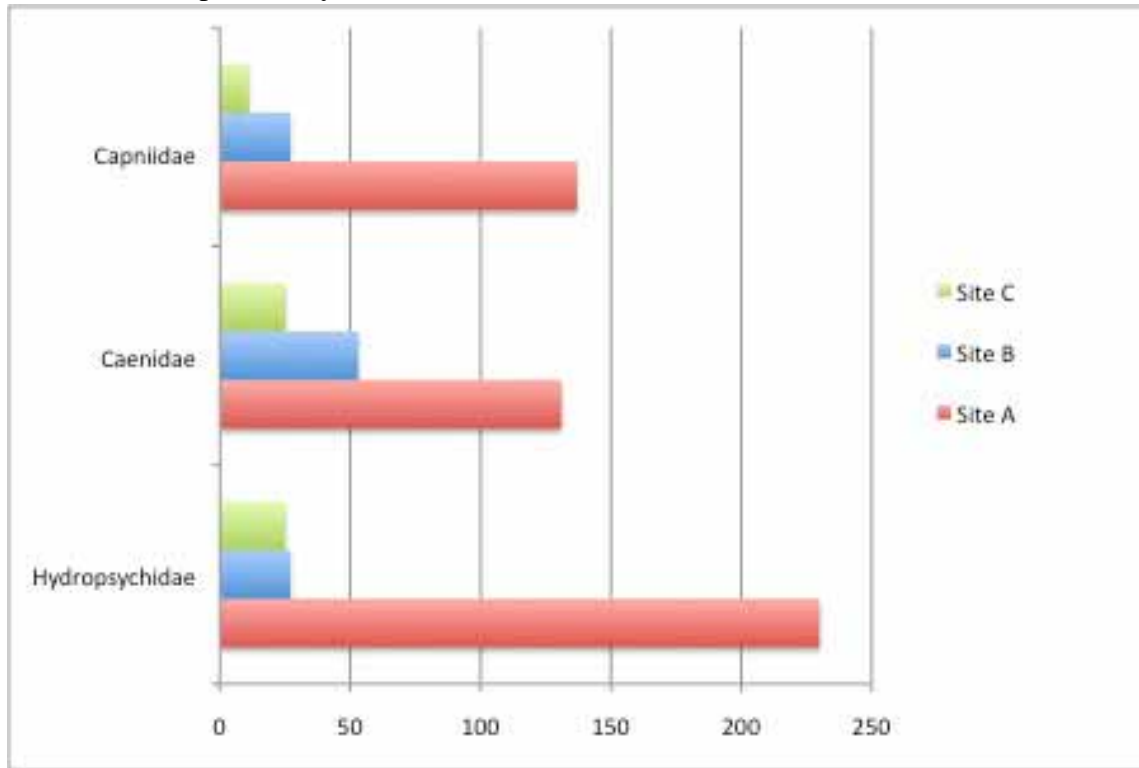


Figure 8. Insect abundance by sampling site, Terrell's Creek, November 2008



Hydropsychidae



Capniidae



Caenidae

The box plot shown in Figure 9 shows the range of values obtained by applying the BI TT and BI EPT conventions to data obtained from Terrell's creek. While, each of the scoring conventions derives from the same set of data, the BI EPT Score demonstrates significantly less variability relative to the BI TT Score. The primary goal of the box plot is to provide a stream-specific, graphical basis to determine whether a particular data point is likely to be an outlier based on historical data. As sampling continues, this precision of this approach will increase accordingly. Outliers are expected to be associated with specific events, which may be either natural such as extreme drought or of anthropogenic origin.

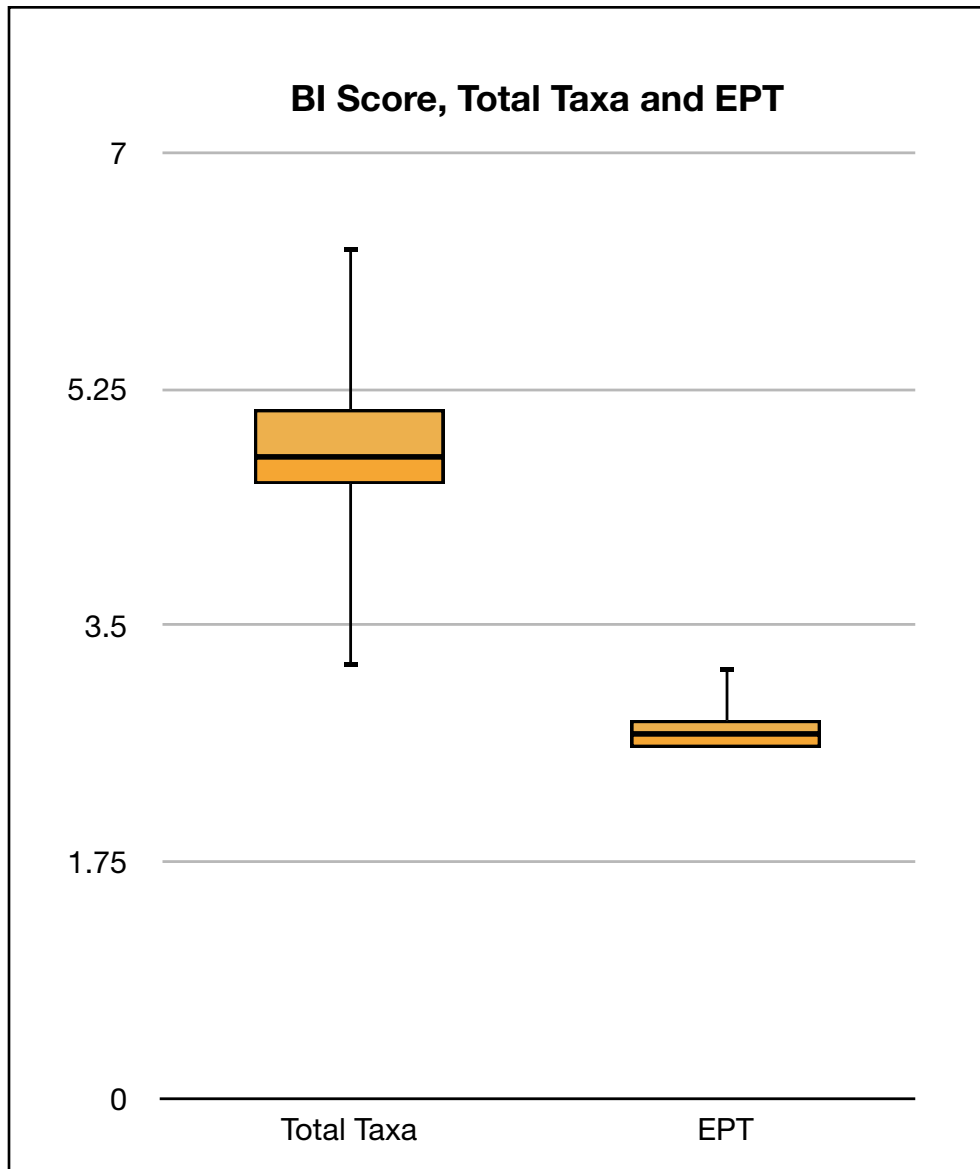


Figure 9. Box plot for Biotic Index Scores for all Terrells Creek samples

Stormwater Monitoring

The drought of 2007 and the fact that not every storm event during the period was monitored limit the comparability of the results with other studies; however, the primary purpose of the stormwater monitoring was to assess differences between upstream and downstream water quality. The drought may have affected the upstream-downstream relationship as well.

Table 2. Summary of Storm Sample Data for Dry and Pokeberry Creeks

	Discharge (gal)	Turb (ntu)	TKN (mg/L)	NH ₄ -N (mg/L)	NO _x -N (mg/L)	TN (mg/L)	TP (mg/L)	TSS (mg/L)
Pokeberry Creek-upstream								
mean	516,710	105	1.24	0.17	0.18	1.42	0.26	210
median	352,250	96	1.12	0.09	0.15	1.27	0.22	146
count	28	21	22	22	22	22	22	22
Pokeberry Creek-downstream								
mean	7,646,500	172	0.87	0.13	0.19	1.05	0.20	113
median	7,349,000	107	0.79	0.07	0.17	0.96	0.19	99
count	25	26	26	26	26	26	26	26
Dry Creek-upstream								
mean	34,081,804	78	1.24	0.11	0.54	1.78	0.24	126
median	7,831,621	49	1.11	0.10	0.60	1.71	0.20	49
count	27	22	23	23	23	23	23	23
Dry Creek-downstream								
mean	91,578,496	112	1.09	0.17	0.27	1.36	0.24	105
median	16,801,000	72	1.02	0.08	0.26	1.28	0.19	53
count	27	23	25	25	25	25	25	25

A complete discussion of analysis for the stormwater monitoring conducted by NCSU WQG is contained in Appendix D.

Pokeberry Creek: The hydrology of Pokeberry Creek is quite complicated which made interpretation of the stormwater data difficult.

Figure 10 contains the differences in loads for Pokeberry Creek, which shows that the storm event loads at Pokeberry were small only through October of 2007 indicating that Pokeberry Creek recovered quickly from the drought conditions.

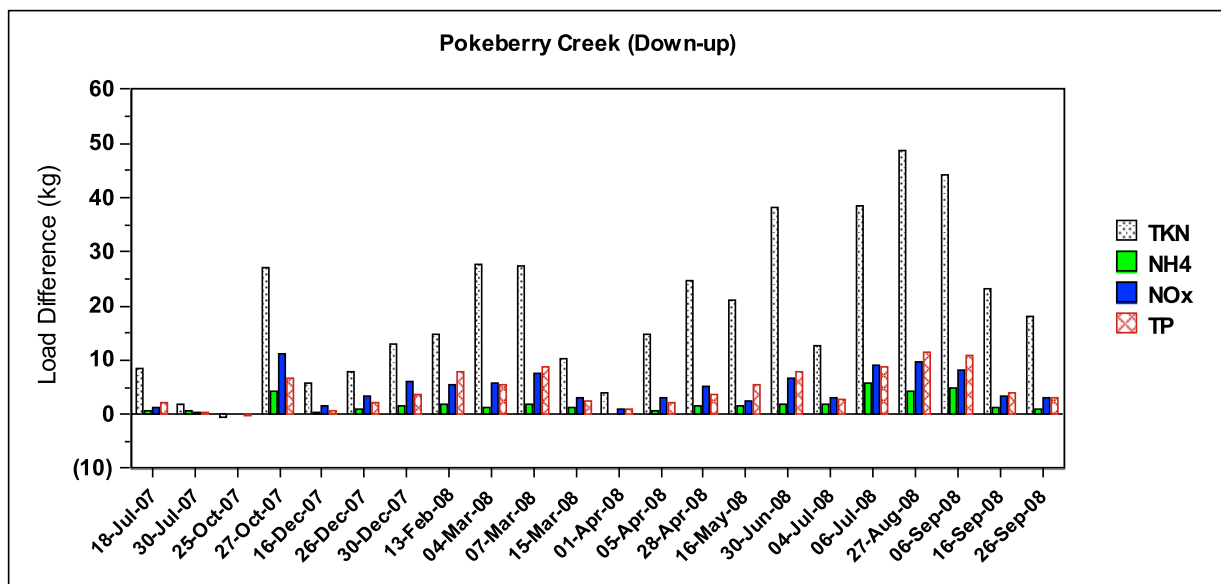


Figure 10. Differences in storm loads from upstream to downstream for Pokeberry Creek

- Mean concentrations of all the pollutants except organic nitrogen and turbidity were greater at the upstream sites
- Total Suspended Solids was skewed due to high concentration of coarse sediment in March 2008 which was the first heavy rainfall after the drought of 2007.
- Higher turbidity downstream may be due to smaller organic particles from flushing out of the wetlands
- Large areas of wetlands may be acting as filters for nitrogen, phosphorus, and sediment.
- Mean concentrations for all pollutants except nitrate+nitrite nitrogen were similar between Dry and Pokeberry Creek.
- The mean turbidity levels in both Pokeberry sites were greater than the state standard for most receiving waters (50 NTU).
- No statistical difference in storm event loads between upstream and downstream sites.

In addition to nutrients and sediment, limited sampling for bacteria occurred. Three grab samples were collected at Pokeberry up in April-June 2008 and one at Pokeberry down. E. coli counts ranged from 9 to 150 mpn/100ml with an average of 61 mpn/100ml. These levels are not uncommon for similar watershed streams and thus are not considered a concern.

Dry Creek: The hydrology on Dry Creek appeared to be more straightforward. There was a pretty clear increase in all pollutant loading/export from upstream to downstream, except for inorganic (nitrate+nitrite) nitrogen.

Figure 11 contains the differences in loads for Dry Creek, which shows that the storm event loads relatively small until the spring of 2008 indicating lingering effects of the drought of 2007.

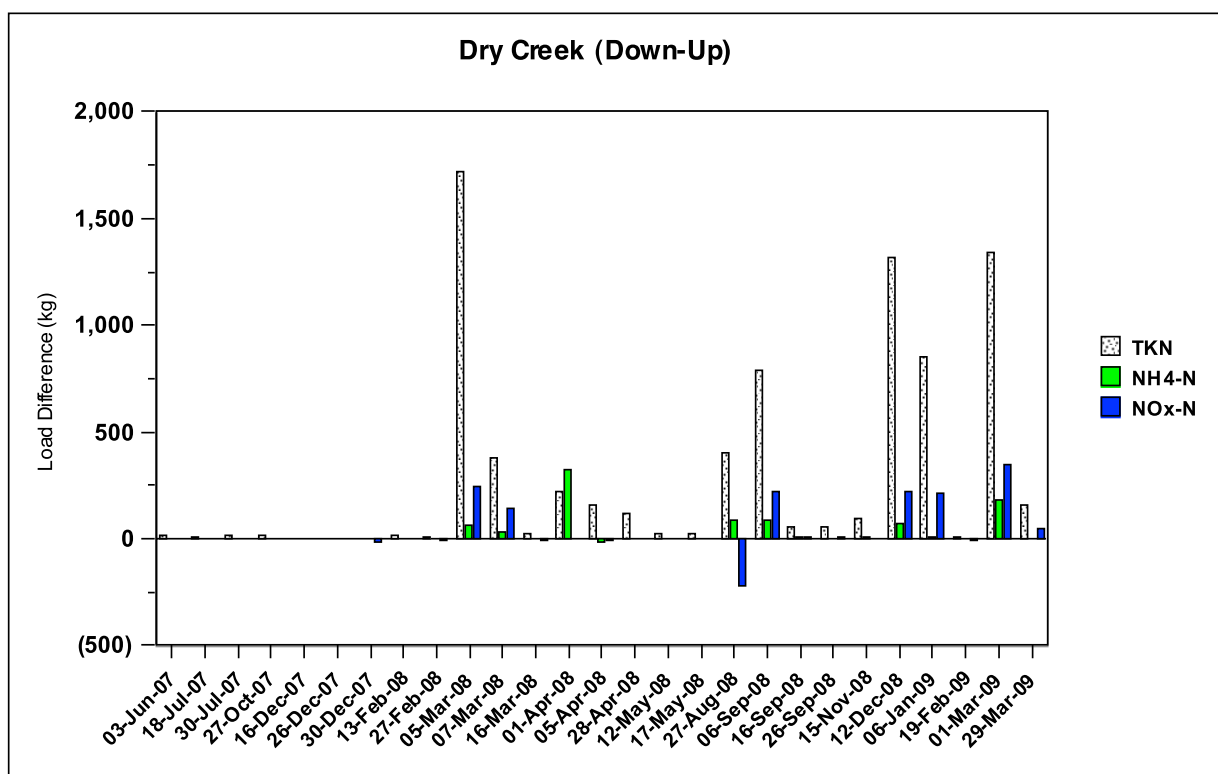


Figure 11. Differences in storm loads from upstream to downstream for Dry Creek.

- Discharge and pollutant movements in Dry Creek are storm event driven.
- Just like Pokeberry TSS decreased from upstream to downstream while Turbidity increased (difference was less than at Pokeberry).
- Mean ammonium nitrogen concentration was greater at the downstream site which may indicate organic waste.
- Mean phosphorus concentrations stayed the same between sites.
- Mean concentrations of other pollutants (TKN, NO_x-N, TN) decreased from upstream to downstream.
- Approximately half of the mean turbidity levels at both Dry Creek sites were greater than the state standard for most receiving waters (50 NTU).

Visual Stream Assessments

The overall score for a reach is an average of the individual scores for the 15 characteristics. If a characteristic is not applicable to a site, it was simply not included in the averaging. For instance a score for *Manure Presence* was included in the averaging only when farm animals had access to the creek or riparian area.

Overall score = or < 6.0	<i>Poor</i>
6.1 to 7.4	<i>Fair</i>
7.5 to 8.9	<i>Good</i>
= or > 9.0	<i>Excellent</i>

Monitoring Sites Assessments: Visual stream assessments were conducted at each of the monitoring sites the first year of the project. Below are the scores for each monitoring site.

- i) Dry 1 - *Good* with an overall score of 8.0
- ii) Dry 2 - *Good* with an overall score of 8.6
- iii) Dry 3 - *Excellent* with an overall score of 9.2
- iv) Dry 4 - *Excellent* with an overall score of 9.5
- v) Poke 1 - *Fair* with an overall score of 6.7
- vi) Poke 2 - *Good* with an overall score of 8.8
- vii) Poke 3 - *Excellent* with an overall score of 9.7
- viii) Poke 4 - *Good* with an overall score of 8.8
- ix) Terrells Creek (reference stream) - *Excellent* with a score of 9.8

All the sites that had an overall score of *Good* or *Fair* scored low for bank stability. An abundance of algae was noted at all the monitoring sites indicating a problem with nutrient enrichment. Poke 2 *Fair* score reflects its deeply incised channel preventing access to its floodplain. Also the macroinvertebrate community during the initial assessment of this site were dominated by tolerant species. Overall the sites were consistent with condition of the stream within the section of the Dry Creek or Pokeberry Creek where they were located.

Pokeberry Creek Assessments

Land use in the Pokeberry Creek watershed is moving away from farming and timber production to residential. Only one farm with cattle is located along the main stem of Pokeberry Creek in comparison to a couple of dozen farms along Dry Creek. The cattle farm along Pokeberry Creek was not interested in participating in a stream assessment so unfortunately that one farm is not included in the results for this project.

From upstream of Briar Chapel Subdivision to Highway 15-501, Pokeberry Creek flows through a string of wetlands and beaver ponds. Pokeberry Creek has a defined channel though most of these wetlands, but where it disappeared completely, we were not able to score the wetland using the NRCS SVAP. The wetlands and beaver ponds are creating amazing undisturbed wildlife

habitat in this primarily residential watershed. Many of the potential conservation easements identified during the assessment are to protect these wetlands. At the beginning of 2008, Chatham County passed a new buffer ordinance that requires 50 foot buffers on wetlands and linear wetlands for new development. Several of the wetland areas identified for conservation along Pokeberry Creek are still undeveloped, so those areas will be provided some protection by the new buffer rules, if they are eventually developed.

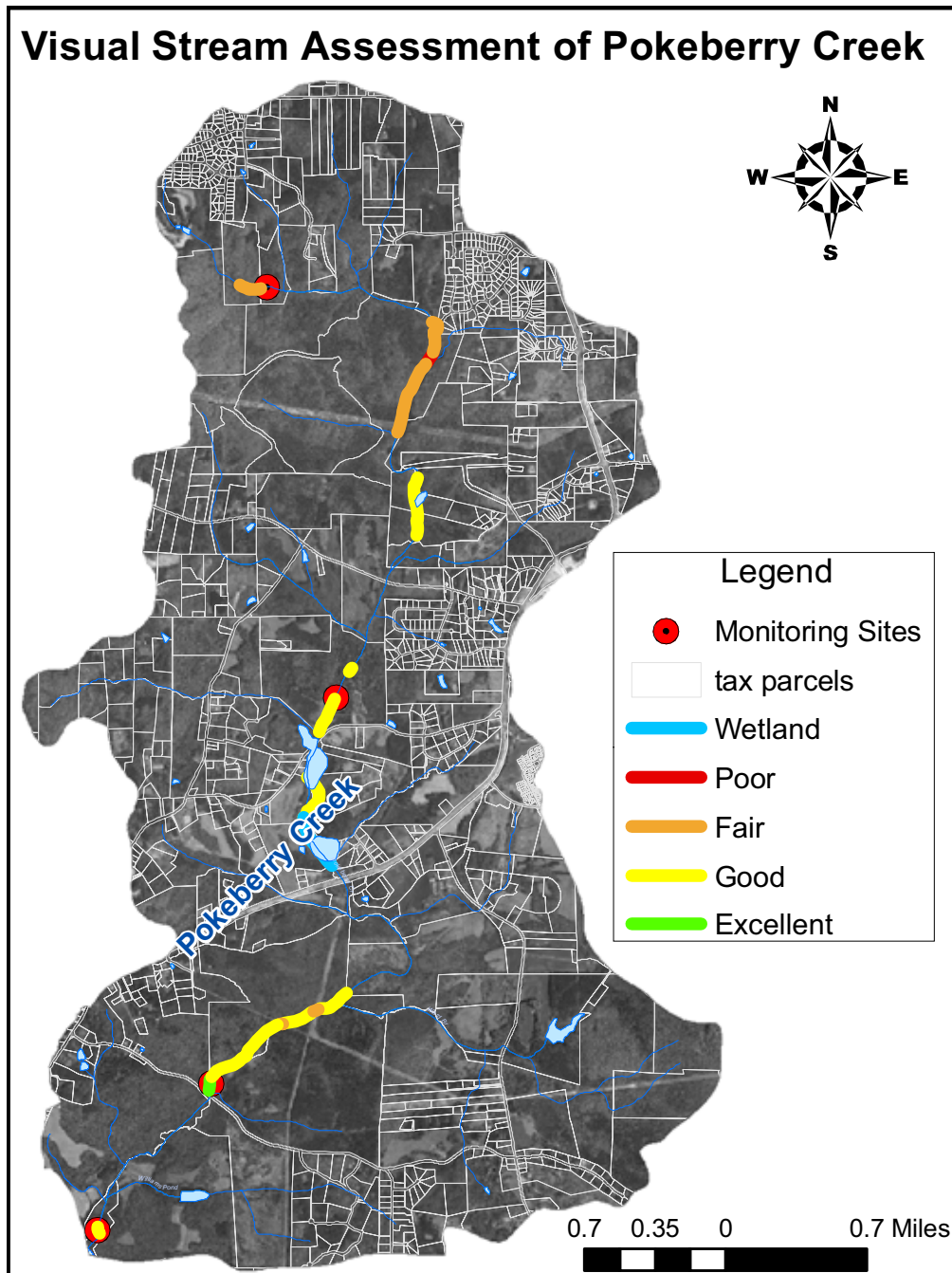


Figure 12. Scores for Visual Assessments along Pokeberry Creek

Table 3. Pokeberry Creek Visual Stream Assessments Scores

The scores are highlighted to indicate *Poor*, *Fair*, *Good*, and *Excellent*.

Number	Parcel #	Channel Condition	Hydrologic alteration	Riparian Zone	Bank Stability	Water Appearance	Nutrient Enrichment	Barriers to Fish	Fish Cover	Pools	Macroinvertebrate Habitat	Canopy Cover	Manure Presence	Rifle Embeddedness	Macroinvertebrates Observed	Overall Score	Recommendations
1	25	10	10	10	10	7	10	10	5	10	7	10		1	15	8.8	Conservation*
2	12	5	10	6	7	3	10	10	3	1	3	1		1		5.0	Streambank stabilization
3	12	10	10	8	8	3	10	10	5	3	7	10		1		7.1	Invasive removal, riparian enhancement
4	12	8	10	10	10	2	10	10	6	10	7	1		1		7.1	Stormwater BMPs
5	15,12	7	7	8	8	7	8	3	8	3	7	10				6.9	River Watch Monitoring Site
6	8	3	10	10	3	5	3	3	10	3	10	10		3	2	5.8	Conservation*
7	9	7	5	10	7	5	3	3	10	3	10	10		8	6	6.7	Conservation
8	32, 33	10	10	10	10	3	5	10	10	10	10	10		3	10	8.5	Conservation*
9	32	3	10	10	10	3	5	10	10	10	10	10		3	10	8.0	
10	34	wetland not scored															Conservation*
11	21	8	8	10	5	5	10	10	10	10	10	10		1	6	7.9	Conservation
12	21, 20	6	3	10	2	5	10	10	10	10	10	10		1	15	7.8	Conservation
13	25	10	10	10	10	7	10	10	5	10	7	10		1	15	8.0	Conservation*
14	45	7	10	10	7	10	7	10	10	10	10	10		10	15	9.7	Conservation
15	45	5	8	10	3	3	3	10	10	10	10	10		10		7.7	
16	45	5	8	10	3	5	3	10	10	10	10	10		10		7.8	Conservation
18	45	7	10	10	7	10	3	10	10	10	10			10		8.0	Conservation
17	45	3	8	1	3	5	3	10	10	10	10	10		10		6.9	Stabilize stream crossing
19	45	3	8	1	3	5	3	10	10	10	10			10		6.9	Stabilize stream crossing
20	45	7	10	10	7	8	5	10	10	10	10	10		10		8.9	Conservation
21	52	3	7	10	3	7	10	10	10	10	10	10		10	15	8.8	Conservation
Average score		6	9	9	6	5	7	9	9	8	9	8		5	12	8	

* wetland

- Visuals Assessment Results for Pokeberry Creek
 - i. 2 *Poor*, 6 *Fair*, 11 *Good*, 1 *Excellent* scores.

- ii. Looking at the average scores, *Water Appearance* and *Riffle Embeddedness* had the lowest averages reflecting the high level of sediment in Pokeberry Creek which is causing the water appearance to be cloudy and filling in the riffles.
- iii. The overall average score was *Good* (8.0)
- Potential BMP and Conservation sites along Pokeberry Creek
 - i. 13 Recommended areas for conservation easements
 - ii. 2 Riparian buffer plantings
 - iii. Streambank stabilization at Briar Chapel Parkway bridge over Pokeberry Creek wetland
 - iv. Stormwater BMPs (bioretention, level spreaders) along Pokeberry Creek wetland within Briar Chapel to protect wetland from runoff from spray irrigation and muddy runoff from power cut.
 - v. 2 Stabilization of 2 stream crossings by gas line and power cuts

Dry Creek Assessments: Streambank and channel erosion were continually noted during the assessment of Dry Creek. Bank stability was scored low in all but a couple of the reaches due to either an incised or an actively widening stream channel. Upstream of Highway 87 the stream channel is often incised 6 to 8 feet deep. After crossing Highway 87 the stream channel begins to contain more bedrock and the channel starts to erode more horizontally than vertically. After Old Graham Road the stream channel is primarily bedrock and large cobble. The stream channel becomes wide and often breaks up into braided channels.

All but a few of the cattle and horse farms along Dry Creek have fenced their animals away from the creek. Unfortunately a number of these fences are within a 10 feet of the stream channel so when the creek floods much of the animal waste is washed into creek.



Trees stranded in the middle of Dry Creek due to eroding streambanks and widening stream channel.

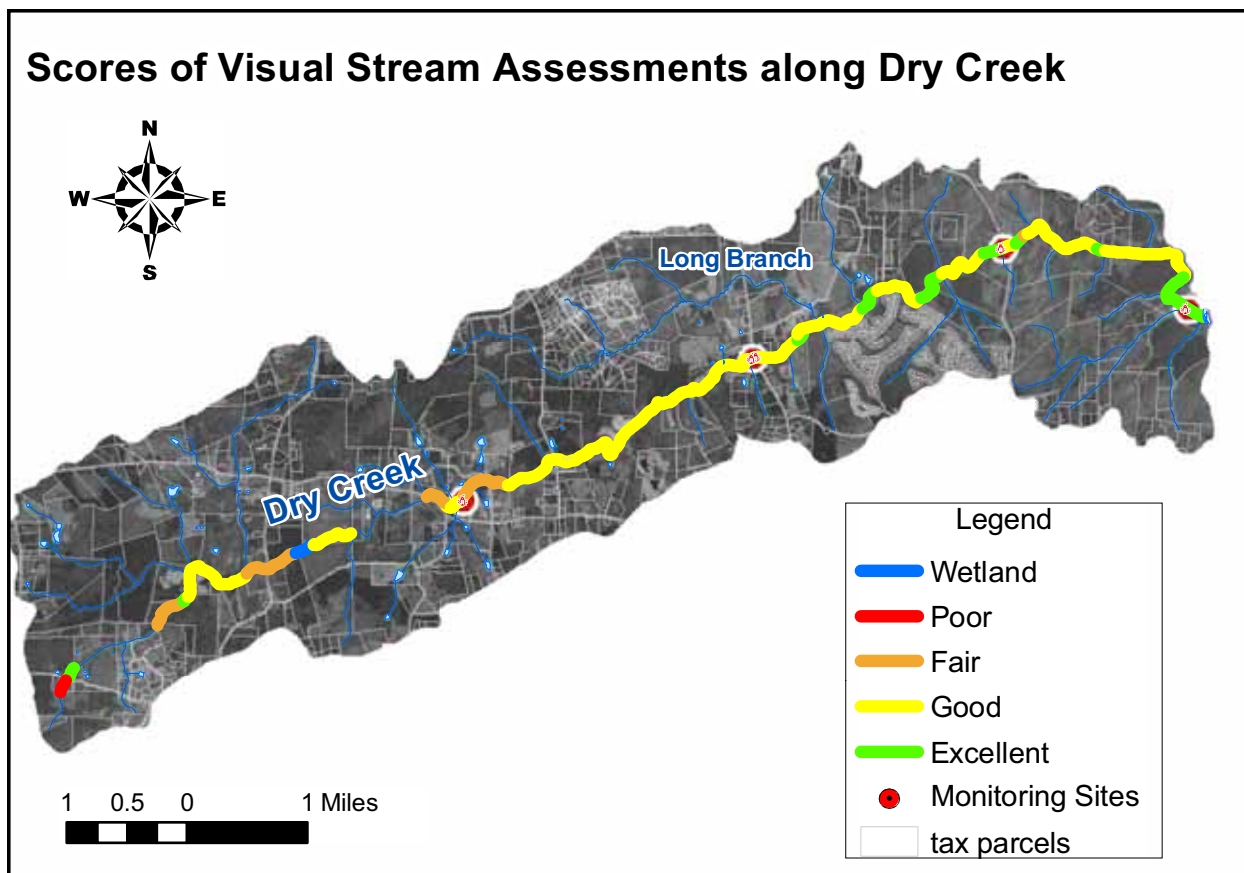


Figure 13. Mapped Scores for Visual Assessments along Dry Creek



Eroded streambanks and incised stream channels were frequently seen along Dry Creek.

Table 4. Dry Creek Visual Stream Assessments

The scores are highlighted to indicate *Poor*, *Fair*, *Good*, and *Excellent*.

Number	Parcel #	Channel Condition	Hydrologic alteration	Riparian Zone	Bank Stability	Water Appearance	Nutrient Enrichment	Barriers to Fish	Fish Cover	Pools	Macroinvertebrate Habitat	Canopy Cover	Manure Presence	Riffle Embeddedness	Macroinvertebrates Observed	Overall Score	Recommendations
1	14, 15	7	10	2	7	8	10	10	5	3	7			3	15	7.3	Riparian enhancement
2	15	3	7	1	5	10	10	5	5	3	10	10	3	10	15	6.9	Riparian enhancement, farm crossing
3	15	10	10	10	3	7	10	10	10	10	10	10		8	15	9.5	Farm crossing
4	16	10	10	5	1	5	10	10	10	10	10	10			15	8.8	
5	16	7	10	3	4	7	7	10	10	10	10	10		15		8.6	Riparian enhancement
6	17	7	10	3	5	5	7	10	10	10	10	10		10	15	8.6	Riparian enhancement
7	18	10	10	10	5	3	7	10	10	10	10	10		3		8.2	Farm crossing
8	18, 20, 22	10	10	10	1	3	7	10	10	10	10	10		10		8.4	Farm Crossing
9	22, 23,	3	10	5	1	3	3	10	8	10	10	10	1	5		6.1	Fence, stream restoration
10	25, 24	3	10	7	3	3	7	10	5	8	7	10	5	1		6.1	Fence
11	25, 26	7	10	5	2	3	7	10	5	8	7	10	5	1		6.2	Fence, riparian enhancement
12	25, 24	7	10	7	3	3	7	10	5	8	7	10	5	1		6.4	
13	27, 25, 26	wetland not scored															
14	27	10	10	7	3	3	7	10	10	8	10	10		1		7.4	
15	27	10	10	8	3	3	8	10	10	8	10	10		1		7.6	
16	27	10	10	7	4	3	4	10	10	10	10	10		10	15	8.7	Discharge pipe, historical assessment
17	35, 33	4	10	1	3	5	5	1	10	10	10			10	15	7.0	Riparian enhancement
18	35, 33	10	7	10	2	6	4	3	10	10	10	10		10	15	8.2	
19	33, 36	10	10	10	1	6	7	3	10	10	10	10		8	15	8.5	
20	36, 37	10	10	10	1	5	5	3	10	10	10	10		5	15	8.0	
21	27, 36	10	10	1	1	5	5	3	10	10	10	10	5	5	15	7.1	Riparian enhancement
22	39, 38	10	10	3	1	3	4	3	10	10	10	10		8	10	7.1	Riparian enhancement

Table 4. Dry Creek Assessments (continued)

Number	Parcel #	Channel Condition	Hydrologic alteration	Riparian Zone	Bank Stability	Water Appearance	Nutrient Enrichment	Barriers to Fish	Fish Cover	Pools	Macroinvertebrate Habitat	Canopy Cover	Manure Presence	Riffle Embeddedness	Macroinvertebrates Observed	Overall Score	Recommendations
23	41, 40	10	10	10	2	3	4	3	10	10	10	10		10		7.7	
24	40, 41	10	10	10	2	3	4	3	10	10	10	10		10	15	8.2	
25	45, 43	10	10	1	3	5	9	10	10	10	10	10	5		15	8.3	Riparian enhancement
26	44, 46, 45	10	10	9	1	5	9	10	10	10	10	10				8.5	
27	47	10	10	5	3	5	9	10	10	10	10	10				8.4	
28	47	10	10	10	2	5	9	10	10	10	10	10				8.7	
29	47	10	10	5	3	5	9	10	10	10	10	10				8.4	Riparian enhancement
30	47	7	10	10	2	5	9	1	10	10	10	10			15	8.3	
31	47, 49, 50	7	10	10	2	5	9	3	10	10	10	10				7.8	
32	53, 49	5	10	10	7	7	9	3	10	10	10	10			15	8.8	
33	53, 49	5	10	5	7	7	9	3	10	10	10	10			15	8.4	Riparian enhancement
34	53, 49	10	10	10	2	7	9	3	10	10	10	10		10	15	8.9	Farm crossing
35	53, 49	9	10	1	7	7	9	3	10	10	10	10		10	15	8.5	Riparian enhancement
36	49, 54, 55	10	10	10	5	5	9	3	10	10	10	10		10	10	8.6	
37	55, 56	7	10	10	7	5	5	3	10	10	10	10		10	15	8.6	
38	58, 56, 59	10	10	10	5	5	7	3	10	10	10	10				8.2	
39	60, 61	10	10	3		5	7	3	10	10	10	10				7.8	Riparian enhancement
40	61, 60	10	10	10	5	7	7	3	10	10	10	10		10	15	9.0	Potential River Watch site
41	62	10	10	8	6	7	7	3	10	10	10	10		10		8.4	
42	63, 64, 65	10	10	9	3	7	7	3	10	10	10	10		10	15	8.8	
43	67, 86	10	10	3	3	7	7	3	10	10	10	10	5	10	15	8.1	Riparian education, stormwater BMPs
44	67, 66, 68	10	10	10	5	7	7	3	10	10	10	10		10	15	9.0	
45	66, 69	10	1	5	7	7	3	10	10	10	10			10		7.5	Riparian enhancement

Table 4. Dry Creek Assessments (continued)

Number	Parcel #	Channel Condition	Hydrologic alteration	Riparian Zone	Bank Stability	Water Appearance	Nutrient Enrichment	Barriers to Fish	Fish Cover	Pools	Macroinvertebrate Habitat	Canopy Cover	Manure Presence	Riffle Embeddedness	Macroinvertebrates Observed	Overall Score	Recommendations
46	66, 73, 74	10	7	10	3	3	7	10	10	10	10	10		10	15	8.8	Potential River Watch site
47	74, 73, 75	10	10	10	2	5	7	10	10	10	10	10		10	15	9.2	Stormwater BMPs
48	75, 73	10	10	10	3	5	7	10	10	10	10	10				8.6	
49	76, 77	10	10	10	7	5	7	10	10	10	10	10		10	5	8.8	
50	79, 78	7	10	10	5	5	7	10	10	10	10	10		10	15	9.2	
51	79, 78	7	7	10	3	5	7	10	10	10	10	10				8.1	
52	79, 78	6	10	10	5	5	7	10	10	10	10	10		10	15	9.1	Stream crossing
53	79	10	10	1	7	5	7	10	5	10	10	1		10		7.2	Riparian enhancement
54	79	5	10	10	3	5	7	10	10	10	10	10		10	15	8.8	Conservation easement
55	78, 89, 82	3	10	10	3	5	7	10	10	10	10	10		10		8.2	Conservation easement
56	82, 83, 81	10	10	10	10	5	7	10	10	10	10	10		10		9.3	Conservation easement
57	85, 84	3	10	10	3	5	7	10	10	10	10	10		10		8.2	Conservation easement
58	84, 86, 89	3	10	10	3	5	7	10	10	10	10	10		10		8.2	Conservation easement
59	84, 90	7	10	10	4	5	7	10	10	10	10	10		10		8.6	Conservation easement
60	84,90	3	10	10	3	5	7	10	10	10	10	10		10		8.2	Conservation easement
61	89	10	10	10	7	5	7	10	10	10	10	10		10	15	9.5	Conservation easement
62	4	7	5	1	3			10			7	10	3	5		5.7	Riparian enhancement, pasture fence
63	5	7	10	10	10	10	7	10	10	8	10	10		10		9.3	Conservation easement
Average Score		8	10	7	4	5	7	7	9	9	10	9	4	6	15	8	

- Visual Assessment Results for Dry Creek
 - i. 1 *Poor*, 11 *Fair*, 41 *Good*, and 9 *Excellent*
 - ii. Looking at the average scores, *Manure Presence* and *Bank Stability* had the lowest scores.
 - iii. The overall average score was *Good* (8.0).
- Potential BMPs along Dry Creek
 - i. Riparian enhancement at Burchette Farm (planted on October 12, 2009)
 - ii. 16 Riparian buffer plantings (scored less than 3 on Riparian Zone in visual assessment or noted during assessment that planting would be useful)
 - iii. 5 Pasture fences
 - iv. Stream restoration site within old cattle pasture
 - v. 7 Actively used farm or stream crossings that could be stabilized
 - vi. 3 Sites that could use stormwater BMPs (bioretention, level spreaders) in new development
 - vii. 3 Sites good sites identified for educational stream watch sites
 - viii. Educate new landowners in Chapel Ridge and the Estates about management of riparian areas.
 - ix. 9 Recommended areas for conservation easements



Primarily the *Excellent* scores for Dry Creek were downstream of Old Goldston Road where Dry Creek flows through the Rock Rest community before emptying into the Haw River. 8 of 9 recommendations for conservation easements along Dry Creek were made for this section.

HRA staff, Kathy Buck, assisting in the assessment of Dry Creek in the downstream reaches just before the confluence with the Haw.

Outcomes and Conclusions

Pokeberry Creek and Dry Creek are just two of many threatened streams in Chatham County. They are already declining and are threatened by increased stormwater runoff from increased development. We found from our Two Threatened Creek project that our concern for increased pollutants from new development was justifiable. We also developed a better understanding of what threats already existed in these watersheds.

Dry Creek has been impacted by a long history of farming that shaped Dry Creek well before the agricultural BMPs we advocate today were developed. In the recent past, Dry Creek was considered to be one of the cleaner creeks emptying into the Haw River. Much of the forested land that was providing a chance for Dry Creek to recover from the intense farming in it's headwater streams is now being cleared and replanted with houses. Unless careful attention is paid to reducing this new load of polluted runoff, Dry Creek will continue to decline.

Pokeberry Creek is a more developed watershed than Dry Creek. It already is the home to many residential neighborhoods. It also is the home to many beavers and has many lovely wetland habitats that have done much to protect the downstream water quality in Pokeberry Creek. Muddy runoff from construction sites is being captured by these wetlands. Without additional protection these wetlands will start to decline. The large wetland in Briar Chapel is a sad picture of what is happening to the wetlands throughout this watershed. Another area of concern is for older subdivisions that are relying on aging septic systems on small lots with no room for repair in the headwaters of Pokeberry Creek.

Some of our tangible results for this project are:

- A good set of baseline monitoring data for macroinvertebrate communities and for stormwater runoff.
- Found that discharge and pollutant movements in Dry Creek are stormevent driven.
- The increase in ammonium nitrogen in Dry Creek between Highway 87 and Old Graham Road indicates there is a potential organic waste source that should be addressed.
- Turbidity is a problem both in Dry and Pokeberry Creeks.
- Macroinvertebrates seems to be improving in Pokeberry Creek at least in the downstream sites.
- Seasonal variation needs to be taken into account when accessing aquatics in Dry Creek.
- Bank stability is a problem in Dry Creek. Some of this instability could be addressed by stream side planting.
- Potential sites for stormwater and agricultural BMPs and areas that should be targeted for conservation were identified along both creeks.

The drought conditions in 2007 complicated efforts in evaluating potential causes for aquatic impairment on Dry Creek. Biotic Index scores for Dry Creek show a slight trend for continual decline that is not being seen in either Terrells Creek or Pokeberry Creek, but it is difficult to determine if this trend is drought driven or not. The aquatic communities further upstream seemed to be suffering more than the downstream communities. Again it is difficult to determine

whether this is do to the drought conditions or due to the decline in habitat such as the eroded streambanks.

The slow down in the housing market and complex hydrology impeded efforts in determining whether there was an increase in polluted stormwater from new development in Pokeberry Creek watershed. The evidence of increased flow due to stormwater runoff on Dry Creek was clearer. On Dry Creek there was a significant increase in polluted load between the upstream and downstream site, but it was unclear what the source of this load was. When the monitoring sites were established, we did not know about the application of biosolids along Long Branch. Future monitoring should take into account the drainage from Long Branch which could contain polluted runoff from the biosolids applications.

We hope that the data collected for this project will be used to supplement the existing biological monitoring that is being done in these creeks by North Carolina's Biological Assessment Unit. In addition, we intend to make the data available on the Haw River Assembly website, so that it can be used by NCDENR DWQ in making watershed decisions, Chatham County government officials in making land use decisions, the Haw River Assembly in its stream stewardship outreach to creekside landowners and others, the Chatham Soil and Water Conservation District in its BMP education and implementation, the Jordan Lake Watershed Oversight Committee in making recommendations, local universities and schools, and the general public.



Pokeberry Creek wetland in Briar Chapel continues to be impacted by muddy runoff from upstream logging, from power line easement, and from new construction.

Budget

Table 5. Stream Steward Campaign (EW07023) Projected versus Actual Expenses

Source of Funds	Description	Projected (\$)	Actual (\$)
<i>Section 319</i>			
Personnel	3 part-time HRA staff for 3 years	65,525	66,820
Staff Development	Workshops, conferences, books	1,900	1,801
Supplies Office	Postage, printing	750	209
Supplies Educational	Educational materials for community meetings	750	278
Equipment	Macroinvertebrate monitoring equipment, computer hardware	1,200	1,104
Travel	Travel costs for project meetings, field visits, workshops	500	415
Riparian Planting	Plants, planting tools	800	797
Contractual	NCSU WQG stormwater monitoring	50,000	50,001
Total Section 319		121,425	121,425
<i>Non-Federal Match HRA</i>			
Personnel	3 part-time HRA staff for 3 years	7,485	7,485
Staff Development	Workshops, conferences, books	574	574
Supplies Office	Postage, printing	946	946
Supplies Educational	Educational materials for community meetings	1,784	1,784
Equipment	Macroinvertebrate monitoring equipment, computer hardware	1,147	1,147
Travel	Travel costs for project meetings, field visits, workshops	578	578

Source of Funds	Description	Projected (\$)	Actual (\$)
CWMTF Lower Haw	Lower Haw River Riparian Corridor Conservation Plan	68,140	68,140
Total HRA		80,654	80,654
<i>Non-Federal Match – In-Kind Contributions</i>			
Volunteers	Two Stream Steering Committee, HRA Stream Steward Committee, volunteers for macroinvertebrate monitoring and identifications	17,955	19,665
Contractual	NCSU WQG stormwater monitoring		16,364
Total Non-Federal Match - In Kind Contributions		17,955	36,029
Total Non-Federal Match		98,609	116,683
Total Project Budget		220,034	238,108



Possible remains of Clarks Mill spanning Dry Creek.

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