Black Creek Watershed Assessment, Monitoring, & Planning

EPA319 Grant Final Report & Watershed Plan

June 2009

Sponsored by NC Division of Water Quality, Department of Environment and Natural Resources

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Project Investigators

Christy Perrin
James Gregory
Stacy Nelson
Patrick Beggs
Dave Penrose
Terri Litzenburger
Elizabeth Nichols

Graduate Students

Shelby Gull Laird
Diane Norris
Molly Puente

Project website: www.ncsu.edu/WECO/blackcreek

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Executive Summary

The Black Creek watershed is a typical urbanized North Carolina central piedmont watershed containing residential, commercial, and public land uses. The riparian area is also home to the Town of Cary's popular Black Creek Greenway. With the watershed having > 21% imperviousness, and mostly developed before the advent of current stormwater controls (including the Neuse Rules), it is not surprising Black Creek is on the 303(d) list of impaired waters due to reduced biological integrity.

The Black Creek Watershed Association (BCWA) was convened in 2006 based on citizens' concerns protecting the character of the Black Creek Greenway and associated natural resources. The partnership, representing neighborhoods and institutions such as Town of Cary, NC State University (NCSU), Lake Crabtree County Park, Cary Rotary, and Wake County Cooperative Extension, studied the causes of Black Creek's impairment and engaged the community to plan for improvements. The NCSU Dept. of Forestry and Environmental Resources technical team conducted a watershed assessment to evaluate the stream channel condition, aquatic habitat, water quality, and land use/land cover. Watershed Education for Communities and Officials (WECO) coordinated the community involvement, planning process, and educational outreach activities. BCWA members learned watershed science, collected stream channel condition and pollution source data, conducted four stream clean-ups, provided links to constituent groups, and leveraged additional resources such as volunteer hours, fecal coliform analyses, and educational materials.

High volumes of storm water runoff that bypass the riparian buffer through stormwater pipes and channels are main cause of impairment. The high volume and velocity flows are likely washing away detritus that provides food for certain species of benthic macroinvertebrates. A secondary cause of impairment is likely toxic organic compounds that are accumulating in the aquatic life, including polycyclic aromatic hydrocarbons (PAHs) from automobile combustion products and parking lot sealcoats, and possibly phthalates from the sewer system. The stormwater flowing off of parking lots, driveways, and roads is presumably carrying PAHs into the stream system.

The BCWA wrote a watershed plan with goals reflecting community interests, specific objectives, and strategies. Goals address protecting public health, improving recreation opportunities, improving aquatic and terrestrial wildlife habitat, and increasing community stewardship of natural resources. Objectives include improving the diversity and amount of macroinvertebrates in Black Creek in 5 years and removal from the 303(d) list in 10 years, and preserving additional natural open space in the watershed. Strategies include engaging homeowners associations and neighborhoods to identify and construct stormwater retrofit projects on residences and rights of way, and working with the Town of Cary and Wake County Schools to locate retrofits on public lands. A table of all objectives and strategies is in this report. BCWA will continue honing strategies, and will amend objectives and strategies if needed as new information is obtained.

Meeting the goals of the watershed plan will require widespread and active participation of landowners, businesses, and the Town of Cary. Resources resulting from this grant, including Google Earth linked GIS layers to use in locating stormwater retrofit projects, educational materials, and an actively engaged watershed group, will help ensure improvements to Black Creek.

Introduction/Background

The Black Creek watershed is a 3.2 square mile area in Cary, NC, that drains to Lake Crabtree and Crabtree Creek, in the Neuse River Basin. The watershed is typical of a developed Piedmont watershed with a hilly terrain, residential subdivisions, a handful of schools, two town parks, and commercial properties such as shopping centers and gas stations. Almost completely developed, with more than 21% impervious surface, the Black Creek watershed also contains the very popular Black Creek Greenway, running alongside the main stem and one of its major tributaries. The creek is 303(d) listed as impaired due to biological integrity.

The Black Creek Watershed Association was convened in 2006 based on concerns voiced by citizens about protecting the health and character of the Black Creek Greenway and its associated natural resources. This collaborative partnership consists of citizens representing neighborhoods and homeowners associations, schools, institutions such as Lake Crabtree County Park and Wake County Cooperative Extension, the Town of Cary, and NC State University. Partners obtained a US Environmental Protection Agency water quality grant to fund an effort to study the causes of Black Creek's impairment, to work with the community to develop management recommendations, and to involve the community in environmental improvement projects and education. Citizen members volunteered to oversee the planning process, learn about watershed science, engage their communities in watershed education and activities, develop recommendations for the watershed, and conduct watershed improvement activities such as stream clean-ups. Staff from Town of Cary and NCSU has provided technical support to the citizen group.

The Black Creek watershed planning initiative was intended as a highly visible effort that could serve as a model for restoring other urbanized watersheds in the Town of Cary and the Triangle area.

The goals of the project are to:

1. work with the community to cultivate a vision for the watershed, and then collaboratively develop community supported recommendations;
2. provide a watershed management and restoration plan that makes recommendations for BMP implementation, community education, and evaluation of the success of plan implementation;
3. conduct a watershed assessment and implement a monitoring program that will more specifically determine the causes and sources of Black Creek's impairment; and
4. develop a demonstration model of cutting edge, robust technology for watershed assessment, monitoring, stressor amelioration assessment, and geodatabase implementation.

To achieve these goals, the project entailed two major components:

- The planning component addresses goals 1 and 2 involving community collaboration and education and the development and implementation of a watershed restoration plan with the assistance of a local watershed association.
- The technical component addresses goals 3 and 4 through a watershed assessment, monitoring, and development of a geodatabase for management of spatial and non-spatial data.

The public involvement and development of the watershed plan by NCSU and the Black Creek Watershed Association (BCWA) is reported in a separate section from the watershed assessment in this report.

Deliverables for 319 grant

- A watershed situation assessment report identifying the stakeholders, their issues of importance in the watershed, and the conditions necessary to encourage their participation in the watershed planning process
    - With assistance from a graduate intern from the NCSU MPA program (at no cost to the grant), WECO staff interviewed 21 stakeholders, and compiled the results into a draft Black Creek Watershed Situation Assessment report. The report contains an analysis of issues and potential conflicts in the watershed, and recommendations for proceeding with community involvement. The report was distributed to watershed stakeholders. A brief description of methods and results is included in this report, with the entire Situation Assessment provided in the Appendix B.
- A technical watershed assessment report based on GIS information, water quality monitoring, fieldwork, and watershed modeling, that indicates likely causes and sources of Black Creek's impairment
    - This was completed and is located within this report in the methods and results/conclusions section.
- A watershed management plan with identified goals and objectives for the watershed based on the assessment results and stakeholder interests, and projects and actions required to achieve those goals and objectives.
    - This has been completed. Goals, objectives, and strategies from that plan are included in the Results section of this report.
- An assessment of homeowners/landowners' knowledge and behavior regarding watershed protection, and of their willingness to participate in watershed restoration activities
    - A public workshop was held to kick off the watershed planning process, at which participants were surveyed to evaluate knowledge and behavior regarding watershed protection. The results are posted below.
- A minimum of twelve watershed association meetings
    - The BCWA was convened in mid 2006 and met 18 times over the course of the project (on average every 2 months). They learned watershed science from expert speakers, guided the watershed assessment, helped gather data, obtained additional resources, and developed watershed plan recommendations.
- Meeting summaries following each watershed association meeting
    - *The Black Creek Watershed Wire* was created as the official BCWA newsletter, and was published in hard copy and electronic copy form. It was mailed or emailed regularly to all 75 members of our Black Creek database (17 copies).
- Two public workshops to inform the public of the planning process and seek their feedback
    - The project started with a kick-off workshop. A public workshop was held to introduce volunteers to stream assessments, and another was held as an event to recognize participants in a student logo design contest in 2008
- The watershed education program far exceeded the deliverables promised. Activities included
    - two stream walks to collect data for the watershed assessment
    - four "Big Sweep for Black Creek" clean-up events (involving 102 participants total, with trash pick-up and snacks provided by Town of Cary)
    - an educational sign along the greenway attached to our monitoring box
    - regular Black Creek newsletters distributed to the watershed community through our database contacts

- educational booths for two years at the BCWA at Lake Crabtree County Park's annual Waterfest,
- a student logo contest for students to design potential logos for the BCWA and creation of stickers and grocery bags featuring a logo (logo contest and materials paid for by Cary Community Foundation), and
- educational presentations to Cary Rotary and both the Beechtree and Silverton Homeowners Associations.

Watershed Assessment

Overview of watershed assessment

The watershed assessment involved evaluating the current conditions in the watershed to help determine the causes and sources of biological impairment experienced by Black Creek, and to guide the development of a management plan for addressing these causes and sources. The watershed assessment involved the following components.

1. Geodatabase development
    a. Watershed geomorphology- the characteristics of the terrain and stream network
    b. Digital elevation model- digital topographic map to use for deriving boundary area, watershed shape, surface topology, and various measures of slope gradient
    c. Mapping the stream network and stormwater system, with the stream network mapped by hand using GPS, and using data for the stormwater system collected by the Town of Cary
    d. Land use/land cover- watershed land cover category information derived from high-resolution satellite imagery
2. Stream health and channel condition assessment
    a. Benthic macro-invertebrate assessment
    b. Stream channel condition survey
3. Watershed monitoring
    a. Stream discharge: stormwater system and rainfall
    b. Hydrologic modeling
    c. Water quality
        i. Physical water parameters- turbidity, suspended solids, pH, temperature, dissolved oxygen, conductivity
        ii. Nutrients
        iii. Fecal coliform bacteria
        iv. Organic contaminants
4. Pollution source inventory

The watershed assessment methods, results and discussion for each component, and a summary of findings follow.

Geodatabase development

Often available data acquired for an area or specific region consists of varying resolutions, scales, and if geographic, these data may also be comprised of different projections. These differences are typically the result of data that have been collected from multiple of agencies, or project-data which has been collected over sporadic intervals. Data compatibility remains the foremost requirement for the development landscape-scale/watershed assessments that rely primarily on existing datasets to assess current environmental conditions, as well as developing the potential to assist planners with detailed information aimed at natural resource management and conservation.

A geodatabase is a GIS-based structure of databases and process software that is used to maintain databases, add new ones when needed, conduct assessments, as wells serves to analyze and summarize data. Geodatabases have several important advantages over the traditional file-based GIS data models. For example, the geodatabase model allows real-world behaviors or natural behaviors to be modeled as opposed to the traditional file-based data models which require the user to develop custom code for each application. Using file-based models, features are aggregated into a generic collection of points, lines, and polygons, and all features are weighted the same according to their attributes. Natural behavior oriented data modeling, as provided through the geodatabase structure, allows users to develop extensive relationships which allow features to behave smarter by conforming to natural spatial arrangements, adjacency constraints, and logical geometric placements and allowing attributes specific permissible values. These intelligent behaviors can also be validated to ensure that data entry and editing are more accurate.

Additionally, geodatabases provide a standardized and IT compliant storehouse for geographic data (vector, raster, TIN, etc.) that can be manipulated and updated simultaneously by several users from remote locations and managed centrally. Data products may even be distributed through the World Wide Web using commonly available Earth Browsers, such as Google Earth that allow GIS data to be viewed in an Internet based environment.

A geodatabase for the Black Creek Watershed was developed using existing municipal, state, and federal data, as well as data developed specifically for this project. The Black Creek Watershed geodatabase is organized by simple categories of information for ease of access by citizen groups and municipal partners (see Appendix G). There are five different vector data categories (known as feature datasets as part of a geodatabase): Municipal, Hydrology, Research, Stormwater System and Land Cover. In addition, raster layers include: land use/land cover, an orthophotography layer, and a digital elevation model (DEM). The goal of this organizational scheme was to allow users, specifically citizen watershed groups, ease of access to all available data. The simple categories make finding the appropriate feature class within each dataset a bit easier. This organization helps to highlight the layers developed for the project, including hydrology and research layers.

Datasets:

- Town of Cary: Greenways (Existing & Planned), Water Lines, Sewer Lines, Streams, Cary River Buffers, Cary Parks, Stormwater System Layers (Channel, Combo Inlet, Culvert, Curb Inlet, Grate Inlet, Pipe I/O, Pipes, Yard Inlet)
- NHD: Streams
- Wake County: Orthophotography, Major Roads, Streets, Property, Schools, Soils. Lakes
- NC GIA: LiDAR points to create DEM

Developed Datsets:

- Stream Origins
- Modified ToC streams based on origins
- Land use/land cover 10 foot and 5 foot elevation contour levels
- Black Creek Watershed boundaries (stream gauge, east fork, west fork, upper east, upper west)
- Cary Academy Water Quality sites
- Black Creek area box

Developed datasets were those created for this project and included in the geodatabase. The stream origins were GPSed using the NC Division of Water Quality Stream Identification requirements. The GPSed stream origins were used to obtain a highly accurate stream map of the watershed, as well as improve the headwater/first order stream network beyond what was currently available through the Town of Cary. The land use / land cover raster layer was also created to derive hydrologically sensitive land cover categories for the entire watershed area. This dataset is elaborated upon in a future section of this report. Simple 10 foot and 5 foot elevation contours were created from the original DEM in order to assist with simple topographic assessment, in addition to the available DEM for this watershed. Watershed boundaries were created using the GIS-based watershed analysis tool ArcHydro to delineate a topologically accurate Black Creek watershed boundary, in addition to smaller sub-watershed, or sub-basins, occurring within the larger Black Creek watershed. Cary Academy water quality samples locations were also created and added to the geodatabase. These points were extracted from GPS points taken by Cary Academy students that took water quality readings at specific site locations within the watershed. These locations were saved as a GIS layer for potential future use. The Black Creek area box defines the area studied and the extent to which all layers were clipped.

Geomorphic character of the watershed

Watershed characteristics determined for the main watershed and for the two principal sub-basins of the watershed are included in table below.

Table 1: Watershed Characteristics

	Stream Gauge Watershed	East Fork	West Fork
Area (A)	8.185 km^2 (3.16mi^2)	3.566km^2 (1.38mi^2)	2.462km^2 (0.951mi^2)
Perimeter length (L_p)	17.1km (10.61mi)	11.3km (7.02mi)	10.2km (6.34mi)
Shape–Horton's form factor ($H_f=A/L^2$)	4.202km = L 0.464	3.007km = L 0.394	2.484km = L 0.399
Basin relief (H)	66m (216.5 ft)	56m (183.7ft)	56m (183.7ft)
Main Stream Length (L_m)	5493m	3753m	2801m
Relief ratio ($R_r=H/L_m$)	0.012	0.015	0.020
Total Stream Length (L_s)	25.94688km	11.46788km	7.22579km
Drainage Density ($D=L_s/A$)	3.17m/m^2	3.22m/m^2	2.93m/m^2
Ruggedness number ($R_n=D*H$)	209.2	180.3	164.1

A field inventory of the first order streams in the watershed stream network was conducted with a mapping accuracy GPS unit. The locations of stream origins were determined in accordance with the NC Division of Water Quality stream identification methods (NCDWQ 2005). The stream points were found to closely agree with the Town of Cary streams data more so than the hydrologically-modeled estimates of stream locations. Using the collected GPS data of first order streams and stream origins, the Town of Cary streams layer was enhanced to create a highly accurate map of the stream network. The enhanced stream map is included in the geodatabase along with the stormwater system map created by contractors for the Town of Cary. Stream network morphometric analyses from the DEM and enhanced stream layers are included in the table below.

Table 2: Stream network morphometric analyses from the DEM

	1st	2nd	3rd	4th	Overall
Drainage density					3.17
Total stream length by stream order	12.06 km	6.41 km	5.67 km	1.81 km	25.95 km
Catchment area by stream order	4.54 km^2	6.15 km^2	7.21 km^2	8.19 km^2	8.185 km
Channel gradients	0.0422 4.2%	0.0305 3.1%	0.0105 1.1%	0.0060 0.6%	0.0299 3.0%

Land-use/Land-cover: Remotely Sensed Land-cover Classification

High-resolution, satellite-derived land use and land cover (LU/LC) classification data are available in the Black Creek ArcGIS geodatabase. General details of this classification, methods, and results follow below.

It has been well-documented that declines in hydrologic, chemical, and biological quality of receiving waters are clearly linked to urban development and changes in land uses. Current research has shown that the amount of impervious surface area within a given watershed can be used as a reliable predictor of corresponding water quality. Additionally, relatively small changes in impervious surface cover can cause major changes in aquatic biota that are often apparent before physical or chemical changes in the water are detected. According to the Center for Watershed Protection (Tom Schueler, 1998), even with as little as 10% of a watershed covered with impervious surfaces, the resulting increase in stream volume from corresponding run-off can have numerous impacts. These impacts include the following:

- Increased floods and flood peaks, leading to stream straightening and streambed erosion;
- Increased erosion, leading to loss of trees and vegetation along the banks (at 8% - 10% impervious surface coverage, streams double in the size of the bed due to the increased volume);
- Increased pollutant loads;
- Increased shell fish diseases and beach closures;
- Increase in stream temperature which messes up lots of biological processes;
- Increased bacteria, often as a direct of a high density of household pets;
- Decreased high weather flow;
- Decreased pooling;
- Decreased woody debris, a crucial habitat element for aquatic insects;
- Decrease in substrate quality;
- Decreased fish passage during dry weather flow periods due to the enlarged stream bed;
- Decrease in insect fish and fish diversity (at 12% imperviousness, trout and other sensitive species can no longer survive in the stream).

Remote sensing assessments of LU/LC represent an efficient method of evaluating human development and impervious surface totals across and landscape. Additionally, the accuracy of this data remains critically important if further watershed modeling or management decisions are to be generated from the results of this data. However, accurate and up-to-date LU/LC can be difficult to obtain, very costly, and labor-intensive to process.

Our LU/LC classification of the Cary North Carolina Black Creek Watershed provides current, up-to-date LU/LC data that can be used to easily evaluate total amounts of human-developed land cover and impervious surface within the watershed. This data may also serve as a baseline in tracking future trends in watershed development, serve as inputs for modeling water quality within the

watershed, as well as provide vital information for management decisions and zoning considerations.

Land Use and Land Cover Assessment

A single Digital Globe's Quickbird satellite imagery, dated June 29th 2004, was used to determine hydrologically appropriate land-cover categories for the Black Creek Watershed in Cary, N.C. from (figure 1). The Digital Globe's Quickbird platform currently represents the world's highest resolution and commercially available multi-spectral satellite. This satellite produces multispectral imagery with a ground resolution of approximately 2.5 meters and panchromatic imagery of 61 centimeters per pixel (Digital Globe, Inc. 2007). Advances in radiometric resolution of satellite data, currently allow the Quickbird senor to collect data at an 11-bit radiometric resolution. This is in contrast to the 8-bit data collected by the NASA Landsat series and many earlier platforms. The radiometric resolution is a measure of the range of digital numbers to which brightness response can be assigned, and potentially increased resolving capability for LU/LC classifications. Data collected at 11-bit resolution can store brightness at a digital number range of 0-2048, which makes it more sensitive to surface feature reflectance than the same responses stored as 8-bit data (value range of 0-255). Eleven land-cover classification categories were generated for the Black Creek watershed from the June 2004 Quickbird imagery. Table 3 below gives complete description of each of these classes.

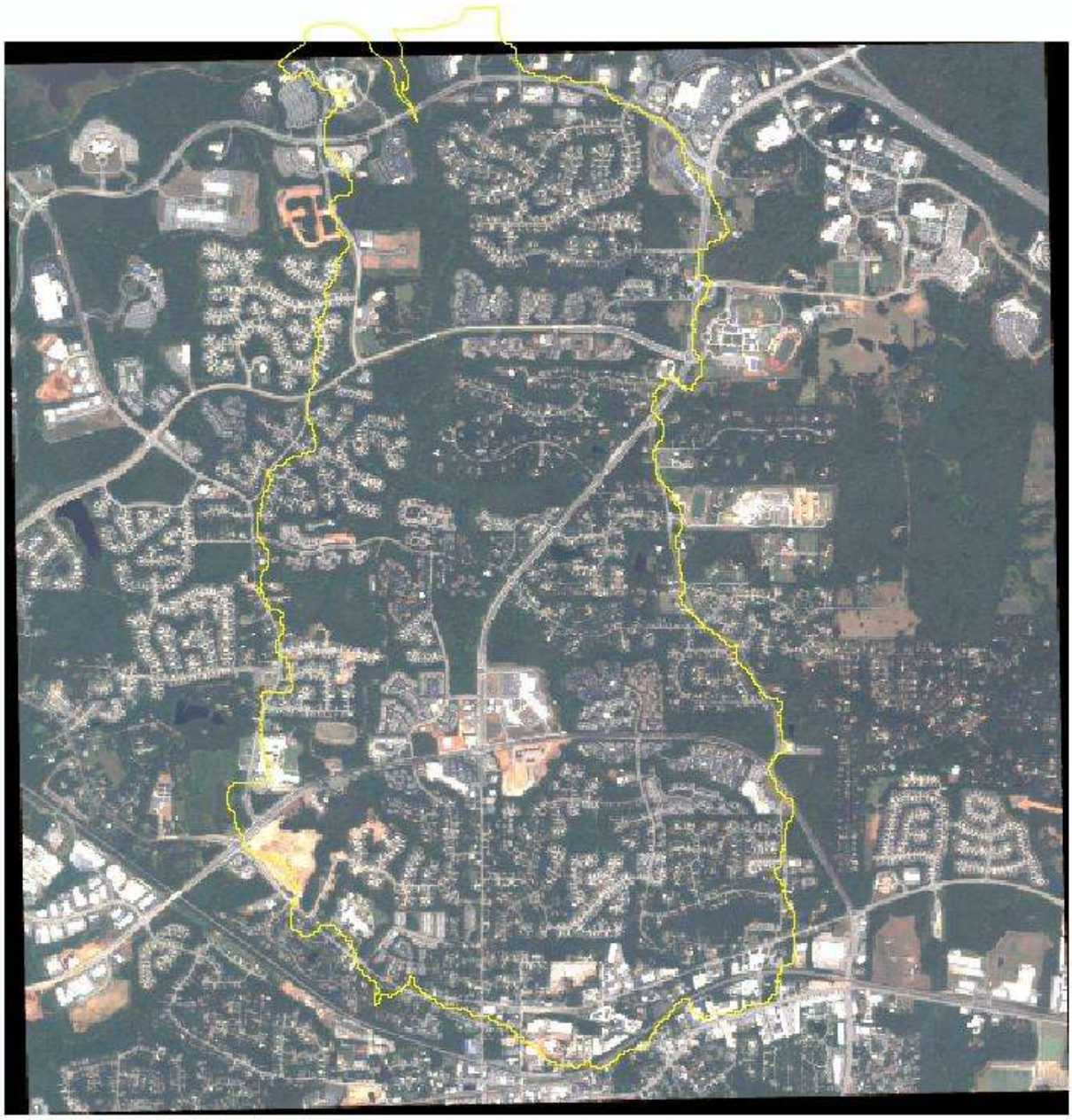


Figure 1: Unclassified Quickbird image of Black Creek watershed (June 29, 2004)

Table 3: Land-Cover Classes: Eleven classes used to develop Black Creek watershed land-cover classes

Black Creek Land Cover Classification	Description
Mid Development	Contained a mixture of residential buildings, streets, lawns and trees. Characteristics of this class include residential housing developments containing clusters of cul-de-sacs.
High Development	Contained large industrial, commercial, and private building, and the associated parking lots. Characteristics of this class include large homogeneous impervious surfaces, including parking structures and large office buildings.
Low Development	Contained isolated residential structures or buildings surrounded by larger vegetative land-covers.
Herbaceous	Contained urban grasses. Characteristics of this class include large mowed/maintained lawns, fields, and vegetated road medians)
Evergreen	Contained large homogeneous vegetative land-covers of trees or shrubs that keep their leaves throughout the winter (mostly coniferous species).
Deciduous	Contained large homogeneous vegetative land-covers of trees or shrubs that lost their leaves during the winter (mostly hardwood species).
Recreational	Contained sports/recreational fields. Characteristics of this class include park areas, baseball/softball fields, and tennis courts.
Streets	Contained major road and rail networks outside of the predominate residential areas.
Streams	Contained stream data derived the USGS National Hydrography Dataset shape file.
Water	Contained lakes and small ponds and all other natural and artificial surface waters outside of the USGS National Hydrography Dataset shape file.
Unclassified	Contained areas of unclassified or misclassified data.

Black Creek land cover classification map and percent area calculations were developed from spectral image processing procedures completed on June 20, 2008 (figure 2). The northern end of the of the Black Creek watershed boundary was not captured in the Quickbird imagery, as seen in figure 1, and was subsequently manually digitized for completeness. This area represented the small area north of Weston Parkway (less than 3% of the total classification).

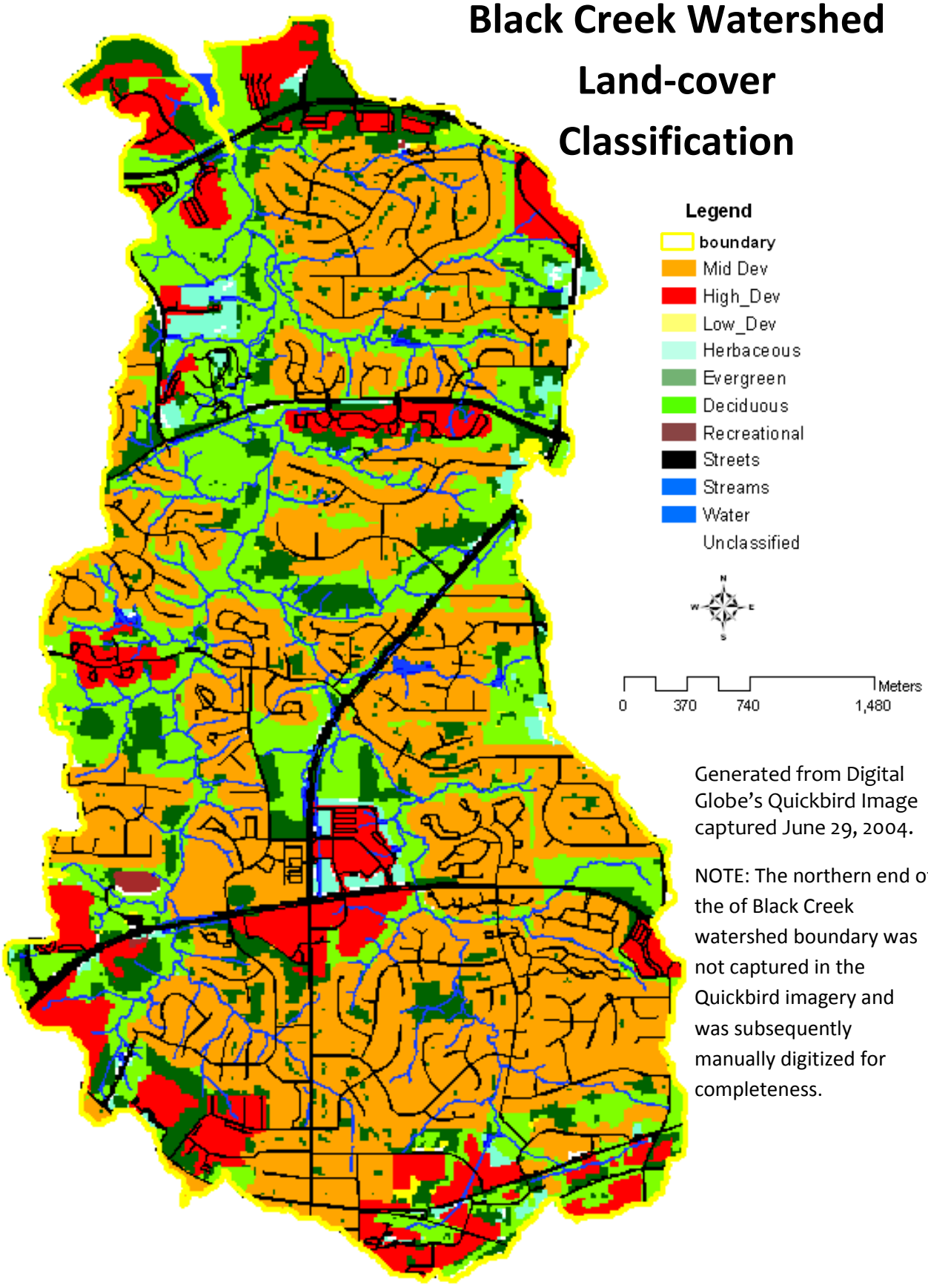


Figure 2: Black Creek watershed Land–cover Classification Thematic Map

Table 4 (below) and Figure 3 denote the eleven land-cover classes that were identified in this analysis in percentages.

Table 4: Percentages of land-cover

Land-cover Classification	Area (percent)
Mid-Intensity Development (Mid Dev)	46%
High-Intensity Development (Hi Dev)	11%
Low-Intensity Development (Low Dev)	0.8%
Herbaceous (Herb)	2%
Evergreen Forest (Evergreen)	11%
Deciduous Forest (Decid)	24%
Maintained Field (Rec)	0.8%
Transportation (Streets)	4%
Streams	0.8%
Water	0.6%

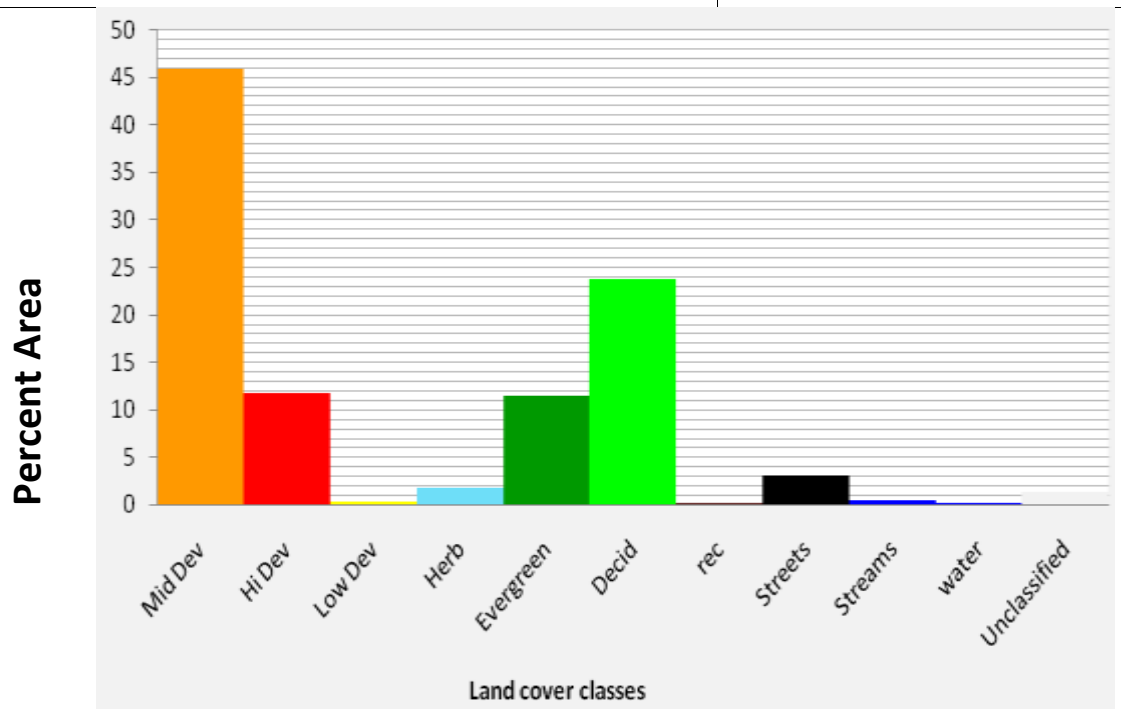


Figure 3: Black Creek watershed Land Use Percentages (in percent area)

Accuracy Assessment

An accuracy assessment was performed using the Digital Globe World View-1 satellite image as a reference image, acquired on January 21, 2008. This image provides a 50cm ground resolution image in a panchromatic (i.e. black and white) format (Figure 4).

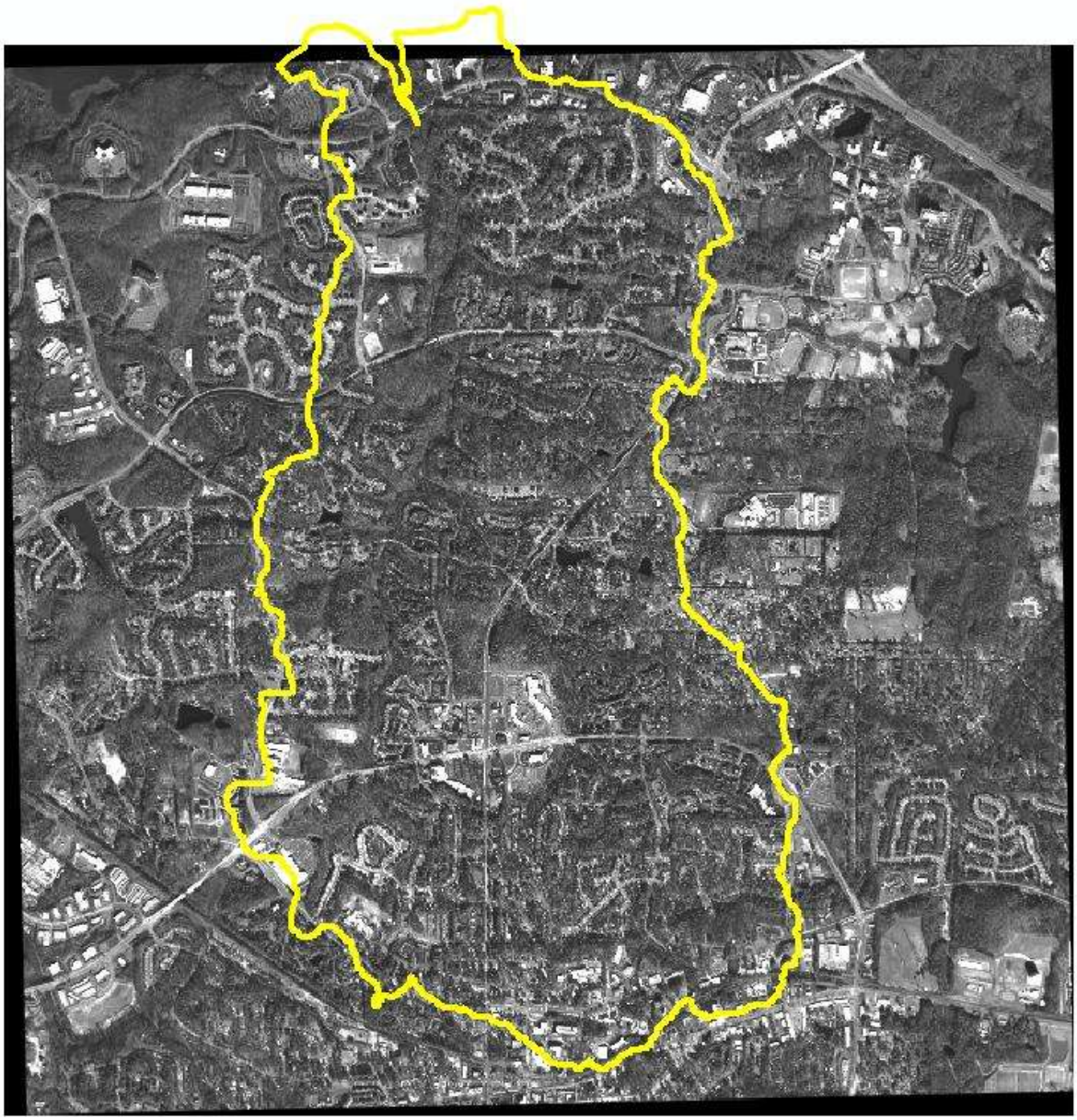


Figure 4: Digital Globe World View-1 panchromatic image of the Black Creek watershed , acquired on January 21, 2008. 50cm ground resolution

The accuracy assessment was performed using Leica Geosystems' ERDAS Imagine image processing package using a random stratified point distribution. This method of point distribution was used to

ensure that each class contained a minimum of 50 points per class. A total of 546 points were distributed within the study area (Figure 5).

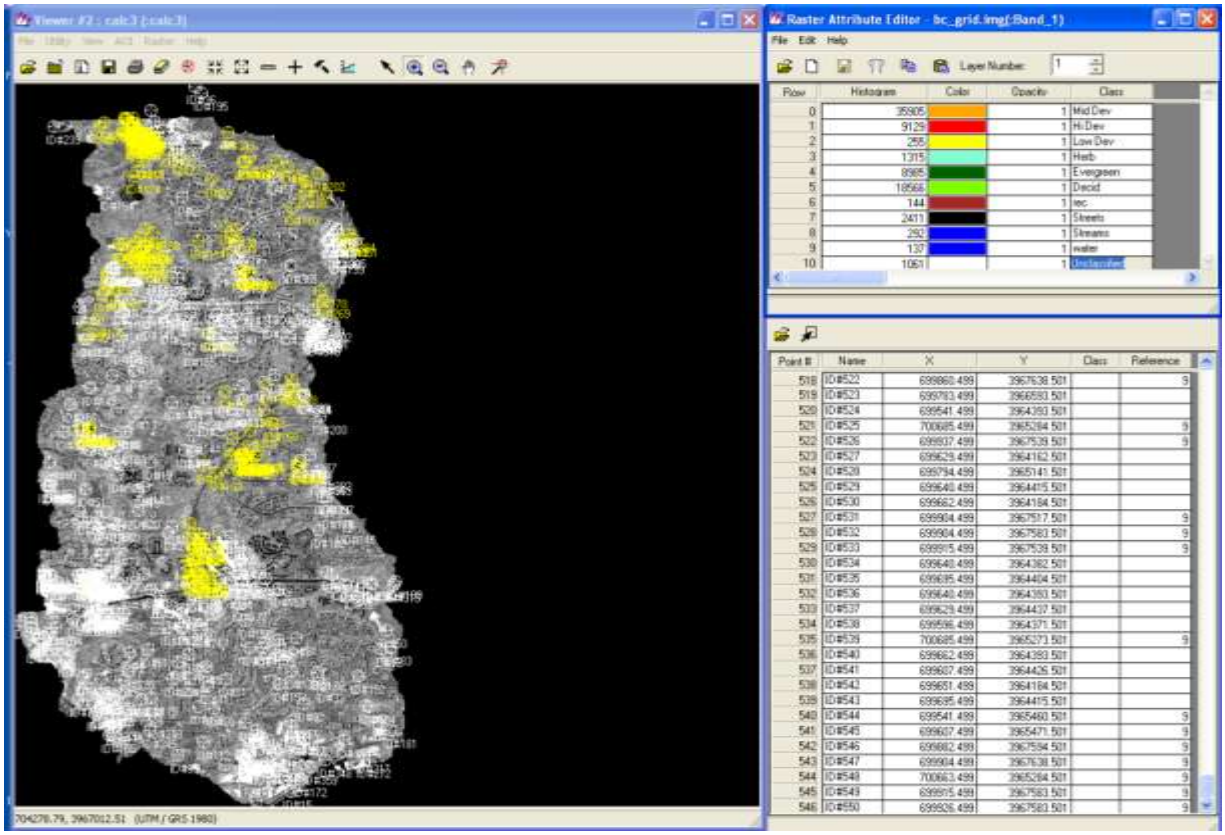


Figure 5: Digital Globe's World View-1 panchromatic image (50cm ground resolution) used as reference image with 546 randomly stratified points to ensure a minimum of 50 points per class

Table 5 denotes the point counts classified versus the reference data of the total 546 randomly generated points. The overall classification accuracy resulted in resulted in a nearly 86% Kappa statistic which estimates the percentage of classification agreement (Table 6).

Table 5: Black Creek Classification Accuracy Assessment Report

Classified Data	Reference Data											
	Mid Dev	High Dev	Low Dev	Herb	Evergreen	Decid	Recreation	Streets	Streams	Water	Un-class	Total
Mid Dev	67	0	0	3	1	1	0	2	0	0	0	74
High Dev	0	50	0	3	2	0	0	0	0	0	0	55
Low Dev	1	0	49	0	0	0	0	0	0	0	0	50
Herb	0	0	0	51	0	0	0	0	0	0	0	51
Evergreen	0	4	0	1	48	0	0	1	0	1	0	55
Decid	0	0	0	2	1	57	0	1	0	0	0	61
Recreation	0	0	0	1	0	0	49	0	0	0	0	50
Streets	0	0	0	2	0	0	0	48	0	0	0	50
Streams	1	0	0	34	0	1	0	0	0	14	0	50
Water	0	0	0	0	0	0	0	0	0	50	0	50
Un-class	0	0	0	0	0	0	0	0	0	0	0	0
Total	69	54	49	97	52	59	49	52	0	65	0	546

Table 6: Overall Classification Accuracy = 85.90%

KAPPA (K^) STATISTICS

Overall Kappa Statistics = 0.8431

Conditional Kappa for each Category

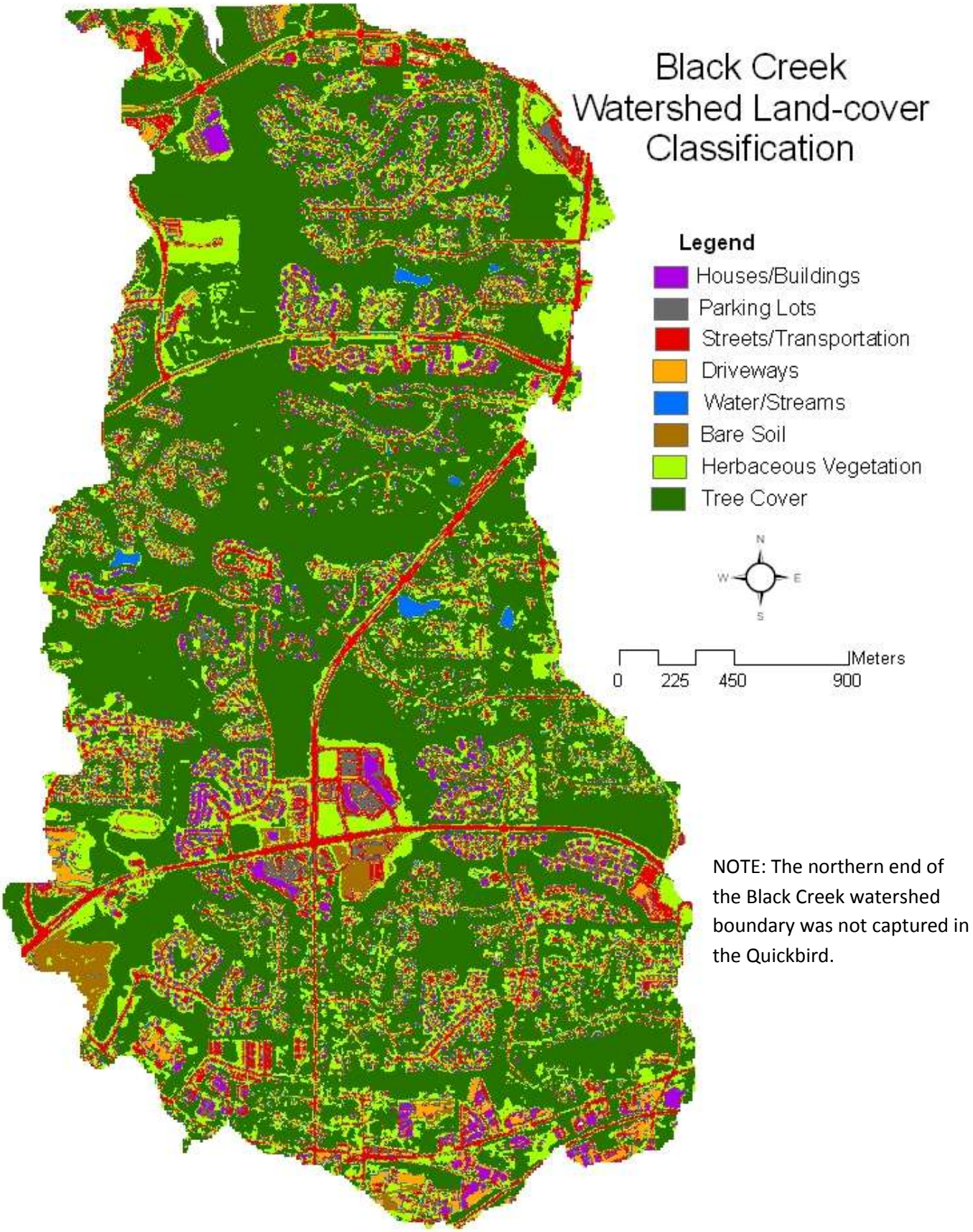
Name	Kappa
Mid Developement	0.8917
High Developement	0.8991
Low Developement	0.978
Herbacious	1
Evergreen	0.8593
Deciduous	0.9265
Recreational	0.978
Streets	0.9558
Streams	0
Water	1
Unclassified	0

Object-Oriented Feature Analyst Classification

An additional land cover classification was performed using an object-oriented classification approach. This classification involved using Visual Learning Systems' Feature Analyst image processing package to derive 8 hydrologically-sensitive land cover categories for the Black Creek Watershed area (Table 7). The imagery used to complete this classification was the original Digital Globe's Quickbird satellite imagery, dated June 29th 2004. This imagery was pre-processed using a customized pan-sharpening algorithm, developed at NC State's Center for Earth Observation, to spectrally fuse the Quickbird multispectral image and coincidental Quickbird panchromatic image to achieve a resultant image with a ground resolution of 61 centimeters. Please note that an accuracy assessment was not performed on this additional classification. However the initial Quickbird LU/LC classification above is provided with a complete assessment of overall classification accuracy.

Table 7: Land-cover classes from object-oriented classification approach

Black Creek Feature Analyst Land Cover Classification	Description
Houses/Buildings	Contained a mixture of residential, industrial, commercial, and private buildings. Characteristics of this class include developments containing clusters of cul-de-sacs as well and individual building structures.
Parking Lots	Contained surface parking structures. Characteristics of this class include large homogeneous impervious surfaces typical of parking lots.
Streets/Transportation	Contained major road and rail networks outside of the predominate residential areas.
Driveways	Contained driveway areas connected to mostly residential building structures.
Water/Streams	Contained lakes, streams, ponds, and all other natural and artificial surface water.
Bare Soil	Contained exposed soil areas, sports, and recreational fields. Characteristics of this class include large exposed soil areas, as well as possible baseball/softball fields.
Herbaceous	Contained urban grasses. Characteristics of this class include large mowed/maintained lawns, fields, and vegetated road medians)
Tree Cover	Contained large homogeneous vegetative land-covers of trees (hardwood and coniferous species).



NOTE: The northern end of the Black Creek watershed boundary was not captured in the Quickbird.

Figure 6: Land–cover Classification Thematic Map created from June 29, 2004 Quickbird imagery

Table 8 (below) and **Figure 7** denote the eight land-cover classes identified in the additional object-oriented classification analysis in percentages.

Table 8: land-cover classes identified in the additional object-oriented classification analysis

Land-cover Classification	Area (percent)
Houses/Buildings	6.83%
Parking Lots	1.85%
Streets/Transportation	9.95%
Driveways	2.46%
Water/Streams	0.33%
Bare Soil	1.73%
Herbaceous	23.05%
Tree Cover	53.81%

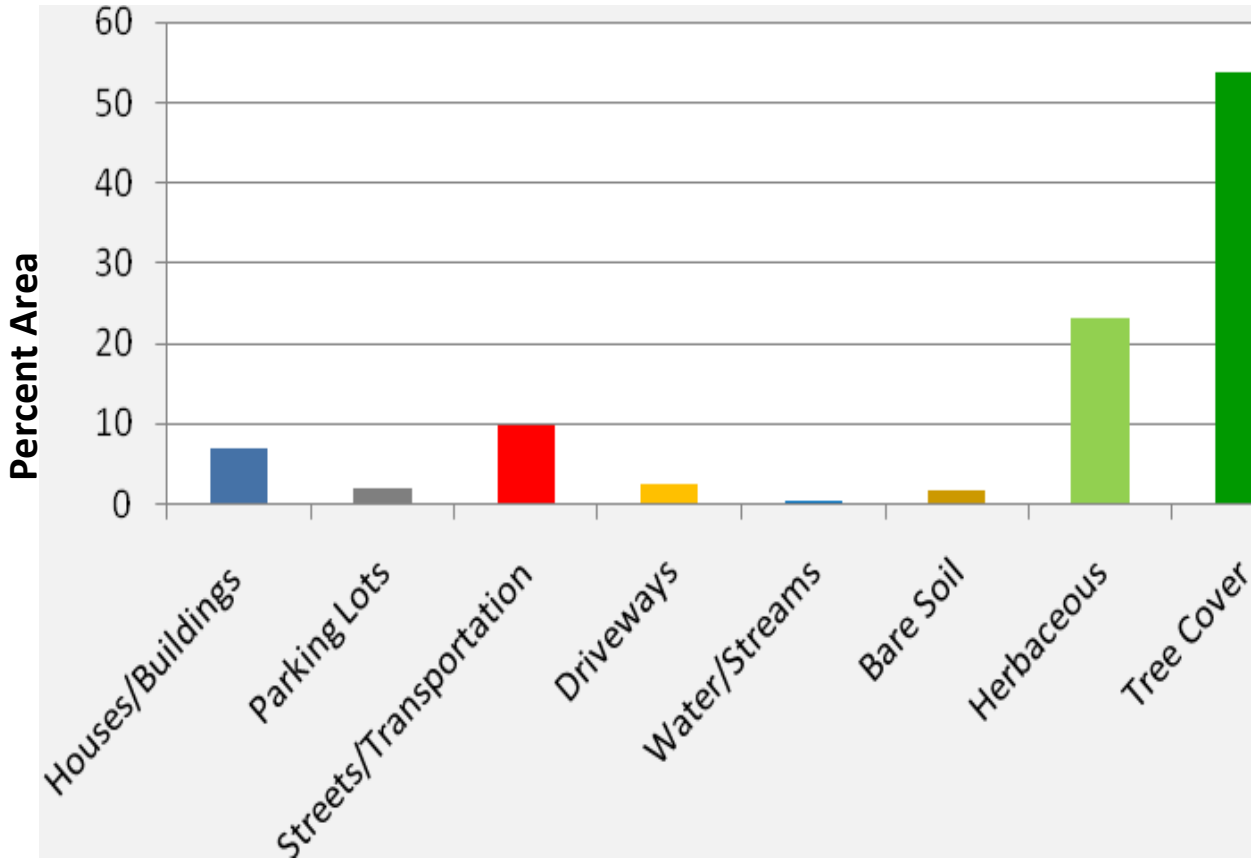


Figure 7: Land cover categories in percent area

The storm water system: Rainfall/runoff

Daily rainfall amounts were determined throughout the course of the study by a National Weather Service standard manual rain gauge mounted at Cary Academy, located just outside of the watershed area. The location is in an open area about 100 yards from Harrison Avenue on the edge of campus. Watershed researchers checked the gauge regularly and compared data to the manual gauge located next to the electronic one. The electronic gauge was a standard tipping-bucket gauge, and recorded rainfall at each tip at 25 milliliters of water. Approximately once per week, researchers would collect data using the electronic datalogger and program that came with the gauge. This data could be exported in a table format, and was exported in 15 minute intervals. Due to its location near a school, it may have been possible for some of the data to have been influenced by the students. The weather station located at the Raleigh-Durham Airport lies within a mile of the watershed, and was used to confirm data obtained from the rain gauge. Due to drought conditions occurring during much of the study period, rainfall amounts were quite small, and large spike/spurious readings found on the study rain gauge may have indicated students tampering with the device. Rainfall data for the two year study period were below normal at both the study gauge and the Raleigh-Durham Airport, but similar readings indicated that the use of the Raleigh-Durham Airport gauge will likely be sufficient for future studies.

A flow measurement and water sampling station was established in Black Creek upstream from and about 20 feet in elevation above the point of discharge of Black Creek into Lake Crabtree, to avoid backwater effects on flow measurement. Stream discharge data was collected throughout the course of the study, but several large gaps in data did occur. Gauge installation began later than anticipated and once the gauge was installed, a pressure transducer was used to collect head measurements on the stream. These measurements required a manual rating curve calculation which was started, but due to location and high stormflow force that made it unsafe to wade in the stream, the calculation was not possible during the course of this study. An estimate for the rating curve was used to estimate storm flow volume for the pressure transducer readings. The 5 minute intervals were found to be too frequent to provide useful data. Fifteen minute data intervals are recommended in the future. Anything longer than this might miss the peak flow of the stream during large storm events. Some summarized data are included from the period of time the stream gauge was working correctly (figures 8-10).

Study of flow was hindered by several factors, including the pressure transducer and sampler failing on two separate occasions (including a large cobble slamming into the tubing during a storm). An additional battery failure created month long gap in data collection. As a result of the drought conditions occurring during the study period, much of the data collected is simply a flat line (i.e. no response) of base flow for weeks at a time, which is not useful for study purposes. Continuation of the gauge measurement, during a normal rainfall year will help greatly with the understanding of the watershed dynamics.

Results and discussion

During a rain event, the Black Creek system experiences heavy storm flow runoff. Rainfall events of over about 13 millimeters (0.5 inches) seem to have notable impacts on stream levels. Normal rainfall amounts for a 1 year-30 minute storm are about 27.7 millimeters in the local area, so rainfall events over 13 millimeters are common. Creek levels within the watershed begin rising rapidly during 13 millimeter events, rising to near bank full after about a 51 millimeter (2 inch) event. This area has seen two storms with very high levels of rain over 24 hours in the past 15 years, including Hurricanes Alberto, in 2006 with 143.5 millimeters, and Fran, in 1996 with 223.5 millimeters (PFDS). The citizen group involved is concerned about flooding as a result of these storms.

Much of the storm flow during rain events arrives from culverts and pipes that drain straight into the creek or its tributaries, bypassing the buffered area. The storm drain network is extensive and typically consists of pipes from parking lots and neighborhood streets. Because much of the watershed was developed before modern storm water management techniques, storm water was simply piped to the nearest stream. The amount of impervious surface in a watershed leads to a shorter time of concentration or time to reach the stream channel, for precipitation falling on the watershed area. This is particularly true if the impervious surfaces are directly connected to the stream channel (Shuster, et. al., 2005). During a large storm a majority of water is expressed through the storm water system and into the creek's floodplains and streams. The storm water then flows from Black Creek into Lake Crabtree, where water may be retained to reduce flooding further downstream in Crabtree Creek in Raleigh, NC.

Some of the precipitation falls directly onto the stream during storm events, as the stream is over 4 meters wide at the stream gauge location. Remaining rainfall falls onto residential lots, park fields or forested areas. From there, the water will flow over the land surface as runoff into a stream, evaporate, flow down tree stems, or soak into the ground. Water that makes it to the ground is absorbed by plants, stored in the soil, or percolated into the groundwater system. This groundwater will flow through the subsurface and eventually return to the surface at a stream. Additionally, water may move into the streams through unsaturated flow through the thick sandy loam soil horizons over the bedrock. Some of the water moving through the soil or ground into the stream during a storm event may be "older" water "pushed" out by the "newer" rainwater. The weighted average of saturated hydraulic conductivity (Ks) for soils in the watershed area is about 10.633 (WSS).

Storage largely occurs as soil water or groundwater between storm events, as Black Creek has eroded its banks to bedrock. This groundwater contributes to the base flow levels of the streams in the Black Creek system. During recent drought conditions, the groundwater and/or unsaturated soil flow levels have been too low to support stream flow in both major tributaries as well as smaller first order streams. The main stem contains very little base flow during drought conditions, but does maintain higher base flow levels for several days after storm events. Even during extreme drought conditions such as those in late 2007, the main stem stream gauge site of Black Creek continues to have some base flow present.

Groundwater contributes significantly to Piedmont streams in North Carolina (Harned and Daniel, 1987). Many Piedmont streams have eroded to bedrock at a certain point along their journeys downslope, and this contribution should not be overlooked. First-order streams that contribute to a watershed can be fed almost entirely by groundwater, and suffer greatly during drought conditions. Groundwater can contribute to storm runoff (Sklash and Farvolden, 1979) in a significant way, but more importantly is a common contributor to base flow in a stream. Accurate watershed modeling requires a model that can predict base flow events as well as peak discharge during storms.

Discharge was estimated for the stream through a rudimentary rating curve estimate. Collection limitations have limited velocity measurements to low flow periods, so a bank full discharge was estimated using techniques from Harmon (1999) in order to create a more accurate curve for the watershed. These points were also collected during drought period, and will likely need to be repeated during a normal rainfall year to ensure accuracy. Continuing data collection will further improve this rudimentary rating curve, and modeling will be changed afterwards accordingly.

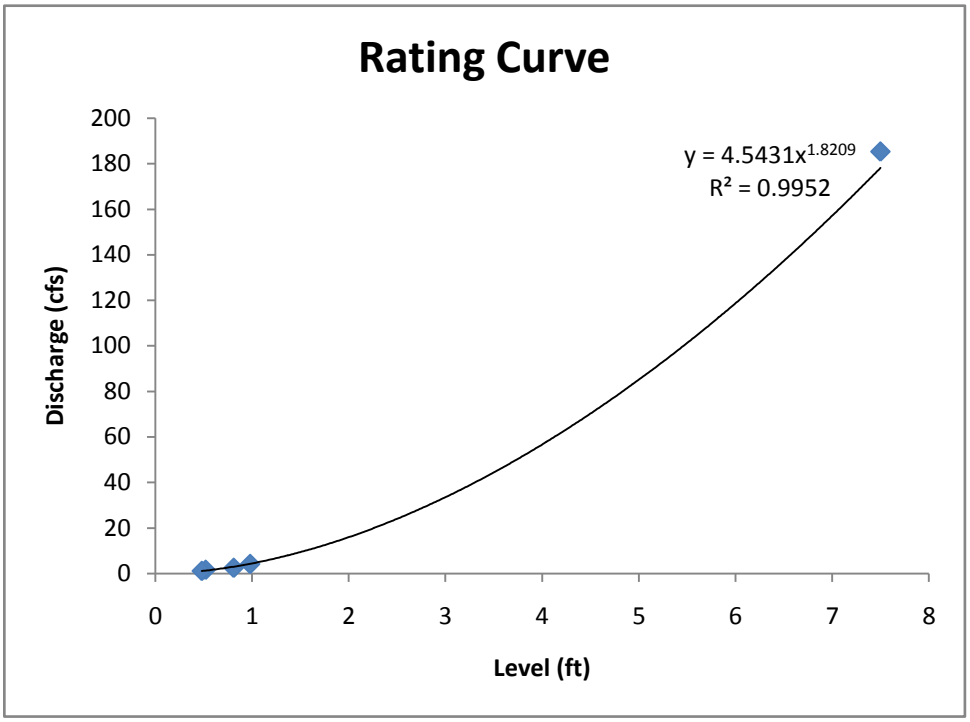


Figure 8: A rating curve representative of several examples of storm flow/rainfall charts

The stormflow/rainfall charts are included below show the typical quick response of the system to rainfall (figures 9-11). These stormflow/rainfall charts represent three monitoring periods from December 13, 2007 – January 10, 2008. The relationship illustrated in the curve of Figure 8 is an example of the flashiness of the Black Creek storm water system.

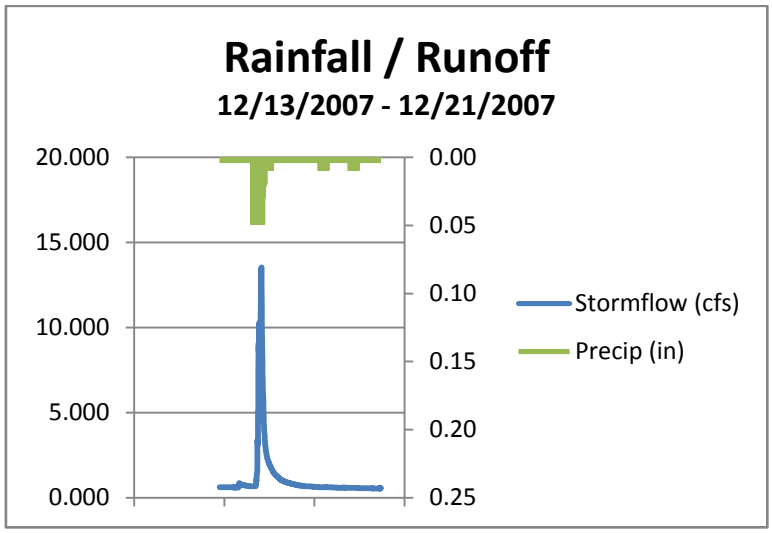


Figure 9: Rainfall/ stormwater runoff graph #1

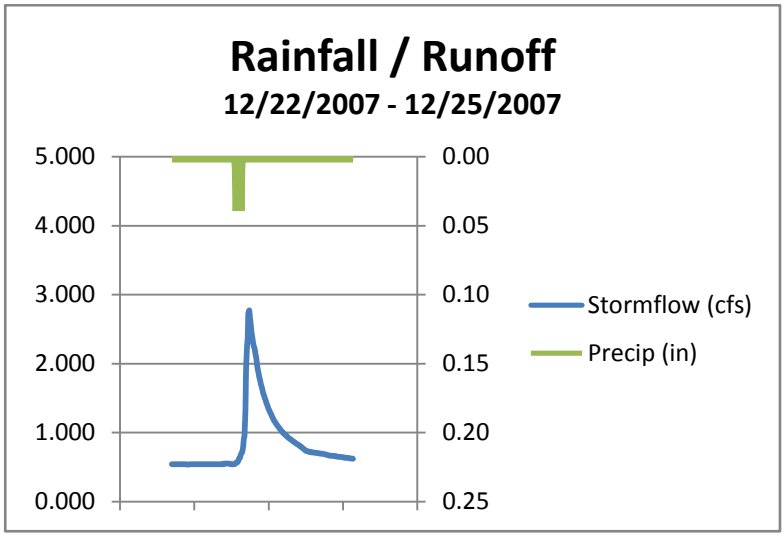


Figure 10: Rainfall/ stormwater runoff graph #2

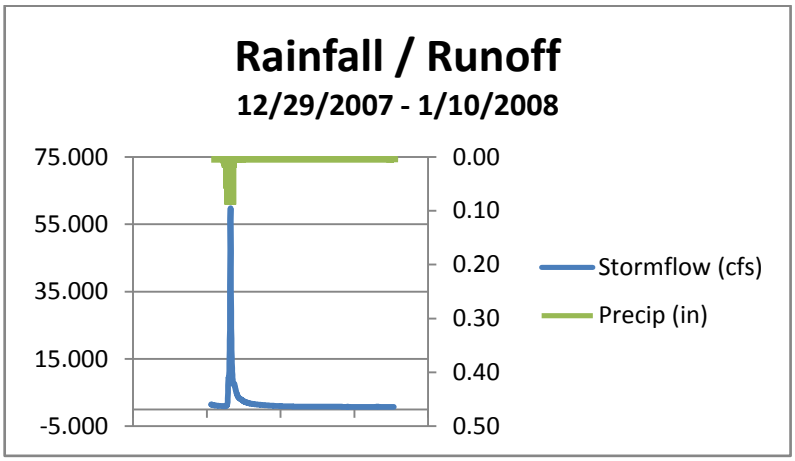


Figure 11: Rainfall/ stormwater runoff graph #3

The storm water system: Hydrologic modeling

A pilot modeling effort was undertaken for a small drainage, approximately 80 acres, located in the Northeast portion of the Black Creek watershed (figures 12-16). This area represented an area with land use categories that were consistent with other delineated sub-watersheds throughout the Black Creek Watershed. Several storm water network features drain into the perennial channel draining this pilot study area. It is evident that some are routed through the existing stream buffer. Our modeling effort was aimed at gauging the impact of the storm water network on flow responses in the selected stream channel, in order to establish an approach to gauge the impact on aquatic biota.

We utilized the Technical Release 55 (TR-55) modeling approach. The TR-55 modeling approach is perhaps the most widely used approach to modeling hydrology in the US. This modeling approach provides a number of techniques that are useful for modeling small watersheds, especially urbanizing watersheds. Applicability has long focused on determining the increase in runoff resulting from the development of rural land into urban land. As well as presenting simplified procedures to calculate storm runoff volume, peak rate of discharge, hydrographs, and storage volumes required for floodwater reservoirs.

The TR-55 modeling approach utilizes runoff equations developed by the Soil Conservation Service (SCS) to predict the peak rate of runoff as well as the total volume. TR-55 also provides a simplified "tabular method" for the generation of complete runoff hydrographs.

The development of the Black Creek TR-55 model was applied using the Natural Resources Conservation Service (NRCS) software WinTR55. WinTR55 uses the Curve Number approach to runoff response, as detailed in the NRCS publication 'Urban Hydrology for Small Watersheds' (NRCS 1986) and in addition incorporates flow routing approaches from TR-20. Input data required for the model are:

- Land use / Land cover (generated from the June 29th 2004 Quikbird data)
- Soil Hydrologic Group
- Channel /Reach - slope, length, flow velocity
- Drainage area

Each of these data inputs, except flow velocity, was determined using data available from government agencies or developed for this project. Flow velocities were assumed to be within ranges commonly found in the Piedmont (2- 2.5 ft/s) for natural stream channels, or calculated for storm drains using Manning's equation (NRCS, 1986).

We developed two scenarios, one using field determined Perennial and Intermittent streams (Scenario A) and their associated drainage area, and the other incorporating the storm water network (Scenario B), using GIS data layers provided by government agencies, and the resultant drainage. For each scenario input data listed earlier were developed. Even though the same point on the stream channel was modeled some of the locations draining to it were different for the two scenarios. The drainage areas for the two scenarios were almost identical i.e. A - 82.9 vs. B - 82.2 acres. For scenario A we modeled existing storm water drains as shallow concentrated flow, thus reducing the velocity of flow.

Our modeling effort indicates that the storm water network contributes to a minor reduction in the amount of time it takes for the peak runoff to be established in the stream. In addition we find that the peak runoff rate increases from 85 cf/s to 92 cf/s for a 2 year 24 hour storm. A more refined analysis of the impact would benefit from a field level validation of channel geometry and flow velocity. While other software tools for a detailed analysis of urbanized areas exist preliminary evaluation of sites suitable for BMP implementation can be conducted using the TR-55 approach.

For each scenario the Curve Number, the index used to determine the volume of runoff, is 73. Thus the differences in peak runoff can be attributed to the differences in the flow network between the two scenarios. We expected a larger difference between Scenario A and Scenario B. This difference of less than 10% is illustrative of the resolution achievable by using a TR-55 approach. Even though there are several stormwater features that could deliver water at higher velocities than open channels, the minimum time of concentration (Tc) that TR-55 uses for any one flow routing feature is 0.1 hrs (6 minutes). Such a coarse temporal resolution would not capture reductions in Tc that would occur when stormwater is conveyed through the existing piped network in a drainage of this size, and thus might result in a lower than expected peak runoff rate for a stormwater network.

Complete TR-55 model details may be found here in the following reference: NRCS 1986. Hydrology Technical Note No. N4. Time of Concentration.
http://www.wsi.nrcs.usda.gov/products/W2Q/H&H/Tools_Models/WinTR55.html

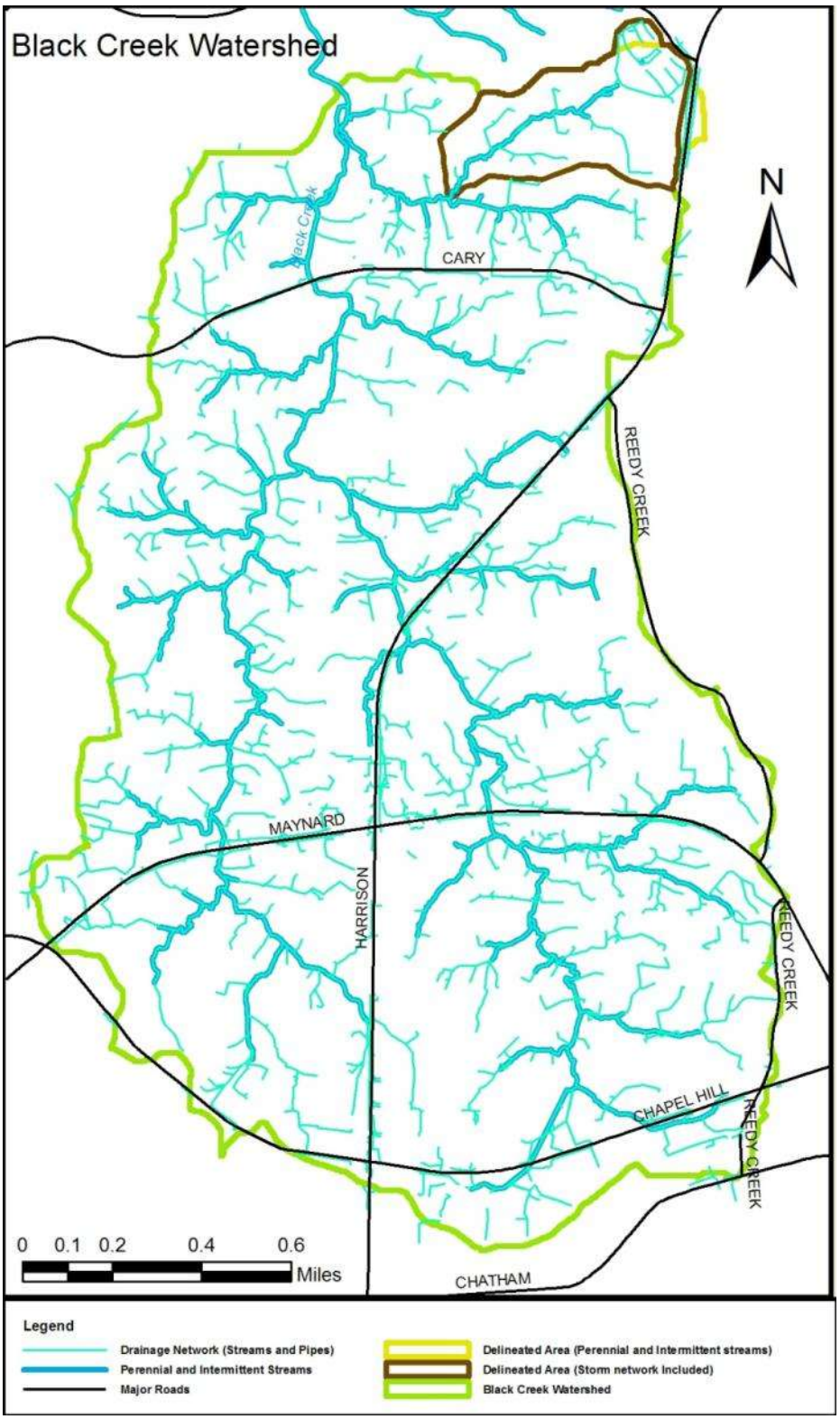


Figure 12: Northeastern pilot study area of the Black Creek watershed delineated by TR-55 model (outlined in brown; storm network included).

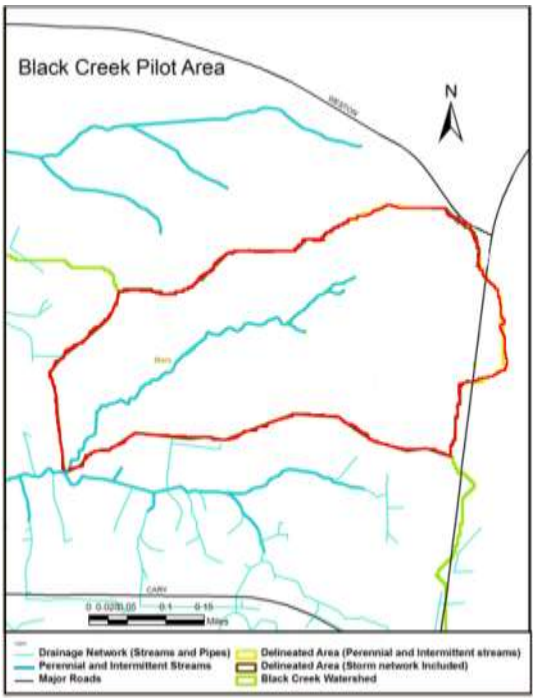


Figure 13: Black Creek watershed TR-55 model delineated area showing main stem of natural network (outlined in red).

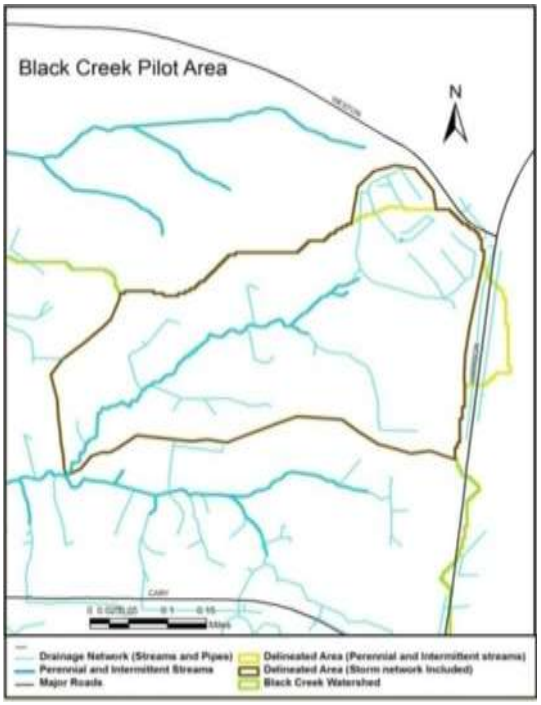


Figure 14: Black Creek watershed TR-55 model delineated area showing new watershed boundary with included storm water network (outlined in brown).

Figure 15: Black Creek watershed TR-55 model land-use/land-cover data set.

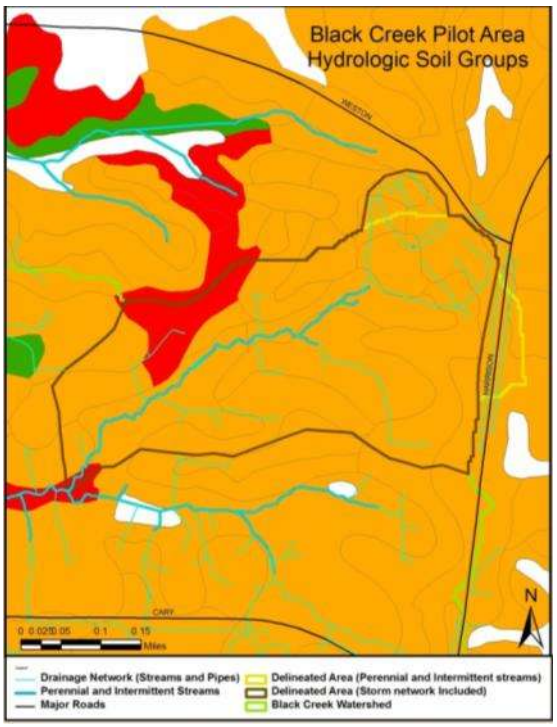


Figure 16: Black Creek watershed TR-55 model hydrologic soil groups data set.

Stream Health Assessment

Objectives of the stream health assessment were to:

- Develop baseline stream health description for macroinvertebrate populations, water quality and channel condition
- Relate water quality and channel condition data to macroinvertebrate indices

The research approach involved choosing three reaches to sample for macroinvertebrate and water quality, and a comprehensive watershed evaluation of channel conditions. Initially, three sample reaches were chosen: one on each of two main tributaries and one in the main channel. The two main tributaries were called West Fork 2 (WF2) and East Fork 2 (EF2), with the main channel called Main Stem (MS1). Macroinvertebrate and water quality data were collected at these three sites and compared to NCDWQ standards. In addition, a site upstream on each of the two tributaries was chosen for less frequent water quality testing. These were called West Fork 1 (WF1) and East Fork 1 (EF1). A stream health assessment of habitat and channel stability was also conducted throughout the watershed.

Macro invertebrates

The macroinvertebrate assessment of Black Creek conducted followed the Standard Operating Procedures for Benthic Macroinvertebrates outlined by the NCDWQ Biological Assessment Unit. The Qualitative 4 method was used because it is appropriate for small streams expected to have few tolerant taxa, but where data is needed to assess differences in the benthic communities (NCDWQ 2003).

Four samples were collected from each site: one Kick, one Sweep, one Leaf-pack, and visual samples. The kick net consisted of a double layer of nylon door or window screen sewn onto two wooden handles. The net was positioned downstream in a riffle area, and a second person disturbs the substrate upstream using feet and hands. The debris and organisms collected are rinsed into a sieve bucket with 0.600 mm mesh. The Sweep was made with a long-handled D net. Undercut banks, submerged roots and aquatic vegetation were vigorously disturbed with the net and the net swept through the area. Leaf packs were collected from snags and stable rocks, preferably in state of partial decomposition. Visual samples were conducted by picking specimens from stationary logs and rocks, and concentrated in areas not otherwise sampled such as pools. Portions of the samples were placed in a white tray for ease of visibility and specimens were removed with forceps. All invertebrates collected were preserved in vials of 95% ethanol.

The invertebrates were identified to the lowest possible taxonomic level and tabulated as Rare = 1(1-2 specimens), Common = 3 (3-9 specimens) or Abundant=10 (> or = 10 specimens). Tolerance values for each species were assigned from Appendix 1 of the NCDWQ SOPs for Benthic Macroinvertebrates (NCDWQ 2003). This data was used to calculate total taxa richness, EPT taxa richness, a Biotic Index value, EPT Biotic Index value, EPT abundance and a final classification score.

Data were collected in the spring and fall of 2006 and 2007 from all three study reaches and compared to available data collected by NCDWQ in 1996 and 2000.

DWQ data for 1994 and 2000 were drawn from EPT species only, and collections were conducted at the main stem site. There was no data for comparison from the two tributaries.

The tributaries maintained poor classifications throughout the study and contained fewer and more tolerant species. There was no baseflow in the Black Creek tributaries at the fall 2007 collection due to drought conditions, but puddles were sampled. The West fork contained lunged snails and no insects. The East fork had midges and mosquitoes.

The main stem received a Fair classification in both 1994 and 2006, the reason for Black Creek's listing as an impaired stream. By the same EPT method used in those years, subsequent classifications would be Poor. The decline was due to a decrease in total EPT taxa between 1994 and 2006 which has leveled off in subsequent collections. The remaining taxa are more tolerant species. The most consistently abundant EPT was a highly tolerant (tolerance value 7.0) mayfly, *Beatis flavistriga.*

The Qualitative 4 Method used in 2006 and 2007 resulted in a Poor classification in Spring 2006 and Fair classification in later collections. The improvement in score was noted to be from higher Biotic Index scores in the non-EPT species and an abundance of a previously absent intolerant (tolerance value 2.8) caddis, *Chimarra spp.*, in Fall 2007.

The feeding mechanisms of EPT species were noted. Collector/gatherers were predominant. Shredders were extremely rare, caddis flies *Triaenodes ignites* and *Lepidostoma spp.* being the only examples. *Triaenodes ignites* was common in 2000 and absent thereafter. A single specimen of *Lepidostoma spp.* was found in Spring 2006. The only predator, stonefly *Perlesta spp.*, was abundant in 1994 and completely absent thereafter except for a single specimen found in the East tributary in Spring 2006. Macroinvertebrate sampling results are presented in below in table 9 for the three sampling locations.

Table 9: Macroinvertebrate sampling results

	East Fork 2				West Fork 2				Main Stem			
Group/Date	4/06	10/06	5/07	10/07	4/06	10/06	5/07	10/07	4/06	10/06	5/07	10/07
Ephemeroptera	3	1	1	dry	1	2	1	dry	2	2	1	3
Plecoptera	1	0	0	-	0	0	0	-	0	0	0	0
Trichoptera	2	1	2	-	2	2	2	-	2	3	4	3
Diptera; misc.	3	1	2	-	1	1	3	-	2	1	4	2
Chironomidae	9	3	5	-	11	2	7	-	10	1	11	5
Coleoptera	2	0	0	-	1	0	0	-	3	2	3	3
Odonata	0	0	1	-	1	0	0	-	2	3	1	3
Oligochaeta	2	1	3	-	1	1	2	-	0	1	1	0
Megaloptera	0	0	0	-	0	0	0	-	0	0	0	0
Crustacea	1	2	0	-	1	1	0	-	1	1	0	1
Mollusca	3	1	3	-	1	1	1	-	1	1	2	2
Other taxa	1	0	0	-	0	0	0	-	1	3	0	2
Total taxa	27	10	17	dry	19	10	16	dry	24	18	27	24
EPT taxa	6	2	3	-	3	4	3	-	4	5	5	6
EPT abundance	15	6	21	-	12	4	14	-	26	43	43	21

The Poor classifications of the two tributaries can be attributed to their small size and the fact that they did not maintain a consistent year round flow. Streams of this size are not presently well evaluated by current methods. The evaluations were made to compare the two tributaries. These evaluations were extremely similar in composition except at an examination of puddles during the Fall 2007 drought. It was notable the West tributary had only air breathing snails, while the East

tributary had midges and mosquitoes. This may be related to the chemical DEET (a common insecticide) being detected in the West tributary in July of 2007.

The decline of EPT species and increased tolerance values between 1996 and 2006 is likely attributable to urban development and increases in impervious surfaces. The leveling off of declines from Spring 2006 to the end of the study may be interpreted as an adaptation to development.

The watershed experiences high storm flows due to impervious surfaces and lack of stormwater retention. This results in coarse organic particulate matter (CPOM) such as leaf packs and small woody materials to be flushed out. CPOM is required by shredders, and these conditions are the likely cause of their rarity in Black Creek.

Pollutants can have a larger detrimental effect on predator species, as bio-accumulation of toxins can occur. There was no decline in actual mass of prey species over the course of the study, so bio-accumulation of toxins is the likely cause of the disappearance of *Perlesta spp.*

Physical water parameters

Physical water parameters were measured at all five sites monthly; three core sites (EF2, WF2 and MS1) biweekly and during storm events for one year beginning in December of 2006. The parameters were turbidity, suspended solids, pH, temperature, dissolved oxygen and conductivity.

Turbidity measures light transmission through the sample. It is used for measurement of the density of suspended particles such as sediments, storm runoff, detritus, phytoplankton etc. A portable turbidimeter was used onsite. Calibration of the turbidimeter was checked prior to each sampling trip using standards provided. The sample portion was poured from the same 1 liter grab sample used for lab analysis of nutrients and suspended solids. The unit of measurement is in NTUs, or Nephelometric Turbidity Units.

Baseflow results showed a consistent pattern of average turbidity scores decreasing from upstream to downstream. WF1 and EF1 were similar with average NTUs of 9 and 10, respectively. WF2 and EF2 had averages of 6 and 5 NTUs (Table 10). The most downstream point, MS1, was 5 NTU. The higher readings depicted in the ranges for each site (Table 11) correlated with readings taken shortly (2- 3 days) after a rain event, but after levels had returned to baseflow.

Stormflow averages showed a different pattern. NTUs again decreased in the tributaries from upstream to downstream, but the main stem at MS1 experienced a more pronounced spike. WF1 and EF1 had averages of 91 and 95 NTUs respectively. WF2 and EF2 were consistently lower at 66 and 80 NTUs. The main stem, MS1, was highest at an average of 119 NTUs.

It should be noted that the sampling size for stormflow data is much smaller than that collected at regular sampling intervals, as rain events were of less frequent occurrence than scheduled sampling.

Also, scheduled sampling events used for the turbidity water quality data never occurred during a storm event, although as mentioned previously some were influenced by recent rains.

Table 10: Average turbidity at sampling sites, in NTUs

Site	WF1	EF1	WF2	EF2	MS1
Baseflow	9	10	6	5	5
Stormflow	97	95	66	80	119

Table 11: Range of turbidity at sampling sites, in NTUs

Site	WF1	EF1	WF2	EF2	MS1
Baseflow	2- 23	5- 23	2- 14	2- 13	2- 16
Stormflow	93- 100	86- 104	41- 123	60- 99	68- 233

The baseflow averages of physical parameters of turbidity, pH, and dissolved oxygen (DO) fall within acceptable NCDWQ standards. The baseflow average of conductivity was higher than expected standards for all sites, and the overall average. Table 12 shows baseflow averages by site.

Table 12: Baseflow averages of physical parameters by site

	Turbidity	pH	Temperature	Conductivity	DO
Site	**NTU**		**◦Celsius**	**µS/cm (microsiemens/cm)**	**mg/L**
EF1	9.70	6.96	15.66	134.47	8.30
WF1	8.70	7.02	16.27	117.19	8.25
EF2	5.29	7.27	15.92	122.81	9.00
WF2	6.06	6.74	15.65	145.51	8.12
MS1	5.10	7.09	16.47	119.06	9.78
Mean	6.97	7.02	15.99	127.81	8.69
Expectation	25	6-9		12-90	≥5

The stormflow averages of physical parameters (Table 13) of pH and DO fall within acceptable standards. Stormflow averages of turbidity for all sites were high, with a mean of 91.41 NTU, as discussed above.

Table 13: Stormflow averages of physical parameters by site

	Turbidity	pH	Temperature	Conductivity (microsiemens/cm)	DO
Site	**NTU**		**◦Celsius**	**µS**	**g/L**
EF1	95.00	5.67	12.20	36.35	10.44
EF2	80.65	6.58	19.58	55.90	7.92
WF1	96.50	6.31	12.15	41.00	10.25
WF2	66.36	6.64	21.16	67.02	6.86
MS1	118.55	6.58	19.30	50.24	8.28
Mean	91.41	6.35	16.88	50.10	8.75
Expectation	25	6-9		12-90	≥5

The NCDWQ water quality standards for turbidity are found in their "Redbook" of Surface Waters and Wetlands Standards. The expectations for Class C surface waters are included in Table 14.

Table 14: DENR expectations for Class C surface waters

Indicator	Standard
Conductivity	12-90 µhmos/cm
Ammonia (NH_3)	below 0.05 mg/l or 50 µg/l
Total Keidhal Nitrogen (TKN)	below 0.5 mg/l or 500 µg/l
Nitrate (NO_3) and Nitrite (NO_2)	below 0.3 mg/l or 300 µg/l
Total Phosphorus (TP)	below 0.05mg/l or 50 µg/l
Turbidity	Below 25 NTU
pH	6-9
Dissolved Oxygen (DO)	not less than 5 mg/L
Fecal coliform	Below 200cfu/100ml geomean

Nutrients

Nutrient samples were collected at all five sites monthly; three core sites (EF2, WF2 and MS1) biweekly and during storm events for one year beginning in December of 2006. The NCSU Center for Applied Aquatic Ecology provided prepared bottles, vials and filters for each collection, as well as conducting all analyses in the lab. The lab adheres to EPA protocols. Samples were kept iced in coolers until received at the lab, usually the same day but within a required 72 hr. time frame.

Parameters measured were total phosphorus (TP), soluble reactive phosphorus (SRP), total Kjeldahl nitrogen (TKN), nitrate (NO_3), nitrite (NO_2) and ammonia (NH_3).

All stormflow averages for total phosphorus (TP), total Kjeldahl nitrogen (TKN), nitrate (NO_3) and Nitrite (NO_2), and ammonia (NH_3) were higher than NCDWQ expectations (Tables 15 and 16). Given the urban nature of the watershed, sources of nutrients in stormwater runoff could include improperly or excessively applied lawn fertilizer, yard wastes, and pet waste. These are more likely to be found in stormwater flows than base flows, when stormflows from the first inch of rain are likely to carry the majority of nutrient sources into stormdrains and stream channels.

Table 15: Baseflow nutrient averages by site

Site	RL=1 mg/L	RL=10 µg/L	RL=6 µg/L	RL=140 µg/L	RL=5 µg/L	RL=7 µg/L
	SS	TP	SRP	TKN	NO3&NO2	NH3
	mg/L	µg/L	µg/L	µg/L	µg/L	µg/L
EF1	2.91	40.80	17.08	374.00	184.32	81.53
EF2	4.73	26.64	16.30	217.63	134.62	31.47
WF1	6.00	37.97	14.78	273.93	151.45	40.32
WF2	3.21	30.14	11.00	232.35	120.48	33.70
MS1	2.10	30.21	13.79	234.85	122.56	38.11
Mean	3.79	33.15	14.59	318.92	142.69	45.03
Adj. EF1 TKN				266.71		
NCDWQ Expectations		**<50**		**<500**	**<300**	**<50**

Purple shading indicates values that exceed expectations

Table 16: Stormflow nutrient averages by site

Site	RL=1 mg/L	RL=10 µg/L	RL=6 µg/L	RL=140 µg/L	RL=5 µg/L	RL=7 µg/L
	SS	TP	SRP	TKN	NO3&NO2	NH3
	mg/L	µg/L	µg/L	µg/L	µg/L	µg/L
EF1	66.11	171.55	27.36	677.98	262.62	131.96
EF2	44.23	125.46	24.82	790.67	353.56	206.34
WF1	81.10	193.86	34.95	1302.67	352.02	291.03
WF2	31.33	120.55	35.98	935.60	368.45	229.93
MS1	91.59	136.85	31.23	1045.71	340.12	402.40
Mean	62.87	149.65	30.87	950.53	335.35	252.33
Expectations		**<50**		**<500**	**<300**	**<50**

Purple shading indicates values that exceed expectations

Fecal Coliform Bacteria

Grab samples of 125 ml each were collected in sterile plastic bottles at all six sampling sites from June 2007- August 2007. Samples were immediately kept on ice and taken to the North Cary Wastewater Treatment Plant, where samples were analyzed using by plant staff using their standard protocol for membrane filter method. (See QAPP appendix 5).

Fecal coliform bacteria is used as an indicator for fecal-borne pathogens. The human health standard is a geomean of 200 colony forming units (cfu)/100 ml. The mean is used to mitigate for erratic spikes in the data. The geomean of fecal coliform at the five Black Creek sites ranged from 104.6 cfu/ml in East Fork 2, to 1,268.08 cfu/ml in East Fork 1. The EF2 site is the only one with a geomean below the human health standard. It appears that the amount of fecal coliform bacteria originating in the upper reaches of the East and West forks are high, with potentially some dilution occurring before the confluence of the tributaries with the main stem of the creek. Although the geomean of 245 cfu/ml at the MS1 station downstream is higher than human health standards, it is much less than the amounts found in the upper headwaters of the tributaries feeding into the main stem. See table 17 and Figure 17 below.

Table 17: Coliform results CFU/100ml

Site	6/5/2007	6/19/2007	7/2/2007	7/17/2007	7/26/2007	7/31/2007	8/2/2007	8/7/2007	Geomean
EF1		590		900	300	4000	1000	144	1268.8
EF2	295	140	59	116	69	200	89	49	104.6
WF1		365		900	75	184	1000	3300	1091.8
WF2	280	570	249	290	590	400	450	140	374.0
MS1	235	117	204	152	106	595	170	204	245.4

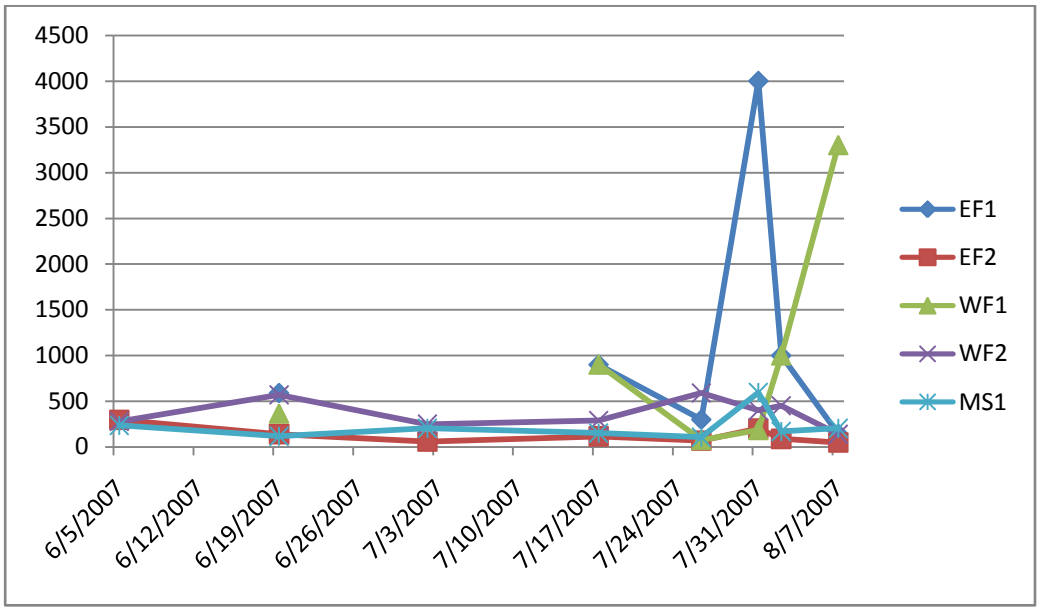


Figure 17: Fecal coliform results at sampling sites in CFU/100 ml

Sources of fecal coliform bacteria can be human, from failing sewer lines or septic tanks (it was thought that some homes on Chapel Hill Road may still have septic tanks), from wildlife, and domestic animals. In the Black Creek watershed, older sewer lines in the headwaters of East and West forks could be contributing through leaks. As BCWA members have commented on the presence of visible dog excrement along the greenway, it is likely that domestic animal waste is another source of fecal coliform bacteria.

Organic Contaminants in Streamflow

Toxic organic compounds in streamflow were assessed utilizing passive sampling devices (PSDs) that are designed to be deployed on the stream bottom for periods of 2-4 weeks. These devices consist of specialized sorbent disks mounted in wire cages that differentially absorb different classes of organic compounds. Passive sampling devices offer an alternative strategy to monitor waterways for organic contaminants. Traditional grab samples for these analyses only represent one single time point, and generalizations of ambient concentrations over longer periods are not reliable (Alvarez, 1999). Passive sampling devices offer a passive *in situ* sampling alternative by accumulating contaminants over a given deployment period (Huckins et al. 1993). The purpose is to simulate bioaccumulation of hydrophobic organic contaminants, particularly PAHs.

Using laboratory derived sampling rates for each individual contaminant, an average ambient concentration over the period of deployment can be calculated for each contaminant using the following integrative (linear) formula:

$$C_w = C_s M_s / R_s t$$

Where C_w and C_s are the analyte concentrations in water and the sampler respectively; M_s is a mass related to the sampler, R_s is the derived sampling rate of individual contaminants in liters per day, and t is the length of deployment (Petty et al., 2000). PSDs have improved our ability to monitor organic contaminants by increasing analyte masses for more reliable instrumental detections and by improving detection of ultra-trace ambient concentrations (Huckins et al., 1993).

Grab samples were collected and analyzed for organic contaminants beginning in July 2007, monthly and during rain events. Two liters were collected for sampling:

- One liter for solid phase extraction of polar organic compounds (pesticides, pharmaceuticals, and personal care products
- One liter for liquid extraction of hydrophobic organic compounds (petroleum hydrocarbons, polycyclic aromatic hydrocarbons or PAHs)

Passive sampling devices, in particular, permeable membrane devices (PMDs) were deployed at 3 sites in July 2007, in each of the two main tributaries (WF2, EF2) and the main stem (MS1). PMDs were collected and redeployed every 2 weeks. They were in a cage made of inert materials containing 2 low-density polyethylene (LDPE) membranes.

Both grab samples and PMDs were extracted in the NCSU Forestry Dept. hydrology lab and refrigerated. The PSD sorbent disks were extracted with organic solvents in the lab, providing a sample in which trace organics are more concentrated than in the water column. The extracts were analyzed by gas chromatography and mass spectrometry in the research laboratory of the NCSU Department of Environmental and Molecular Toxicology.

A variety of phthalates (plastics) was found at all sites, sometimes in baseflow, sometimes in stormflow, and sometimes in both (see table 18). Phthalates were recently implicated in interference with male reproductive development after prenatal exposure. Effects on benthic macro-invertebrates are unknown, but phthalates do bioaccumulate up the food chain. DEET was

found in one West Fork stormflow sample. On October 16, 2007, small stagnant pools were sampled for macro-invertebrates at the West Fork site. No insects were found, only 3 species of lunged snails. Samples taken at the East Fork site showed mosquitoes and midges. In a quick literature search for impacts of DEET on aquatic invertebrates, one study (Xue 2000) found impacts on macroinvertebrates at very high levels, however they concluded that "the experimental repellents were considered safe to the aquatic nontarget organisms when employed as oviposition repellents for Aedes albopicus (Skuse) Mosquitoes". EPA (1998) states that "the available data characterize DEET as slightly toxic to birds, fish, and aquatic invertebrates and as practically nontoxic to mammals". Although DEET was detected, the concentration of DEET in the stream at the time is unknown.

Table 18: Compounds found in grab samples

Grab sample		Compound found	Description of compound
	EF2 B	Dimethylphthalate	insect repellants, plastic
	EF2 BS	Diethyl phthalate	personal care products that have fragrances
WF2 BS	EF2S	Di-n-propyl phthalate	A plasticizer. Phthalate ester (suspected carcinogen, estrogenic)
WF2 S	EF2S	Dicyclohexyl phthalate	Plasticizer
WF2 B	MS1 BS	Di-n-butylphthalate	Varnish, perfume, plastics, mosquito repellant
WF2 B		Bis(2-ethylhexyl)phthalate	Cosmetics, liquid soap, detergents
WF2 S		N,N-Diethyl-m-tolumide	DEET- most common active ingredient in insect repellents

EF2= East Fork 2
WF2= West Fork 2
MS1= Main Stem
B=Base flow sample
S=Storm flow sample

During the monitoring period, flow levels in EF2 were too low to collect data via PMD. Two PMD collections were possible each at the West Fork 2 and Main steam 1 site, before water levels in the channels became too low to collect data. As of the time of this writing, the results of the PMD analyses have not been made available. If and when these results are obtained, they will be reviewed and presented to the BCWA for considering whether there is a need to changes the objectives, strategies, or priorities of the watershed management plan.

Given that Black Creek and its tributaries are upstream from the North Cary Wastewater Treatment plant, and receives no treated wastewater effluent, it is hypothesized that phthalates and DEET are entering the tributaries and possibly the mainstem through leaks in sewer lines. The compounds

appear to be entering during base flow and stormflow events. Sewer line easements follow both tributaries and the mainstem before flowing into a collection pipe that enters the wastewater treatment plant adjacent to Lake Crabtree.

We recently discovered that Black Creek was one of thirty streams in the Raleigh-Durham area that were assessed in 2003 as part of the USGS National Water-Quality Assessment Program. A recent publication (Bryant et al, 2007-5113) summarized the results of using semipermeable membrane devices to assess bioavailable organic pollutants at the USGS NWQAP sites. The USGS study found 5 compounds in Black Creek, listed in Table 19. These included two herbicides; trifluraline and benfluralin, and three polcyclic aromatic hydrocarbons (PAHs); phenanthrene, fluoranthene, and pyrene (2007-5113, P. 20, and its appendix). The USGS study found that fluoranthene and pyrene were measured above the reporting level in every stream sampled in the Raleigh-Durham.

PAHs are contaminants and known carcinogens that adversely affect mammals (including humans), birds, fish, amphibians, invertebrates, and plants. Bryant et al (2007, p. 41) list the effects of PAHs on aquatic insects including inhibited reproduction, delayed emergence, sediment avoidance, and mortality. Effects on fish include fin erosion, craniofacial and spinal deformities, liver abnormalities, cataracts, and immune system impairments, among other documented effects. PAHs are a product of the incomplete combustion of petroleum, oil, coal, and wood. Sources in an urban environment include industrial emissions and wastes; home heating with fuel oil, wood, and coal; power plants; vehicles; and pavement sealants. Van Metre et al (2008) state that flouranthene and pyrene ratios are an indicator of coal-tar pavement sealants. The ratio of these compounds found in Black Creek are unknown, but their presence adds evidence to coal-tar based sealants as a potential source. Recent research also links coal-tar pavement sealants to developmental problems in amphibians (Bryer et al, 2006). Although the data on PAHs from the 2007 study were not available at this writing, evidence of PAHs found in the 2003 USGS study indicate that the presence of these contaminants in the Black Creek watershed may be contributing to negative impacts in the aquatic biota.

Table 19: Organic pollutants found in Black Creek in 2003 (Bryant et al, 2007. P. 20 and Appendix)

Organic pollutant	Type of compound	Level reported µg/l	Toxicological benchmark values*
Trifluraline	Dinitroaniline herbicide	4.13	NA
Benfluralin	Dinitroaniline herbicide	2.30	NA
Fluoranthene	PAH	123.51	6.16
Phenanthrene	PAH	60.03	3.23
Pyrene	PAH	122.05	NA

*for screening potential contaminants of concern for effects on aquatic life or human health

It is interesting to note that the 2003 USGS study did not find any phthalates (plasticizers, personal care products, mosquito repellents), while the grab samples analyzed in 2007 yielded evidence of five of these compounds. Bryan et al (2007, p. 40) state that sources of wastewater compounds in streams in their study "would include but not be limited to leaking sewage lines, sewage overflows during storms or due to clogs, septic tanks, overland runoff (for example, animal feces), and atmospheric deposition." Based on the discovery of some wastewater compounds in our 2007 study, it is possible that sewer lines in the Black Creek watershed have begun to leak sometime after the 2003 USGS study.

Additionally, assay tests that were intended to address mixtures of organic contaminants and toxicity were conducted and reported by the USGS study. We have not yet been able to interpret what the assay test results mean for Black Creek, but results may provide additional insight into the levels of toxicity contributed by organic contaminants.

Rapid channel condition assessment

A Stream Condition Assessment developed by NCSU Water Quality Group, was used to measure:

- Stream bank stability
- Bedform macrohabitat
- In stream cover and refuge
- Floodplain condition

Each parameter that was measured was rated as Excellent (4), Good (3), Fair (2) or Poor (1). The watershed was divided into 8 approximately equal sectors. Volunteers from BCWA and NCSU were trained by Dr. Jim Gregory and Dr. Greg Jennings in a workshop that had a classroom and field component. Each volunteer team was assigned a confluence, and evaluated 200 ft. of both upstream reaches of a confluence. They were provided with Worksheets to fill out (Appendix F). Most took photos of the reaches. A total of 32 reaches, 6,400 ft. of stream, were evaluated.

Many of the stream channels evaluated were smaller tributaries, with little or no buffers from lawns and roads. The stream condition at the monitoring sites EF2, WF2, and MS1 were observed to have better buffers and stability than the smaller tributaries. Overall, the results of the assessments showed fair-good conditions.

Table 20: Stream condition assessment results for all reaches

Stream condition indicator	Average result	Rating
Bank stability	2.4	Fair
Bedform macrohabitat	2.8	Good
Instream cover & refuge	2.3	Fair
Floodplain condition	2.6	Good

Pollution Source Inventory

The Black Creek Watershed was subdivided into 9 survey areas. Volunteers were recruited via the Black Creek Listserve to conduct a pollution source survey within each area, using an informational guide and filling out a standard survey form. The informational guide explained in thorough detail what the different potential pollution sources were, and how to identify these sources.

Volunteers were asked to review a GIS map of the subarea and conduct a driving survey to become familiar with the area. Draft a list of potential pollutant sources/sites and examine these sites more thoroughly. Examine sites along the streams within your survey area for evidence of trash dumping, oil slicks, etc. A complete walk of all streams in the survey area was not required, but volunteers were asked to visit as many accessible sites along the streams in the survey area as feasible. There were asked to be thoughtful of private property and stay on publically accessible areas. Volunteers listed and briefly described the potential point and nonpoint sources on the Pollution Source Survey forms. Volunteers took digital pictures of the sites/sources that are listed on the survey form, then turned the data over to the technical team for analysis.

Volunteers were asked to look for:

- Point sources: Illicit discharge – untreated polluted water that is discharged directly to a stream or to a storm sewer. An illicit connection is the discharge of pollutants or non-storm water materials into a storm sewer system via a pipe or other direct connection. Sources of illicit connections may include sanitary sewer taps, wash water from laundromats or carwashes, and other similar sources. An illicit discharge is the discharge of pollutants or non-storm water materials to storm sewer systems via overland flow or direct dumping of materials into a storm drain. A component of the Town of Cary's stormwater management program is illicit discharge detection and elimination (IDDE). For background reading on IDDE, see http://www.neiwpcc.org/iddemanual.asp.

- Potential nonpoint sources: Residential and commercial areas with intensively managed lawns and landscapes.
    - very well maintained lawns and landscaping, often with in-ground irrigation systems, in upscale residential neighborhoods or commercial or institutional sites.

- Large areas of impervious surface that can potentially deliver pollutants to the storm sewer system.
    - large building/parking lot complexes with evidence of trash in the parking lot or around buildings, evidence of fuel or oil spills that have not

- Active construction sites with poorly managed erosion and sediment control practices that result in delivery of sediment to streams that receive stormwater runoff.

Figure 18: Dumpsters on impervious surfaces draining directly to stream system

    - freshly deposited sediment in nearby streams or sediment deposits in riparian areas close to streams, evidence of stormwater and sediment being carried over or under poorly constructed/maintained silt fences, detention basins that are more than half-filled with sediment or there is evidence of overwash over the basin berm, etc.

- Pollutants in streams
    - Evidence of dumping of yard/landscape management residues such as grass clippings, branches pruned from shrubs, etc.
    - Evidence of dumping of trash into the stream or trash in the stream that may have been be carried from roadways or parking lots by stormwater runoff.
    - Evidence of dumping of oily liquids. Note that iron oxidizing bacteria are common during the spring and summer months in quiet water areas of small streams. Such bacteria utilize reduced (i.e. dissolved) iron in ground water discharging to the stream in respiration and in turn, oxidize the iron.

The spatial data layers were analyzed and combined with field reconnaissance and assessment of stream water quality data with the intention of classifying and mapping different types of potential source areas for nonpoint source pollution.

No obvious hotspots for nonpoint source pollution were identified; however egregious nonpoint source pollution was seen throughout the watershed. These included:

- Poor construction site management (open barrels of unknown substances, visible erosion)
- Leaking garbage containers
- Barrels containing unknown materials
- Lawn and landscape chemicals
- Litter

More than one participant pointed out apparent failure of erosion control BMPs at construction sites.

Wildlife and greenways

Terrestrial and aquatic wildlife were topics of interest for participants of the public kick-off meeting and the BCWA. Although the watershed assessment was limited to the sampling of aquatic macro invertebrates, the BCWA sought information on other species to inform their planning process. They found that Dr. Chris Moorman, and Dr. George Hess had engaged graduate students in studies of wildlife and greenways, using Black Creek Greenway as one of the study sites. Dr. Hess and Dr. Moorman presented the findings of these studies to the BCWA. Their presentation *Greenways for Wildlife,* and a summary of their findings and recommendations in the October 2007 *Black Creek Watershed Wire* are both posted on the project website. At the time of the salamander study in 2004, southern two-lined salamanders (Eurycea cirrigera) were documented in Black Creek. The BCWA is attempting to obtain the data results for these salamanders in Black Creek. The BCWA chose to include the southern two-lined salamander in their logo.

Dr. Moorman and Dr. Hess' recommendations on how to manage greenways to benefit migrating birds, breeding birds, and salamanders follow.

To provide high quality breeding and stopover habitat for birds, forested greenways should:

- Lie within forest corridors >50 m (150 ft)
- Contain narrow trails that don't break the canopy
- Lie adjacent to development with high canopy retention
- Be managed for complex native vegetation structure

Conservation implications for salamanders include:

- Efforts must be coordinated across an entire watershed (not just buffers) and large parks or reserves should be conserved
- Greenways are not sufficient to conserve all wildlife
- Parks should be managed to provide habitat diversity

Final Assessment Summary and conclusions

Based on the assessment results, stable bedrock, large cobbles, and low siltation may help mitigate the high stormflow effects on macroinvertebrates. High stormflows are likely removing snags and leaf packs, which may help explain why shredders are rare. A lack of predator macroinvertebrates may be a result of organic contaminants (PAHs, phthalates) bioaccumulating in the foodchain.

Fecal coliform bacteria was found to be highest in the headwaters of the two main tributaries to Black Creek. The inputs of fecal coliform bacteria, as well as the presence of phthalates that are usually found in wastewater, provide some evidence of potential sewer line leaks in the headwater areas of the watershed. Improper pet waste disposal is also a potential contributor to fecal coliform bacteria throughout the watershed.

Nutrient levels were found to be high in samples taken during stormwater events. Lawn care and landscaping practices, as well as pet waste could contribute to these high nutrient levels.

The Black Creek watershed is a typical piedmont urban/suburban developed watershed. Because of the large amount of development that occurred before more modern storm water management techniques were put into practice, much of the storm water runoff runs directly to the streams without passing through the extensive and beautiful buffer the Town of Cary maintains, over 100 feet in some places. Because of this bypass, the system has been greatly compromised and is subject to very rapid flow increases during even small one inch rain events. Residents who are reporting frequent flooding along the banks in their backyards will continue to suffer from these floods for typical storm events until some of the more major storm water contributors, particularly large apartment complexes and stores agree to retrofit their storm water systems.

Our land use/Land cover analysis of the complete Black Creek Watershed estimated an approximate 62% coverage of human developed land cover categories within the watershed. The object-oriented analysis showed >21% impervious cover (housing, parking lots, streets, driveways). This level of watershed development correlates with documented declines in hydrologic, chemical, and biological

quality of receiving waters and may be further exacerbated by changes in land uses and future urban development.

Smaller watersheds could be assisted by the implementation of individual homeowner retrofits to control the storm water contribution for neighborhoods on a home-to-home basis, or in homeowner association right of way. Because of the large residential areas within the watershed, this could make a major difference for some of the tributaries in the system. Implementing stormwater retrofits to control stormwater contribution from large parking lots is an essential component to reducing stormwater runoff volumes as well as PAHs, pyrogenic and petrogenic toxic organic compounds that were found in a 2003 USGS study of Black Creek.

The Black Creek Watershed Association and public involvement (methods, results, conclusions)

Situation Assessment

The purpose of the Situation Assessment was (1) to identify stakeholders, members of the community with a stake in the Black Creek watershed, (2) to learn what the stakeholders see as problems, and (3) to learn what the stakeholders may wish to gain by participating in a watershed planning process. Stakeholders were identified through a snowball sampling method, which relies on referrals from initial subjects to generate additional subjects. Initial subjects included known stakeholders who have been actively involved with Black Creek issues. WECO interviewed twenty one stakeholders including residents, developers, and local and state government staff, representing a cross-section of interests. For example, the team did not speak to every resident identified, but tried to interview people from upper, middle, and lower watershed neighborhoods. Responses were not attributed to specific individuals. We summarized responses, and made recommendations for moving forward. The following paragraphs were amended from the Final Situation Assessment Report's Executive Summary:

The Black Creek watershed has seen rapid growth in residential and commercial development in recent years. This growth has put various stakeholders at odds with each other. A recent conflict regarding a move of the popular Black Creek Greenway to accommodate a new apartment complex left trust badly strained between lower watershed residents, development interests, and Town of Cary elected officials. However, the Situation Assessment reveals that residents, developers, and other watershed stakeholders are interested in coming together to search for innovative solutions to the problems impacting Black Creek.

Development is the greatest concern for most respondents. Residents are concerned development may be degrading the environment; developers are concerned that regulations may impair their ability to develop in economically sound and environmentally innovative ways. This issue was brought into focus with the recent Black Creek Greenway conflict. Stakeholders are concerned about increasing populations, accompanying traffic increases, and residential practices impacting

water quality and recreation. PCB contamination in Lake Crabtree also ranks high among concerns, as well as concerns about other unknown potential toxins in the watershed. Finally, respondents are concerned about the overall ecological health of the watershed, including its ability to provide healthy wildlife habitat.

Almost all stakeholder groups interviewed expressed interest in participating in a collaborative watershed planning process through the formation of a watershed association. Respondents made the following suggestions for the process: provide education; conduct unbiased research; produce a measurable specific product, include broad participation; and provide a safe, neutral climate for building trust and negotiations. Their willingness to engage one another allows participants to seek opportunities for mutual gain if careful attention to process is followed by NCSU facilitators and participants alike. NCSU will follow these recommendations while convening a collaborative watershed association for the Black Creek watershed. Important principles to be adhered to include: 1) science-informed decision-making (a technical watershed analysis is currently underway), 2) mutual education, 3) collaborative decision making, and 4) neutral facilitation. This will allow participants' to learn from one another and make decisions for restoring the watershed while also meeting their individual needs.

Watershed Planning Public Kick-off and Survey

We shared results of the situation assessment at a public workshop on March 21, 2006, where participants learned about watershed planning and completed surveys about watershed protection beliefs and practices.

We asked the attendants to fill out a preliminary survey, and we got nineteen completed surveys in response. The majority of surveys were completed by residents in the watershed. Several salient points came out of this survey:

- Most people consider the greenway system the most visible feature of the watershed.
- Water quality is a major concern for most stakeholders, but many think the watershed is healthy enough for all purposes short of ingesting the water.
- The community is interested in taking action, but would like to learn more about specific actions they can take.
- Landscaping practices could be a potential target for action, as most respondents indicated that they used chemical treatments for their lawns, few indicated that they

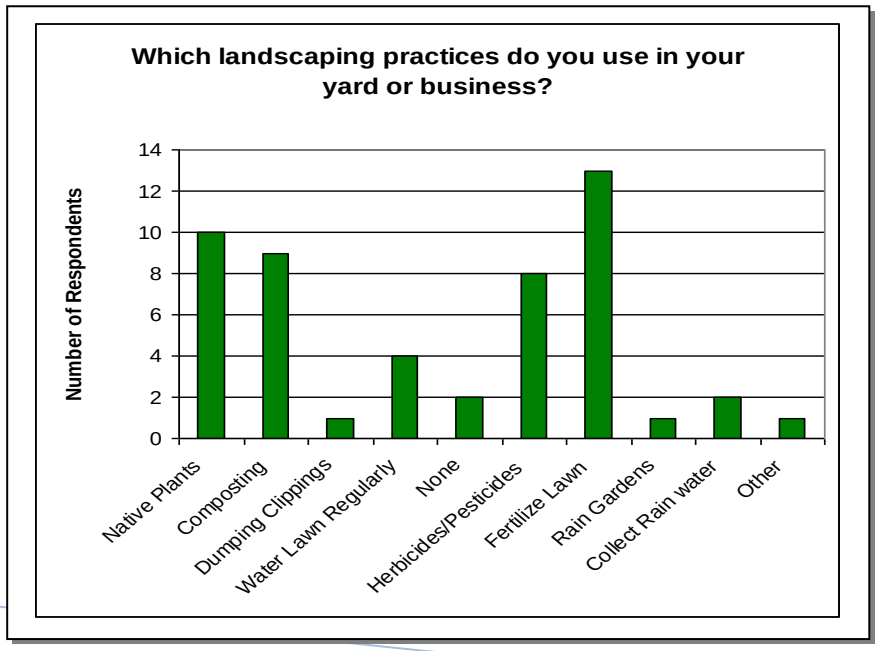


Figure 19: Landscaping practices used by survey respondents

used best management practices for rainwater retention, and individuals expressed interest in learning about better landscaping options (See figure 19)
- People expressed interest in the impacts of development, but it was not the primary concern for most respondents.

Additionally, we asked about how people handled pet waste and where people got environmental information. We did not get enough pet owners to make any notable conclusions on that subject. People's sources of environmental information varied, but print information in newspapers and Town of Cary mailings were the most common. A complete summary of the survey is in Appendix C.

Convening the Black Creek Watershed Association

The BCWA was convened in 2006 by NCSU, with participants representing several homeowners associations and unorganized neighborhoods, Cary Academy, Lake Crabtree County Park, Cary Rotary, Town of Cary (TOC) Parks, Recreation, and Cultural Resources Advisory Board, TOC Greenways Committee. Technical expertise is provided the TOC Stormwater program in the Dept. of Engineering, Wake Cooperative Extension, Wake Soil and Water Conservation District, NC division of Water Quality, and NCSU Watershed Education for Communities and Officials (WECO) program, Dept. of Agricultural and Resource Economics, and NCSU Dept. of Forestry and Environmental Resources.

The BCWA participated in several educational and interactive sessions to build a common base of knowledge among participants. Every educational session was summarized in the Black Creek Watershed Wire (newsletter) and sent to all members, so absentee members could also learn about the topics, and PowerPoint files were posted on the website. Educational topics and speakers included:

- *Interactive collaborative skills training,* Dr. Steve Smutko, Natural Resources Leadership Institute, NC State University
- *Aquatic macro-benthic invertebrates,* Dave Penrose, Water Quality Group, Dept. Biological and Agricultural Engineering, NC State University
- *Watershed hydrology and stormwater BMPs,* Mitch Woodward, Wake County Extension
- *Watershed education and outreach principles,* Annette Lucas, NC Division of Water Quality
- *Stream geomorphology and restoration,* Barbara Doll, Stream Restoration Institute, Dept. Biological and Agricultural Engineering, NC State University
- *Stream channel assessment skills,* Dr. Greg Jennings, Stream Restoration Institute, Dept. Biological and Agricultural Engineering, NC State University
- *Low impact development,* Laura Szpir, Dept. Biological and Agricultural Engineering, NC State University; Dr. Lee-Anne Milburn, College of Design, NC State University; Anna Readling, Town of Cary Planning Dept.
- *Greenways and wildlife habitat,* Dr. Chris Moorman, Dr. George Hess, Dept. Forestry and Environmental Resources, NC State University
- *Pollution source survey techniques (point and nonpoint source),* Dr. Jim Gregory, Dept. Forestry and Environmental Resources, NC State University

Education and outreach

The BCWA was very active in brainstorming and helping to develop educational outreach programming that has endured beyond the life of this grant. An annual stream clean-up was implemented in coordination with Wake County Soil and Water Conservation District's Big Sweep, called Big Sweep for Black Creek. Four clean ups were conducted by 102 volunteers, resulting in 176 bags of trash and 63 bags of recycling removed from the creek and riparian buffer. Town of Cary provided pick-up, at a benefit of ~$158 per event for a total of $632 in cost sharing.

In partnership with Lake Crabtree County Park, BCWA hosted educational booths at two WaterFest events held at the Park. Presentations about the project and watershed science were developed and presented to Cary Rotary and Beechtree Homeowners Association. Volunteers were trained for two stream walk events. The first involved learning about and participating in stream channel assessments, while the second involved learning about and conducting pollution source inventories in subwatersheds.

Middle, high school, and college students were involved at different stages of the project. A Cary Academy science teacher involved her high school students in maintaining a rain gauge on campus, and provided extra credit for students who participated in BCWA meetings. Middle and high school students throughout Wake County participated in a logo design contest, and were recognized for their efforts in a celebration before a BCWA meeting. Students and faculty from a UNC-Chapel Hill graduate class, Public Affairs and Community Involvement, attended and evaluated a BCWA meeting for adherence to public involvement principles. Finally, NCSU graduate students were funded through the grant to collect watershed assessment data and develop the geodatabase, and a graduate student volunteered to assist with the Situation Assessment.

The watershed planning process

The planning process involved a back and forth dialogue between the NCSU technical team, and the Black Creek Watershed Association. One important component of collaborative planning is for participants of the decision-making group to have common understanding of the science and issues related to the watershed. Potential methods for the assessment were explained to the BCWA, with room for changes and additions as requested. As results were acquired, the technical team would report these results back to BCWA, and make sure they understood and were comfortable with the results. Invited speakers would often provide the scientific and technical background necessary for understanding the technical teams work, while sometimes the technical team provided that education within their own presentations. The BCWA gathered information about issues of

Figure 21: BCWA at work

community interest that was in addition to the data collected by the technical team. This included information on wildlife and greenways, low impact development, and a former Natural Heritage entry in the NC Natural Heritage Database called the *Black Creek Slopes* (see figure 23).

BCWA members participated in collecting the data that was used in the assessment. Their participation in stream walks to collect data on channel and riparian condition, and visible pollution sources, provided more eyes than possible with just the technical team.

Early in the planning process, BCWA was asked to think about the services provided by the watershed that they valued. For example clean water is valued for providing safe contact for children exploring the creek. This initial brainstorming session, informed by the watershed assessment results, led to the goals for the watershed plan. Once goals were agreed upon, BCWA brainstormed specific, measureable objectives that would likely lead to achieving the goals. Participants listed specific strategies with action items that would work towards objectives and goals. This list was supplemented by suggestions that had been provided by members throughout the planning process (newsletters were reviewed to find suggestions provided at meetings). The working drafts of goals, objectives, and strategies were provided at meetings, on the listserv, and posted on the website for review. Participants provided their feedback in person at the meetings and via email.

Participants considered the connections between the proposed strategies and the goals the plan seeks to achieve. The goals were placed on one side of a large piece of paper posted on a wall, and juxtaposed across from the main strategies under consideration. The exercise promoted discussion about the potential impacts of the strategies. Lines were drawn between each strategy and its respective goals. The number of connections was then tallied to determine potential impact. Strategies that were perceived to have the broadest range of impact across goals scored higher.

The scores were as follows:

7 Continue/expand litter removal
6 Protect natural areas adjacent to greenway
5 Design/create BMPs in public spaces as demos
5 Increase forest canopy in developments adjacent to greenway
4 Remove exotic & invasive plants
4 Hold community workshops to educate about BMPs
4 Install pet waste stations
4 Install many residential/HOA BMPs
4 Create view spots of natural areas
3 Present Education & watershed plan to TOC Boards & Council
3 Citizens learn to recognize & report erosion control failure
3 Maintain forest canopy over greenway
2 Educate HOAs & community groups though presentations

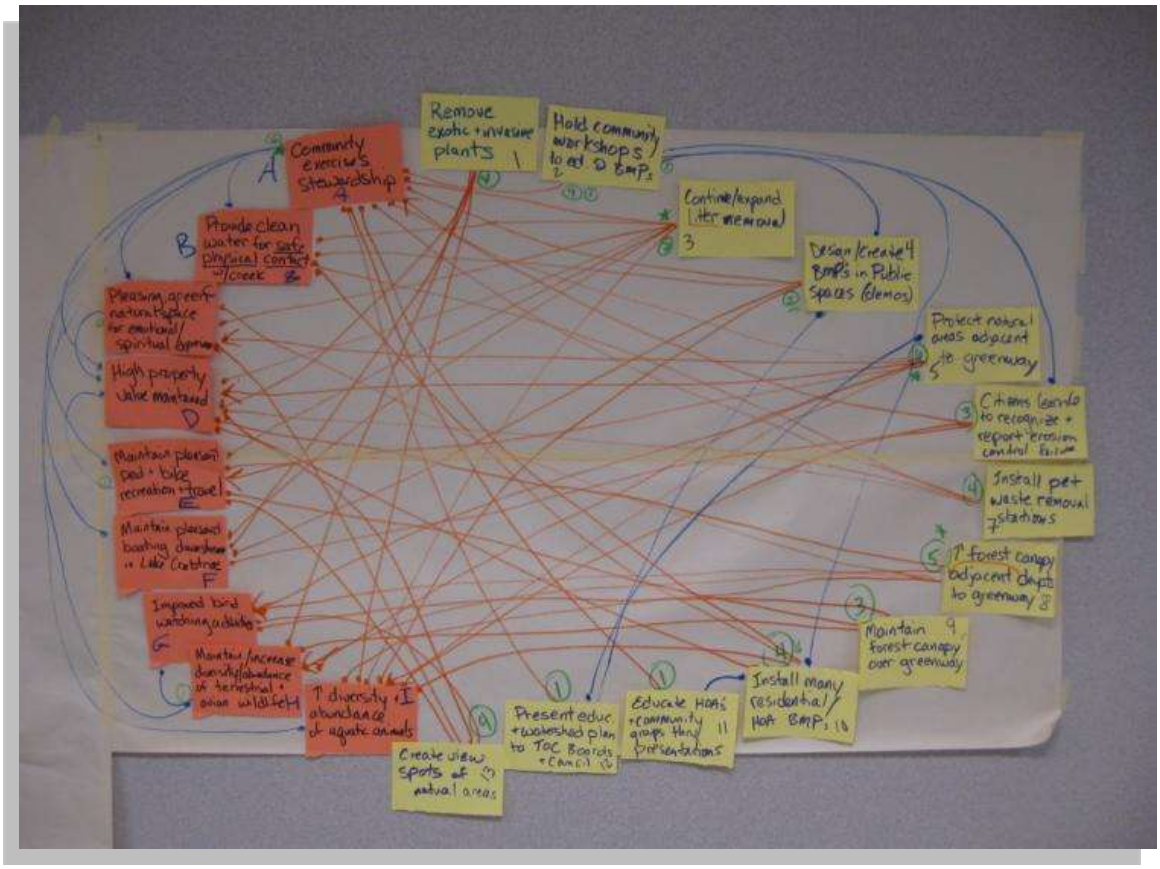


Figure 22: Connections between goals and strategies mapped

The table of Goals, objectives and strategies (Table 21) serves as the watershed plan that is referenced for seeking implementation funding and planning next steps.

Next steps:
NCSU, Wake County Extension, Town of Cary, and BCWA will:

- Identify areas on public property for potential stormwater best management practice retro-fits
- Develop educational workshop curriculum and marketing materials for neighborhoods for a campaign titled "*Less rain down the drain*"
- Through the campaign, recruit participants in residential retro-fit projects
- Develop and conduct a watershed resident survey to learn how they view ecological resources in the watershed, improvement projects, and public and private options for funding projects
- Seek funding to design and construct stormwater best management practices, including BMPs to go along the greenway in coordination with the Town of Cary's planned renovation.

Black Creek Slopes

The following is from the NC Natural Heritage Program's 1985 description of the area encompassing the north-facing slopes upstream of where Black Creek and Lake Crabtree (formerly Crabtree Creek) meet. The Black Creek Slopes site was removed from the state's Natural Heritage database due to the subsequent development of most of the area. (A small portion of the remaining area is undeveloped and owned by the Town of Cary as North Cary Park.)

This is a small area of less than 10 acres. It is located just north of Cary off of (Harrison Avenue). This was probably a beautiful area several years ago before development cleared most of the surrounding forests. Some of the forests in the ravines and on the slopes still maintain their integrity, but it is likely that they too will be developed.

Some ravines and slopes are very rich with herbaceous species. In places there are thousands of maidenhair ferns (Adiantum pedatum) present. The canopy species include Acer saccharum spp. Floridanum (Sugar Maple), Fagus grandifolia (American Beech), Carya spp. (Hickory), and Quercus alba (White Oak). Some trees are greater than 25 inches dbh.

Figure 23: Description of the Black Creek Slopes former Natural Heritage Site

Table 21: Black Creek Watershed Goals, Objectives, and strategies

A. Goals (long-term results)	B. Objectives (Specific, Measureable, Achievable, Realistic & ambitious, Time-bound)	C. Strategies to achieve objectives
Educational Opportunities		
1. Community has increased understanding about and exercises stewardship towards Black Creek.	• People attend workshops held 3-4x/year and understand concepts • New members recruited to BCWA, including TOC Block Leaders • 75% of BCWA residents aware of BC situation and 25% implementing individual water quality best management practices (raingardens & rain barrels) • People solicit help for best management practices • Use information targeted towards BC residents to improve outreach methods	• Create demonstration sites in public spaces • Community workshops ○ Involve Lowes with workshops ○ Incentives- rainbarrel door prize ○ Partner with TOC Water conservation and volunteer coordinators for workshops • Raise awareness of TOC buyback for removing turf • Involve Town of Cary "Block Captains" in the BCWA & disseminating "green" water quality information such as DWQ document "Improving Water Quality in Your own Backyard" and NCSU document "Landscaping for Wildlife w/ Native Plants". • Provide plants from local garden store • Create path markings (indigenous veg., stream elements) • Conduct stormdrain stenciling • Conduct willingness to pay study for watershed improvements

A. Goals (long-term results)	B. Objectives (Specific, Measureable, Achievable, Realistic & ambitious, Time-bound)	C. Strategies to achieve objectives
Health/Welfare		
2. Provide clean water for safe physical contact with creek (secondary recreation)	• Stormwater BMP retrofits on outfalls • Reduce fecal coliform levels in stream to <200 cfu/100ml • 75% of dogowners pledge to pick up after dogs • Reduce illicit discharges in BC tributaries	• Illicit detection elimination program through TOC to investigate potential cross connections • Educate residents about pet waste – distribute materials through HOAs • Install pet waste stations along greenway, at HOAs
3. Aesthetically pleasing natural green space provide for emotional/spiritual experiences	• Preserve additional open space in watershed- do not allow offset payments (payments in-lieu) • Protect TOC property adjacent to Creek/Cary Parkway as natural area, use as natural resource education site, use LID on any facilities • Identify areas of natural interest, such as vestiges of the former Natural Heritage Site, wildflowers, outcroppings • Create view spots and opportunities for sitting, bird watching, reflection	• Work with TOC staff and PRCR Advisory Board on design of BC Greenway renovation Maintain greenway • Encourage more watershed groups in Neuse • Identify areas of natural interest (green infrastructure) for preservation or recreational opportunities using GIS • BCWA participates in BC Greenway Public Art Project planning
Local Economy		
4. High property resale value maintained	Aesthetically pleasing greenway, natural resources, and clean water	• Improve access to greenway • Improve greenway (camouflage sewer manholes; remove exotic species)

A. Goals (long-term results)	B. Objectives (Specific, Measureable, Achievable, Realistic & ambitious, Time-bound)	C. Strategies to achieve objectives
Recreation		
5. Maintain pleasant pedestrian & bicycle recreation & travel	• Protect TOC property adjacent to Creek/Cary Parkway as natural area, use as natural resource education site, use LID on any facilities • Consider establishing BC Greenway as linear park • Preserve additional open space through acquisition and/or conservation easements • Expand litter maintenance efforts (2 times per year) • Reduce pet waste on the greenway	• Continue and/or expand Big Sweep for Black Creek • Consider pervious pavement options • See pet waste strategies in "Provide Clean Water" strategy • Provide community recreational events (training runs, bird counts)
6. Recreation in Lake Crabtree is improved.	Reduce sediment and pollutants from Black Creek	• Control sedimentation and erosion from devpt sites • Citizens learn to recognize and report erosion control failures (through Muddy Water Watch)
7. Bird watching opportunities are maintained or improved	• Increased bird habitat (natural and manmade, like bluebird houses)*See wildlife category*	• Make and sell birdhouses with BCWA logo, or sell for naming rights • See recs. Under "Wildlife" category

A. Goals (long-term results)	B. Objectives (Specific, Measureable, Achievable, Realistic & ambitious, Time-bound)	C. Strategies to achieve objectives
Wildlife		
8. Maintain and increase diversity and abundance of terrestrial and avian wildlife in watershed	• Bird species remain same or increase relative to last survey (Hess & Hull, Kohut studies) • Maintain/ improve quality riparian corridor • Increase native vegetation	• Remove invasive vegetation & manage for native vegetation • Maintain unbroken forest canopy over greenway, narrow trails • Maintain forested corridors of >150 ft. • Maintain or provide high canopy coverage in devpts. adjacent to greenway • Install many raingardens and wetlands • Bird/bat houses
9. Increased diversity and abundance of aquatic animals in Black Creek and its tributaries by improving water quality through • reduced volume & velocity of stormwater reaching Black Creek and tributaries • reduced amounts of organic pollutants in stormwater • improved in-stream and terrestrial habitat	• Three large retrofit BMPs completed and 24 residential retrofits by 2012 • No additional stormwater runoff is generated from new development (to result in a net loss of runoff) • Macro-invertebrates have a "good" rating in 10 years, with increases of EPT species seen within next 5 years • Salamander populations stabilize or increase (see Miller 2005 data)	• Retrofit BMPs throughout watershed through partnerships with HOAs, neighborhoods, commercial landowners, TOC, Wake County Schools. (BMPs for lots, small catchments, and intersecting stormwater channels/outfalls) • Encourage TOC to promote protection of existing riparian buffers and headwater stream/wetland areas, and restoration of impaired riparian buffers to at least 100' wide on perennial streams where practical. • Recognize businesses, organizations who partner for retrofits • Work with NC Museum Natural History experts to determine feasible goals for salamanders

Estimates of removals and costs

Estimating load reductions of stormwater flow and nutrients

Two methods are used here to estimate load reductions of stormwater flow and nutrients. All scenarios are based on implementation within a 58 acre subwatershed that drains the Silverton neighborhood and the Town of Cary's North Cary Park.

1. To obtain estimates for hydrologic improvements, the Center for Neighborhood Technology's online Green Values Stormwater Toolbox was used http://greenvalues.cnt.org/
Three scenarios for complete retrofits were used for a subwatershed that drains the Silverton neighborhood and the Town of Cary's North Cary Park. The drainage size is 58 acres, with 148 lots, and mostly B soils. Results are conservative, given that the calculator did not allow slopes higher than 3%, but the subwatershed's actual average slope is 9.4%. The calculator's default values were used for roof size, driveway area, sidewalk width, average street width, since they were close to what is seen in this watershed. A conservative estimate of 5 trees per lot was used as a baseline.

Scenario one: All roofdrains rerouted to rain gardens.
Results: This scenario would reduce peak discharge by 12.4%, and increase 30-year life cycle costs and decreases benefits by $63,826 in the watershed. Annual average ground water recharge would increase by 4.33 acre ft.

Scenario two: Provide tree cover for additional 25% of lots
Results: Adding trees decreased 30 year life cycle costs by $42,660, and reduces peak discharge by 12%. Annual average ground water recharge would increase by 4.11 acre feet.

Scenario three: Replace half of lawns with native landscaping
Results: Decreased 30-year life cycle costs and increases benefits by $869,678. Reduces peak discharge by 14%. Annual average ground water recharge would increase by 4.78 acre feet.

Although the scenarios depict total retrofits, which will not be possible, they illustrate the effectiveness of various scenarios. The most cost effective for homeowners and hydrologically effective method is to replace lawn with native landscaping. This is would be a comparably low-cost option and would dovetail nicely with the Town of Cary's Turf Buy Back Program.

2. To obtain estimates of nutrient removals through retrofit BMPs, we used a spreadsheet developed by Dr. Bill Hunt, NCSU, for raingardens and rainbarrels.

By implementing twelve residential raingardens (treating 800 ft sq.each), 4 large scale raingardens (treating 2,000 square feet of impervious surface each), twelve 55 gallon rainbarrels, and three 2,500 gallon cisterns, the following removals would be seen:
308 pounds of nitrogen removed over 20 years, 106,080 gallons of potable water captured annually (assuming 25% of rainbarrels/cisterns are used weekly).

Cost scenarios

In regards to the above described scenario one, The construction cost to implement raingardens on each residential site in the one subwatershed proposed for a focus area would be $59,200 (148 lots at $400/lot), not including the staff time required to provide community education, coordinate involvement, and help design and construct BMPs. Residential BMPs such as raingardens and replacement of lawn are relatively inexpensive to install, but require many participants to make a difference. Larger but more expensive projects will be required to treat the larger swaths of impervious surfaces such as parking lots. As an example, a 15,000 sf parking lot retro-fitted with bioretention and fitted with underdrains at Port City Java in the City of Wilmington, NC cost approximately $30,000. However, if land is available adjacent to a parking lot, installing a similarly sized bioretention area without removing impervious surfaces would be less expensive, approximately $5,000-$10,000 depending on the source of labor (whether volunteers or professionals install plants). This illustrates that costs will vary depending on the sites available for retrofits.

Potential sources of funding include NCCWMTF, EPA 319 grants, NC Division of Water Resources grants, and private contributors. An innovative stormwater CWMTF grant for evaluating resident willingness to pay for projects will be awarded when state funding allows. BCWA members are also interested in approaching members of the business community for donations.

Results and Conclusions

The project resulted in a comprehensive watershed assessment that identifies the most likely causes and sources of impairment, a solid watershed management plan containing goals, objectives and strategies to address those causes and sources, a working watershed group to carry on implementation of the plan, and a grant notice from the NC Clean Water Management Trust Fund to help fund implementation.

Public participation throughout the entire planning process was outstanding. Thanks to the high level of participation from citizens, the goals of the plan address the uses of the watershed that the community values, including public health, recreation, wildlife habitat, and community stewardship of resources. Participants contributed to the watershed assessment and planning process at all points, including helping to collect stream channel condition data and conducting a pollution source inventory. Spontaneous leveraging of resources was prompted by stakeholders and included bacterial analysis by the North Cary's Wastewater Treatment Plant, donated sampling bottles, hundreds of hours of volunteer labor, members obtaining training on recognizing erosion control failures, and a grant for developing and purchasing educational outreach materials from the Cary Community Foundation. The BCWA also collaboratively wrote letters to the Town of Cary Council, and Parks, Recreation, and Cultural Resources Advisory Board recommending the use of low impact development on a proposed recreational facility. Subsequently, the PRCR Advisory made recommendations to the Town that all new recreational facilities be designed using low impact development.

The watershed assessment data was gathered by graduate students of NCSU, providing career-building opportunities. High school students were involved at points, by participating in stream clean-ups, and occasionally participating in meetings.

The very thorough benthic macro-invertebrate data that was collected provides a solid baseline for measuring improvements in the future. Although difficulties were experienced with the stream gauge, the equipment has been repaired and is ready for continued data collection to further hone information about stream flow and velocity as implementation of the watershed plan moves forward. The geodatabase developed for the watershed assessment includes the Town's stormwater system, and has also been adapted for online use with GoogleEarth. The files have been posted to the project's website for public download and use. The ease with which this data can be viewed and manipulated will help the BCWA engage homeowners and businesses in locating potential stormwater retro-fit sites.

The main cause of impairment is found to result from high volumes and velocity of storm water runoff that bypasses the riparian buffer through stormwater pipes and channels. A secondary cause of impairment is likely toxic organic compounds that are accumulating in the aquatic life, with compounds including PAHs coming from pyrogenic and petrogenic sources (incomplete combustion products from automobiles and parking lot sealcoats are likely suspects), and phthalates coming from the sanitary sewer system. The concentrations of these organic toxins are not known at this time, but additional data on this topic is expected. Additionally, high nutrient inputs during storm events could be coming from lawn and landscaping practices, while fecal coliform bacteria inputs could be coming from improper pet waste disposal and potential sewer line leaks.

Improving the water quality and aquatic habitat of Black Creek and its tributaries will require widespread and active participation of landowners, businesses, and the Town of Cary. Strategies must reduce the volume of stormwater runoff reaching the creeks, which will take many small scale projects throughout the watershed. Individual homeowners and business owners will need to be engaged in learning about and adopting pollution and runoff reducing techniques.

The current active participation of representatives from several homeowners associations and neighborhoods, with solid support from the Town of Cary, Wake County Extension, and NC State University, lends credence to the likelihood that strategies from the management plan will be implemented. Tools have been developed throughout this project for educating and involving neighborhoods (educational outreach materials and a PowerPoint presentation), and for identifying effective retro-fit projects (the Google Earth linked geodatabase). Time for writing grant proposals was budgeted into this grant in order to minimize the amount of time between planning and implementation- subsequently two grant proposals were submitted. A NC Clean Water Management Trust Fund Innovative Stormwater grant will be awarded when the State budget allows it, and a proposal for an EPA 319 implementation grant was submitted.

We find that much can be gained by funding a part-time position to coordinate a community watershed planning effort and citizen's group. Citizens and local government staff often do not have time or funding resources available to manage a watershed planning and restoration project like this, in addition to their other responsibilities. However, committed participants, such as those in the Black Creek Watershed Association, are able to attend meetings to provide information and feedback, help collect data, obtain additional resources, and provide essential connections to their homeowners associations and other civic and government organizations. These roles are crucial to any successful watershed restoration project. We expect that this organization will experience many successes in the future, as long as funding can be secured to manage the effort and implement projects on the ground.

Budget

Note- these values should not be used for the final budget expenditure. The official financial statement will be sent to NCDENR with the Final Invoice from the NCSU Contracts and Grants Office.

Table 22: Final budget summary for EPA 319 Grant

Budget Item	Grant Funds Spent	Non-Federal Match*	Total
NCSU Direct expenditures (salary, fringe, monitoring, educational supplies	$159,786	$77,196	$236,982
Indirect (10%, 35%)	$15,979		$15,979
Forfeited indirects		$39,981	$39,981
Total	$175,765	$117,177	$292,942

*Non-federal match included salary and fringe from Jim Gregory, Stacy Nelson, Steve Smutko, as well as cash match from Town of Cary.

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Appendices

A. 2006 Workshop Flyer

B. Situation Assessment Report

C. March 2006 Public Workshop Survey Results

D. Stream Walk Flyer

E. Stream channel assessment worksheet example

F. Pollution Source survey worksheet example

G. Geodatabase categories of information

H. Black Creek Monitoring Station Sign

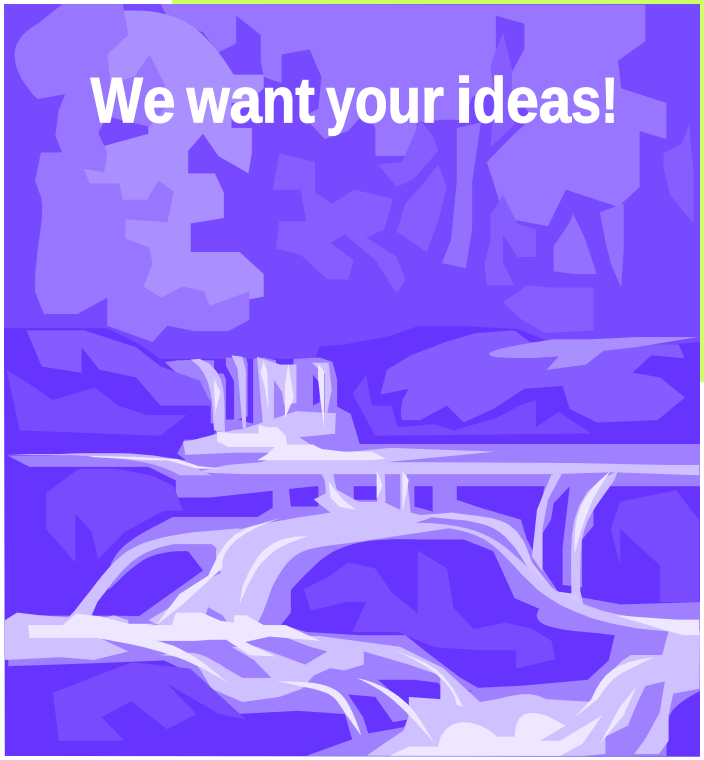
I. Newsletter Examples

J. Black Creek Watershed Association Photo Album

Appendix A:

Workshop Flyer

Help to Restore and Protect Black Creek



Tuesday, March 21
6:30 - 8:30 pm
Herbert C. Young Community Center
North Academy Street, Cary, NC
(next to Town Hall and parking deck)

Join officials from the Town of Cary and specialists from NC State University in a discussion about a new project to improve Black Creek (yes- the Creek next to the Black Creek Greenway!).

For more information, contact Christy Perrin at
(919) 515 - 4542
christy_perrin@ncsu.edu.
www.ces.ncsu.edu/WECO/Blackcreek

Watershed Education for Communities and Local Officials

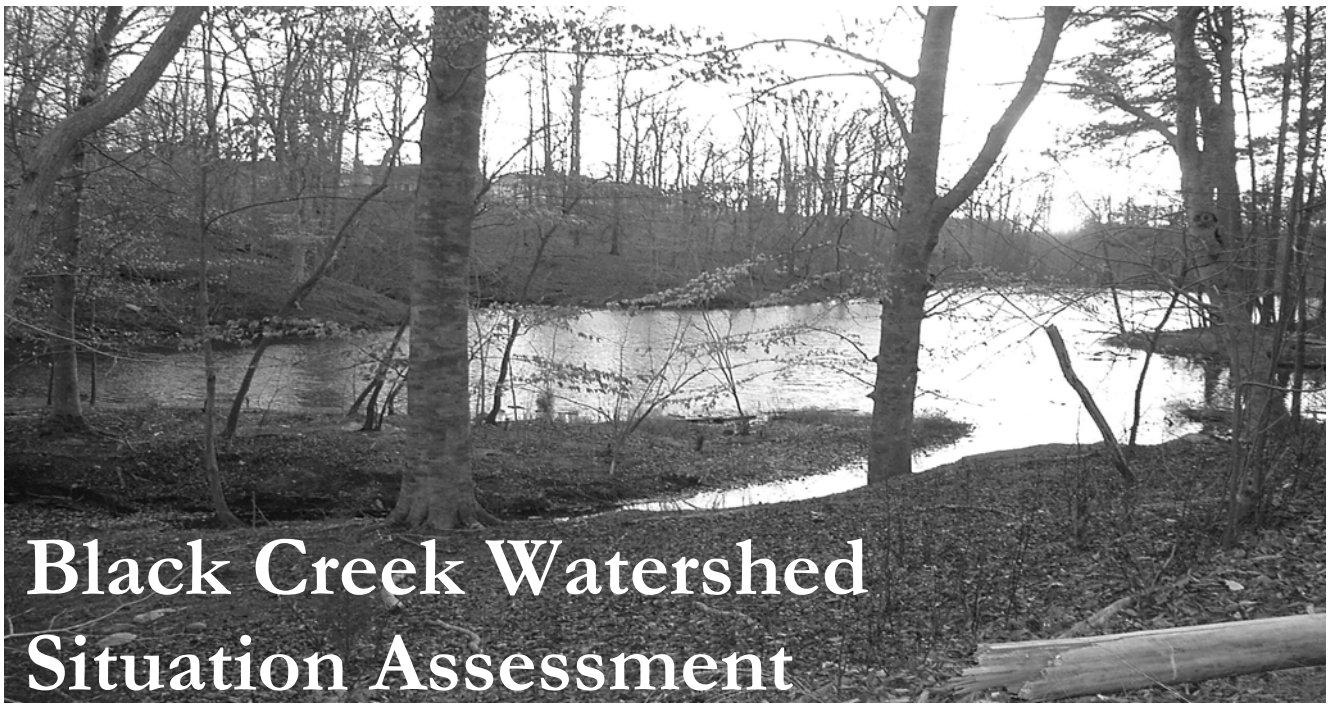
NC STATE UNIVERSITY

Department of Forestry and Environmental Resources
NC State University

#1 Cary
North Carolina

Appendix B:

Situation Assessment Report



Black Creek Watershed Situation Assessment

Molly Puente - Christy Perrin - Patrick Beggs
North Carolina State University
June 1, 2006

Table of Contents:

Black Creek Watershed Issue Assessment - Executive Summary

The Black Creek watershed, which begins in downtown Cary, NC and flows into Lake Crabtree through northern Cary, has seen rapid growth in residential and commercial development in recent years. This growth has put various stakeholders at odds with each other. A recent conflict regarding a move of the popular Black Creek Greenway to accommodate a new apartment complex left trust badly strained between lower watershed residents, development interests, and Town of Cary elected officials. However, this Situation Assessment reveals that residents, developers, and other watershed stakeholders are interested in coming together to search for innovative solutions to the problems impacting Black Creek.

Black Creek is rated *impaired* on the NC Division of Water Quality (NCDWQ) 303(d) list. This means Black Creek is not supporting its appropriate aquatic life. NCDWQ regards non-point source pollution from stormwater runoff as the likely cause of impairment, and suggests that removal Black Creek from the 303(d) list will require the joint effort of many stakeholders.

To address the rising social and ecological crises in the watershed, NC State University in partnership with the Town of Cary received a US Environmental Protection Agency grant to involve the community in a watershed assessment and restoration planning process. The project began with a Situation Assessment to determine the community's concerns in the watershed, and how to most effectively proceed with collaborative watershed planning. The assessment involved interviewing 20 representatives of a cross section of watershed interests, summarizing responses, and making recommendations for moving forward.

Development is the greatest concern for most respondents. Residents are concerned development may be degrading the environment; developers are concerned that regulations may impair their ability to develop in economically sound and environmentally innovative ways. This issue was brought into focus with the recent Black Creek Greenway conflict. Stakeholders are concerned about increasing populations, accompanying traffic increases, and residential practices impacting water quality and recreation. PCB contamination in Lake Crabtree also ranks high among concerns, as well as concerns about other unknown potential toxins in the watershed. Finally, respondents are concerned about the overall ecological health of the watershed, including its ability to provide healthy wildlife habitat.

Almost all stakeholder groups interviewed expressed interest in participating in a collaborative watershed planning process through the formation of a watershed association. Respondents made the following suggestions for the process: provide education; conduct unbiased research; produce a measurable specific product, include broad participation; and provide a safe, neutral climate for building trust and negotiations. Their willingness to engage one another allows participants to seek opportunities for mutual gain if careful attention to process is followed by NCSU facilitators and participants alike. NCSU will follow these recommendations while convening a collaborative watershed association for the Black Creek watershed. Important principles to be adhered to include: 1) science-informed decision-making (a technical watershed analysis is currently underway), 2) mutual education, 3) collaborative decision making, and 4) neutral facilitation. This will allow participants' to learn from one another and make decisions for restoring the watershed while also meeting their individual needs.

Introduction

Black Creek Watershed

Black Creek is located in northern Cary, NC. The 3.3 square mile Black Creek watershed drains to Lake Crabtree, a flood control reservoir. The Town of Cary's popular Black Creek Greenway runs adjacent to most of Black Creek. The Greenway connects to Umstead State Park and Crabtree County Park, and experiences heavy use.

Black Creek is listed on the state's 303(d) list as biologically impaired. The 2002 NCDWQ Neuse River Basinwide Plan indicates habitat degradation from urban runoff as a likely cause of impairment, stating that great effort will be needed to reduce impacts from urban runoff. The watershed is approaching build-out with residential, commercial, industrial, and municipal parkland uses, although several forested parcels are yet to be developed. Future plans include development of a private Veteran's Memorial Park, as well as commercial, industrial, and residential throughout the watershed.

Purpose

This Situation Assessment is part of a larger project, the *Black Creek Watershed Assessment, Monitoring, and Restoration Planning Program.* The project is sponsored by North Carolina State University (NCSU) and the Town of Cary, and funded through the US Environmental Protection Agency (EPA).

The purpose of the Situation Assessment is (1) to identify stakeholders, members of the community with a stake in the Black Creek watershed, (2) to learn what the stakeholders see as problems, and (3) to learn what the stakeholders may wish to gain by participating in a watershed planning process. The results of the Situation Assessment will help determine a public involvement process to best meet stakeholder needs while creating a sustainable watershed management team.

The EPA grant was received through the NC Division of Water Quality Section 319 Non Point Source Grant Program. Section 319 refers to the US Clean Water Act. Non Point Source (NPS) refers to any pollution that does not have a discreet source. The main source of NPS is polluted runoff from stormwater. Watershed Education for Communities and Officials (WECO), a NC Cooperative Extension program housed in the NCSU Department of Agricultural and Resource Economics, and the NCSU Department of Forestry and Environmental Resources received this grant in partnership with the Town of Cary. NCSU and the Town of Cary are also contributing funds to this project. The project timeline is January 2006-December 2008, and involves two components:

1. Convene a watershed association of representative stakeholders to collaboratively develop community supported recommendations for watershed management and restoration.
2. Conduct a watershed assessment and monitoring program to determine the causes of Black Creek's impairment and identify practices that will improve the its health.

Methods

Stakeholders were identified through a *snowball sampling method,* which relies on referrals from initial subjects to generate additional subjects. Initial subjects included known stakeholders who have been actively involved with Black Creek issues. WECO interviewed twenty one stakeholders including residents, developers, and government staff, representing a cross-section of interests. For example, the team did not speak to every resident identified, but tried to interview people from upper, middle, and lower watershed neighborhoods. Responses have not been attributed to specific individuals. Appendix A contains the questions used as guidance during the interviews.

The results of the interviews are summarized in this report, including the project team's recommendations for moving forward.

Stakeholder interests represented include:

- Cary Academy
- Town of Cary Departments of Engineering; Planning; Parks, Recreation and Cultural Resources
- Homeowners associations (HOAs) including Silverton, Beechtree, Wessex, and Harrison Trace, and the North Cary Community Coalition (NC3)
- Neighborhoods not represented by HOAs in middle and upper watershed
- Commercial land development and management companies
- Non-profit organizations
- Reedy Creek Middle School
- Wake County Parks, Recreation and Open Space (Lake Crabtree County Park)
- Wake County Cooperative Extension
- Wake County Soil & Water Conservation District
- Division of Water Quality, NC Department of Environment and Natural Resources (NCDENR)
- Ecosystem Enhancement Program, NCDENR

This report intends to:

- identify issues of importance to the local community,
- identify organizations and individuals who can influence watershed decisions or are influenced by watershed decisions,
- determine how best to bring diverse interested stakeholders together, and
- begin the process of learning about and understanding individuals' interests in the watershed.
- assist the technical team in addressing research questions that concern the stakeholders.

This report does *not* intend to provide a quantitative, statistically accurate analysis of the issues, but rather a summary of the issues identified.

This report also does *not* include feedback received during a public meeting held in March 2006. The meeting results, including a survey, can be found on the WECO website. [http://www.ces.ncsu.edu/weco]

Characterizations of Black Creek Watershed

How does the community use the watershed?

The Black Creek Greenway, one of the most extensive trails maintained by the Town of Cary is located in the watershed. Respondents cited recreation along the greenway (walking, running, biking, wading, and fishing) as a primary use of the watershed. The greenway is also an important location for socializing by neighborhood walking, biking, and even religious groups. The greenway serves as a transportation corridor from residential areas to shopping areas and parks, including Lake Crabtree County Park, North Cary Park, and Umstead State Park.

Stakeholders cited preserving natural ecosystems and wildlife as an important function of the watershed. The greenway allows for some natural connectivity for wildlife habitats, and open space maintained by the Town of Cary within the watershed can also provide important habitat for wildlife in the area.

The watershed's location makes it a promising target for development. The watershed contains commercial, office, industrial, and residential development. Developers noted that property in the Black Creek watershed is valuable for future development.

Compared to Other Watersheds

Several stakeholders feel the health of Black Creek is about what should be expected for an urban watershed. The general consensus is that while the Black Creek watershed is not ideal, there are worse situations in surrounding areas. New Hope Creek in Durham County was suggested as a reference watershed. It is similar in size and location but has less bank erosion since the undeveloped Duke Forest comprises some of the drainage area, thereby reducing runoff.

Government staff pointed out other bodies of water in or near Cary are also impaired or may soon be identified as impaired. These include Jordan Lake, Swift Creek, Crabtree Creek, and Walnut Creek. Improvements in Black Creek could serve as a model for other watersheds.

It was identified that there are more regulatory requirements for development in nearby Briar Creek than in Black Creek, making Black Creek watershed a better candidate for economic development. Briar Creek watershed contains the Ward Transformer site. This EPA-designated Superfund site is releasing PCBs into Briar Creek, which also flows into Lake Crabtree.

Stakeholders

This section identifies the major stakeholder groups with interests in the watershed. These include the residents; recreationists; and commercial, non-profit, and government interests. No local environmental non-profits were found to be active in the watershed, although regional environmental organizations with some interest may include

the Neuse River Foundation and the Umstead Coalition. Many residents expressed environmental interests, so the lack of an active environmental organization in the neighborhood does not indicate a lack of representation of environmental interests.

Residents

Residents have recently engaged in civic activities about watershed development issues including greenway impacts, the Veteran's Freedom Park, and flooding. This interest may indicate that residents are interested in getting involved in a watershed planning process.

It is important to distinguish between the headwaters and the lower watershed, as the issues and demographics are distinct. Most residential development in the lower watershed is recent and high-end, with organized homeowner's associations (HOAs). The Black Creek Greenway was built concurrently with many of the developments in the lower end of the watershed, and has been one of the attractive selling points of the area. Residents in this part of the watershed have been vocal about issues relating to the greenway. Several HOAs in this area are organizing a larger umbrella organization, called North Cary Community Coalition (NC3). NC3 currently provides a communication network in the lower watershed, but they hope to include the headwater neighborhoods.

The upper watershed, or headwaters, was developed earlier, which may give rise to more concerns over maintenance issues (such as leaking sewer systems) than new development issues. These older developments typically have no formal HOAs. Additionally, there are many multifamily residences throughout the watershed, which were mentioned as a difficult target for education and involvement. Government staff mentioned past difficulties in communicating with Hispanic populations as well.

Recreationists

People travel from other areas to bike, walk, and run on the greenway. Other recreational facilities in the watershed include Godbold Park, which has a dog park and outdoor skateboarding facility, and North Cary Park which includes sports fields. Residents and local government staff noted the importance of including visiting recreationists' viewpoints in watershed decisions, but indicated that local recreationists may be able to represent this group in watershed planning activities.

Commercial Interests

Overall, respondents viewed development as having the greatest impact on the watershed. Residential, commercial, parkland, and industrial projects are in different stages of development throughout the watershed.

Even after listing several current construction projects, developers and some residents feel the area is nearly "built-up" with the focus soon to shift from large developments to smaller in-fill developments. It was noted that this transition generally favors local development companies over national companies, with the potential for some developers to stay active in the area.

The headwaters of Black Creek are located in downtown Cary. The redevelopment plans for the Town Center Area of Cary may therefore affect the watershed.

Major business areas located in the watershed include Weston Business Park in the lower watershed, Chatham Street in the headwaters, and several strip-mall commercial centers throughout. Businesses in these areas may see this project as an opportunity to explore stormwater best management practices, or they may see it as a threat which may cause increasing environmental regulation.

Finally, many residential and commercial areas have professional landscaping and lawn care. Because fertilizer runoff is one of the major concerns of the residents interviewed, lawn care professionals may be an important stakeholder group to target in this watershed, although their business offices may be located elsewhere.

Government

Government agencies with the authority to make decisions to affect, Black Creek or have resources to benefit, Black Creek include:

- US Environmental Protection Agency (EPA)
- North Carolina Department of Environment and Natural Resources (NCDENR)
    - Division of Water Quality (DWQ)
    - Ecosystem Enhancement Program (EEP)
- Wake County
    - Soil and Water Conservation District (SWCD)
    - Lake Crabtree County Park
    - Cooperative Extension
- Town of Cary
    - Department of Parks, Recreation and Cultural Resources
    - Department of Engineering
    - Department of Planning

(See Appendix C for government agency roles.)

Some government staff expressed an interest in working more with the public, but also expressed that it was difficult to generate public input or enthusiasm for past town projects. Some residents expressed concern that there may be a conflict of interest involving the Town Council, opining that Council appears to side with development over residents on many issues. However, it was unclear whether these residents were disgruntled with the entire Town of Cary government, or just the elected Council.

Concerns

Development

Nearly every stakeholder interviewed considers development to be one of the primary issues in the watershed. Several respondents point out that most of the land has already been developed. The transition from large development plans to in-fill development is suggested to be challenging due to the topography of the area.

Many stakeholders, primarily residents, point out negative environmental impacts from development including: increased stormwater run-off, creek bank erosion, sediment in streams, flooding, and habitat destruction through clear cutting. One resident observed upstream of a nearby construction site the stream was clear, but downstream of the site it ran orange. Stakeholders from all interest groups recognize that development increases impervious surface area, which increases storm water runoff impacts on downstream properties and natural resources. One respondent said we have two parallel watersheds that function differently: the natural one and the one made with cement.

Some residents expressed frustration that government was not providing enough of a check on development, while others expressed mixed feelings towards development. They appreciate the new amenities such as nearby shopping, but they also want to see more forested areas preserved.

Respondents with development interests expressed concern that they were unfairly blamed for environmental degradation. They noted stricter regulations increase development costs and can impede economic development. They pointed out many existing regulations they must abide by, such as the Neuse River Nutrient and Buffer Rules, and commented that the general public may not be aware of regulations that developers must follow. They are concerned that unfounded blame will lead to stricter regulations, and also pointed out that some regulations contradict environmental best management practices. For example, to comply with the Americans with Disabilities Act, greenways must be paved for wheelchair accessibility, which increases impermeable surface area.

Government staff from various agencies expressed some frustration regarding environmental regulations. They worry that while most new developments are required to put in stormwater best management practices (BMPs), many settle for the cheapest solution, including unattractive retaining ponds that may not provide optimum environmental benefits. Residents and government staff both expressed concern over unattractive BMPs, and how confusion regarding innovative development techniques and BMPs can be a deterrent to using them.

Human Health Risks

Several stakeholders expressed concern about toxins in the watershed, such as PCBs and the potential for other yet unidentified toxins. Because Black Creek and Briar Creek both drain into Lake Crabtree, and PCBs are a problem in Briar Creek, many people are concerned that PCBs could travel up into Black Creek from Lake Crabtree. Currently, fish in Lake Crabtree and downstream Crabtree Creek are designated as unsafe for consumption. Developers are concerned that if PCBs are found in the watershed, EPA regulations for developers will become more strict, as they are in Briar Creek. Residents are concerned the water may not be safe for their dogs to drink or for their kids to play in. Concerning air quality, one respondent worried that increased particulate matter released during construction grading activities may pose a health hazard.

The Black Creek Greenway

The Black Creek Greenway is operated by the Town of Cary Parks, Recreation and Cultural Resources (PRCR) Department, and connects several private trails such as homeowners association access ways. New greenway construction is primarily

concentrated in the headwaters, while greenway maintenance is the focus in the lower watershed.

In 2004-2005, the Black Creek Greenway was the focal point of conflict between developers, residents, greenway users, and the Town of Cary. A site at the mouth of Black Creek, adjacent to the greenway, was rezoned for a new apartment complex. As a condition of the rezoning, the developer offered to move the greenway away from the apartment complex, with the purpose of providing space between the greenway and the apartment property, and increasing the distance between the apartments and the adjacent municipal sewage treatment plant. This move would bring the greenway closer to the creek. Residents learned of this change after the rezoning was approved, too late to provide input, and subsequently organized efforts to prevent the movement of the greenway. While able to generate a great deal of grassroots support, the residents were unable to change the approved development plans for either the apartments or the greenway.

The major result from this interaction is that trust between the various groups is badly strained. Developers are frustrated that they were vilified even though they followed regulations and worked out a zoning agreement with municipal staff and elected officials. Residents feel the Town of Cary elected officials are too influenced by the power of development interests. Government staff, at both the local and state level, express frustration at being drawn into the conflict without having viable options for addressing it. Although the substantial issues regarding development of a recreational and natural resource were at the forefront, process issues compounded the frustration. Much of the residents' frustration likely stemmed from a lack of meaningful input in the process, since the rezoning was approved before they were aware of it. The Town of Cary Dept. of PRCR was left dealing with the inflamed public conflict, since the only means of input left for residents was to comment on the details of the greenway design. Residents realize the PRCR was unfairly left holding the bag, so trust with this department remains high. Trust of Town of Cary elected officials did not fair as well.

Residential Practices

Residential stormwater runoff containing fertilizers, pesticides, and motor oil is a likely contributor to water quality impairment. Government staff indicated that this may be a greater problem than most people think. They also acknowledge the difficulty of educating about cumulative impacts from household practices. While residents recognized they could be contributing to the problem, they did not know what they could do to improve the situation.

Demographics

Development in the watershed has led to population increases in the area. Respondents are concerned the increase in residents means an increase in traffic. More traffic can lead to pressure to widen roads, thus increasing impermeable surface. Population increase also means more traffic on the greenway, which may increase complaints about continued development according to one respondent. Some respondents also noticed increased litter in the greenway and creek.

The changing demographics have also put the headwaters (upper watershed) and lower watershed at odds over what the priorities should be. Neighborhoods in the

headwaters are older, and are concerned about flooding and broken sewer connections that result from an aging utility infrastructure. Respondents noted more cases of illegal dumping in the headwaters area. Town resources are split between maintaining the current quality of life in the headwaters and incorporating the new developments in the lower watershed. While residents in the headwaters may have a disproportionate impact on Black Creek, residents in the lower watershed are more likely to notice changes in the water quality. Some respondents also believe development activities in headwater (tributary) streams impact Black Creek less than development near the main body of the creek. This likely misconception may stem from the fact that more people see development adjacent to the greenway so respond more negatively to it. It also may stem from a lack of watershed education, concerning the effects of nonpoint source pollution on smaller streams and tributaries.

Ecological Health and Wildlife

Several respondents are concerned about the ecological health of the watershed. One mentioned considerable woody debris along the greenway and on footbridges after big storms, and thought it may indicate the creek is becoming more prone to flash flooding. Residents express concern about the small amount of natural or open space remaining. Some respondents are concerned about the amount of streambank erosion they see. They attribute this to disturbance of the natural hydrology of the watershed, and resulting channelization (straightening) of Black Creek. One respondent was concerned that acid rain may be a problem.

Residents and government staff note that changes in the environment may be impacting local wildlife. A resident pointed out that water quality decline may explain why blue herons have not visited a local pond in recent years. Another noted a decline of kingfisher activity in the area over the last couple years. Conversely, Lake Crabtree Park staff noted the positive attribute of a nesting pair of bald eagles near Black Creek, but thought (and hoped) they obtained some of their food from marshes nearby that are not polluted with PCBs.

Respondents from all groups recognize that ecological health is tied to economic health for the area. Developers and government staff pointed out that a good greenway system with natural space increases local property values. One resident worried that poor environmental health would lower property values, saying no one wants to move into a neighborhood where birds are dying and aquatic animals are unhealthy.

Watershed Planning

Watershed planning involves the formulation of a plan based not on municipal boundaries, but on hydrologic boundaries. Local watershed planning assesses the climatological conditions, water resources, and current and future uses of a watershed and incorporates the ecological and socioeconomic demands for those resources. It relies heavily on local data and local input. A local watershed plan will include recommendations for sustaining and improving the watershed.

Visions for the Black Creek Watershed

Identifying what stakeholders would like to see in the Black Creek watershed can help a watershed planning group set priorities.

Respondents expressed a desire for Black Creek to be:

- Safe enough for dogs to drink from.
- Safe enough for children to play in.
- Clean enough to support wildlife.
- Able to maintain natural hydrology, and not be channelized.

Ideas for the greenway system include:

- Environmental information displayed on signs along the greenway to educate the public.
- Enough traffic, lighting, etc. for women and children to feel safe using the greenway.
- A dog waste program to help dog owners take care of their pets wastes.
- A large enough natural corridor to connect wildlife habitats.

In terms of development, suggestions include:

- Environmental practices should be adopted by the construction workers, and not just the corporate offices.
- Installed stormwater BMPs should work better and be aesthetically pleasing.
- Development in the lower watershed should be balanced between residential and retail, to help balance the demands on the traffic infrastructure.

Additionally, respondents commented on how Black Creek efforts could benefit the region:

- Black Creek should be a model stream for others in the area.
- Education in Black Creek should benefit Lake Crabtree downstream.

Questions for Scientific Research Studies

To complement the watershed planning efforts, a study will be conducted by scientists from NC State University. Stakeholders asked that the study address the following research questions:

- Where is pollution in Black Creek coming from?
- Can you pay close attention to the Chatham Street area when sampling?
- How safe is the water in Black Creek?
- Are there any effects caused by using reclaimed water for irrigation?
- Where can we put aesthetically pleasing BMPs?
- Can you check erosion using aerial photos?
- What are the cumulative effects of small polluting events (like car fluid spills)?
- Can you check the nutrients and metals in the stream?
- Is the creek subject to flash flooding?
- Do fish migrate from Lake Crabtree to Black Creek?
- Can the researchers use input models to provide specific recommendations for management practices upstream?
- Are there endangered species in the watershed?

Willingness to Participate in Watershed Planning / Alternatives to Negotiations

To determine how to get various parties to the negotiating table, it is important to recognize alternative routes which various stakeholder groups have for achieving their goals.

Residents of the lower watershed have tried to influence policies in the watershed by organizing community grassroots efforts and petitioning the Town Council. The various HOAs are capable of acting on their own or in concert with the newly-formed neighborhood organization, North Cary Community Coalition (NC3) to organize educational programming and political action. A resident who has been trying to negotiate better stormwater management practices with a developer commented that residents may be in a weak bargaining position. In the headwaters, residents may call the Town of Cary and make complaints about flooding and dumping. Although residents could continue this pattern of organizing, petitioning, and filing complaints, some of the residents expressed frustration that these actions have not resulted in change. Therefore, they are interested in participating in a watershed planning group as a new option.

Land developers can follow the regulations required by city, state, and federal ordinances. They may have little incentive to go beyond these minimum requirements. In some cases, developers have financial incentives to seek waivers to environmental regulations. For example, the Neuse Rules allow developers to pay a fee to develop in protected areas or to remove a lesser amount of nutrients from runoff. Those fees go into a state fund that is used by the NC Ecosystem Enhancement Program to install restoration practices throughout the Neuse Basin, exchanging increased local degradation for benefits in other, usually downstream, areas. Developers must apply to the Town of Cary, but can also appeal to the State if Cary rejects requests for waivers. Before developers (and other landowners) are willing to negotiate, they may need to believe:

a) *not* participating could result in an unfavorable change in regulations, or

b) earning the good faith of the community will aid them in pursuing other business ventures in the community, or

c) participating could yield new options that will enhance development products at no additional cost.

While government agencies see public involvement as part of their mission, they have the option of following the minimum public notice and hearing requirements for planning, zoning, and regulatory changes. Time sensitive opportunities such as purchasing an available tract of land for conservation may require them to act without consulting a watershed planning board. However, all government staff contacted are interested in some level of participation, as they recognize the potential educational benefits for the community, the possibilities for finding innovative ways to improve ecological health and recreation, and the potential for the watershed to serve as a model for other similar troubled streams in the region.

Visions of the Process

Respondents made recommendations for the watershed planning process, including:

<u>Provide education</u>: Respondents believe the group could provide an educational opportunity for both adults and schoolchildren. Several residents feel they need a better understanding of basic watershed issues before knowing which questions

they want answered. Topics mentioned include watershed science and residential best management practices to protect water quality. In addition, some think the process can be an opportunity to educate local elected officials, government staff, and developers about the value the residents place on the watershed.

Conduct unbiased research: Residents are interested in the scientific study portion of this project, especially in identifying the type and source of any pollutants. Respondents mentioned the need for unbiased water quality studies, to include long term trends and solutions.

Produce a measurable specific product: Both government and commercial interests feel a watershed planning group should produce measurable outcomes, with specific action plans for remediation projects rather than vague recommendations.

Include broad participation: Respondents recognize the importance of capturing a representative cross-section of interests, including headwaters and lower watershed representation, commercial landowners, Hispanic residents, and schools.

Provide a safe, neutral climate for building trust and negotiations: Respondents hope this will be an opportunity to renew faith between developers and the community. They noted that trusting the watershed planning process would require proper moderation by a neutral third party.

Additional stakeholder recommendations concerning current resources and potential solutions can be found in Appendix B.

Recommendations for Proceeding

The results from interviews confirm the project team's conjecture that interest in participating in a watershed planning process is high. The level of interest expressed is actually greater than anticipated. Respondents raised a number of concerns, some of which may appear contradictory or intractable (development impacts on Black Creek vs. environmental regulations stifling development). However, all respondents interviewed expressed a curiosity about the issues, and are open (some with trepidation) to working with other participants who may not share the same views. This willingness to engage with each other allows participants to seek opportunities for mutual gain, rather than win-lose solutions, which has been the case in recent activities in the watershed.

Careful attention to the watershed planning process will be necessary to enable stakeholders to feel comfortable and interested in participating. Some principles that need to be adhered to include:

Science-informed decision-making

People are interested in seeing the results of the technical watershed analysis. However, if the study results seem to contradict participants' beliefs, they may feel less inclined to want to base their recommendations on it. For this reason, it is crucial that the watershed group participates in the research project as it moves forward, by hearing interim results and questioning researchers' assumptions. Ongoing participation will increase the likelihood that watershed group members will accept the results.

Mutual education of each others interest and values
Collaborative skills training and team building will create a group environment where participants can hear each other's concerns and work together to address those concerns.

Meeting participants' process, psychological, and substantial needs
Participants must feel:

1. they are being heard,
2. their input will influence watershed plan recommendations, and
3. these recommendations will result in specific, measurable actions.

The facilitators must be neutral and unbiased, and ground rules should be adopted and enforced by the group.

By adhering to respondents' vision for the project and these recommended principles, the Black Creek Watershed planning process will be best equipped for success.

Appendix A: Situation Assessment Interview Script

1. What is your connection to the Black Creek Watershed? How do you and your family, friends, coworkers use the watershed? What plans does your organization have within the watershed?
2. Do you involve this community in your activities? Are you involved in community activities?
3. How do other people in the community use the watershed?
4. What groups do you know about in the watershed?
5. Do you belong to a homeowners association in the watershed?
6. Do you know if you have a town Block Leader, and who that is?
7. Who has authority to make decisions about the watershed?
8. What are the biggest issues facing the Black Creek Watershed? What issues in the watershed affect your organization?
9. Do you think it is a healthy watershed? Why or why not?
10. Can you share any specific observations about insects, fish, odors, flooding, etc.?
11. What information should we collect to determine the health/environmental quality of Black Creek?
12. Are there any imminent changes to the watershed that you think might impact Black Creek, either positively or negatively?
13. What do you think can and should be done concerning the Black Creek Watershed?
14. Where do you get information about local environmental issues?
15. What questions would like answered about the Black Creek Watershed?
16. Would you like to be kept informed of this Black Creek Watershed project?
17. Would you be interested in participating in a watershed planning group? Representing what interest? Who could represent your org? How do you see your organization involved in the watershed-what do you bring to the table (during the planning & implementation phases)?
18. What would you like this group to accomplish?
19. Who else should we interview?
20. Before we leave, is there any other issue you want to talk about?

Appendix B: Opportunities and Potential Solutions

Stakeholders made many suggestions for how the watershed planning group could take advantage of current resources to improve Black Creek. These suggestions will be considered during the watershed planning process.

Distributing information:

- NC3, an organization of HOAs, has a communication network and would be willing to pass on announcements to residents in the watershed.
- The Herb Young Community Center is a convenient location for posting notices and holding meetings in the watershed.
- Announcements in the Cary News or The News and Observer are helpful.

Potential sources of collaboration:

- The Town of Cary has a series of workshops "Gardening for Transplants" which would be a good format to teach environmentally sound lawn care.
- The Town of Cary has begun a study of stormwater run-off on the greenway.
- The Town of Cary Area Planning (TCAP) group may be interested in collaborating for retrofitting opportunities in the headwaters.
- Lowe's Home Improvement Store offers gardening classes. They may be willing to offer a class on environmentally sound lawn care.
- Lake Crabtree Park has a network of local teachers that may be interested in getting involved in environmental programs.
- Lake Crabtree County Park staff are willing to collaborate on educational activities and scientific sampling.
- Cary Academy may be interested in collaborating on a stream monitoring program.
- The EPA is conducting PCB studies in Lake Crabtree and may be willing to collaborate on monitoring toxin levels at the mouth of Black Creek.
- Wake County's Extension Service is willing to conduct education and outreach programs on raingardens, biorention ponds, and other BMPs.
- The Army Corps of Engineers is working on a stream restoration project in West Cary/Apex, and may want to collaborate.
- Culturas Unitas is a local nonprofit that may help with outreach to Spanish-speaking residents.
- Researchers at NC State studying urban streams with and without buffers may be able to provide assistance.
- The Neuse River Foundation may be willing to provide financial or organizational support.

Development opportunities:

- The transition to in-fill development may allow for more Low Impact Development (LID) because the economy of scale is not active any more.
- There are several locations where retrofitting may be appropriate.

- The Town of Cary owns some land that may be made into an easement to help filter nitrogen.
- Neuse River Buffer and Nutrient mitigation resources may be available.

Watershed association activities:

- The Town of Cary's Stormwater program has a drain stenciling program.
- Big Sweep is an Annual event for litter pick-up, and the Lake Crabtree coordinators could include areas in the Black Creek watershed.
- Waterfest is an annual event at Lake Crabtree where environmental information can be distributed to interested visitors.

Appendix C: Government Agencies and Roles

Government agencies with the authority to make decisions to affect, Black Creek or have resources to benefit, Black Creek include:

- US Environmental Protection Agency (EPA): Creates federal regulations through the US Clean Water Act that are passed on to NCDENR to implement, and provides funding for watershed protection and restoration. EPA is funding the Black Creek watershed planning process.
- State of North Carolina, Department of Environment and Natural Resources (NCDENR)
    - Division of Water Quality (DWQ): Oversees EPA grants, planning at the basin level (Neuse), and enforces state regulations that impact Black Creek, including the Neuse Buffer and Nutrient rules, and the new Phase II Stormwater Rules
    - Ecosystem Enhancement Program (EEP): Charged with mitigating for construction impacts by using funds generated by NCDOT road construction and mitigation fees from Neuse Buffer and Nutrient Rule payments. Funds can be used for stream and wetland restoration and stormwater best management practices.
- Wake County:
    - Soil and Water Conservation District (SWCD): Has responsibility for water quality in all County watersheds, including Black Creek. SWCD can help with watershed planning and implementation.
    - Lake Crabtree County Park: Oversees recreation in Lake Crabtree, which is impacted by Black Creek water quality. The greenway is part of a connection of park facilities that includes the Crabtree County Park.
    - Cooperative Extension: Has expertise in stormwater management that they can share with the community
- Town of Cary: The entire Black Creek watershed is contained within the Town of Cary's (TOC) borders. Town staff value improving the quality of life for Cary citizens and also meeting state and federal regulations.
    - Parks, Recreation and Cultural Resources: Plan, build, and maintain park facilities, including greenways.
    - Engineering: Contains the Town's Stormwater and Erosion Control programs. Responsible for overseeing stormwater management and implementing state and town stormwater regulations.
    - Planning: Responsible for planning the Town's growth and reviewing rezoning requests and site development plans.

Appendix C:

March 2006 Public Workshop Survey Results

Black Creek Watershed Survey Results
Public Meeting – March 21, 2006

Summary:

As a "kick-off" to the Black Creek Watershed Project, a public workshop was held for any interested stakeholders. We asked the attendants to fill out a preliminary survey, and we got nineteen completed surveys in response. The majority of surveys were completed by residents in the watershed. Several salient points came out of this survey:

- Most people consider the greenway system the most visible feature of the watershed.
- Water quality is a major concern for most stakeholders, but many think the watershed is healthy enough for all purposes short of ingesting the water.
- The community is interested in taking action, but would like to learn more about specific actions they can take.
- Landscaping practices could be a potential target for action, as most respondents indicated that they used chemical treatments for their lawns, few indicated that they used best management practices for rainwater retention, and individuals expressed interest in learning about better landscaping options. People expressed interest in the impacts of development, but it was not the primary concern for most respondents.

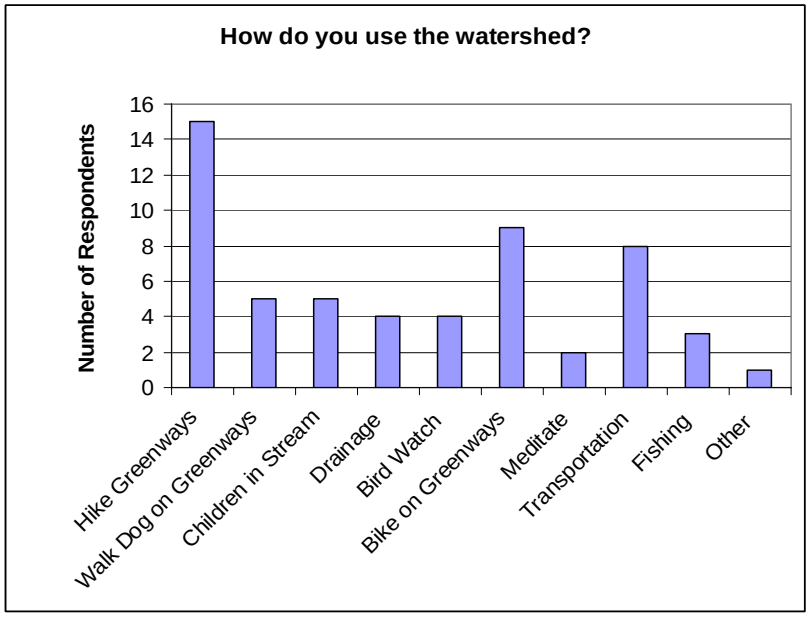
Additionally, we asked about how people handled pet waste and where people got environmental information. We did not get enough pet owners to make any notable conclusions on that subject. People's sources of environmental information varied, but print information in newspapers and Town of Cary mailings were the most common.■

Question 1: What is your connection to Black Creek?

We had 19 completed surveys turned in; 14 were from residents, 2 were from business owners, and four were from government officials (2 local, 1 state, and 1 unknown). Additionally, three of the residents also listed other connections to black creek: one person served on the Parks and Cultural Resources Advisory Board, one person taught science at a middle school in the watershed, and one person listed recreational ties to the watershed.

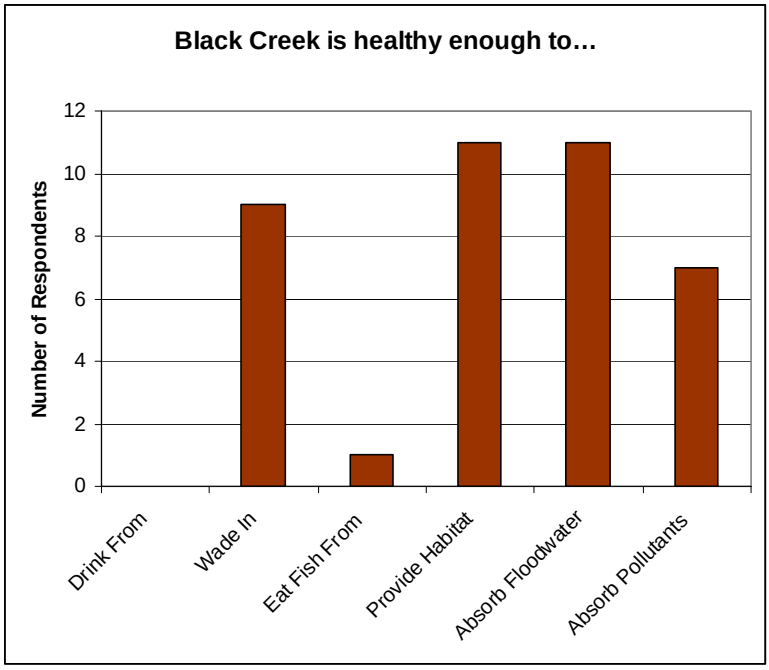
Question 2: How do you use the watershed?

The most common response to this question was 'hiking on the greenways', followed by 'biking on the greenways', using the greenways for 'transportation', 'walking dogs on the greenways', and letting 'children play in the stream'. Clearly, the greenway is the most visible use of the watershed for those surveyed. A smaller number used the watershed for access to nature (bird watching, fishing, meditating). Only about a fifth of those surveyed considered 'drainage' a major use of the watershed. One person listed "regulated development" as an 'other' use of the watershed.



Question 3: Check all of the following that can complete this sentence: Black Creek is healthy enough to…

Over half the respondents felt that the watershed was healthy enough to 'provide habitat to local wildlife' and 'absorb floodwaters' to some degree. Over a third of the respondents felt the watershed was safe to 'wade in' and could 'absorb pollutants'. Nobody felt the watershed was healthy enough to 'drink from' and only one person felt the watershed was safe to 'eat fish from'. Of the 19 respondents, only one individual did not find any of the provided options adequate.

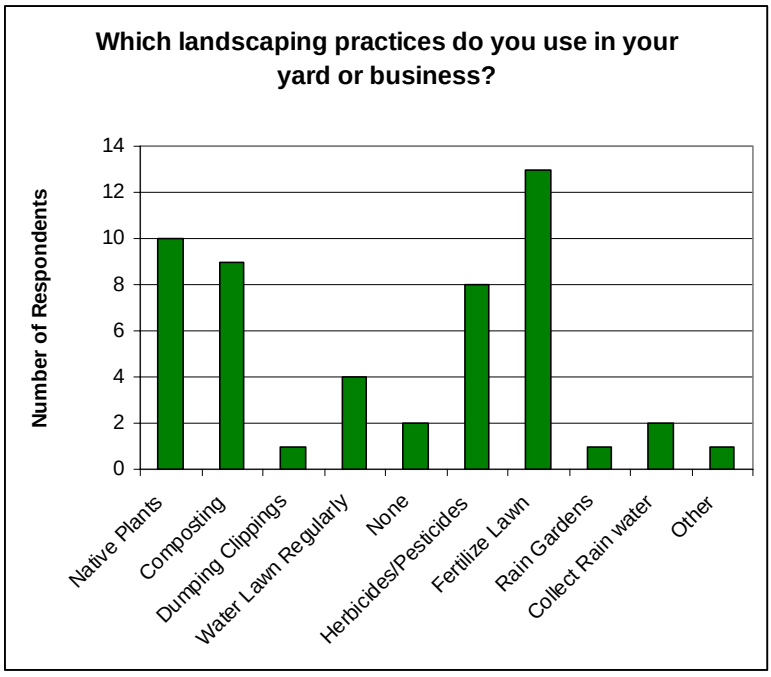


Question 4: Are there actions you can take to improve the condition of Black Creek Watershed?

Fifteen respondents said "Yes"; three respondents said "Not sure"; one respondent did not check any of the available options. No one selected "No actions needed", indicating an interest in the community to improve the watershed. On a positive note, no one selected "No", indicating a general sense of empowerment.

Question 5: Which landscaping practices do you use in your yard or business?

The most common practice was 'fertilizing a lawn', followed by 'using native plants', 'composting', and 'using pesticides/ herbicides'. Four respondents 'watered their lawn regularly'. Only one person admitted to 'dumping clippings'. Two people 'collected rainwater' and one person used a 'rain garden'. Of the two people listing 'none', one person commented that they lived in a complex, so yard work was not relevant. The person who listed 'other' wrote in that they installed a French drain to alleviate flooding.

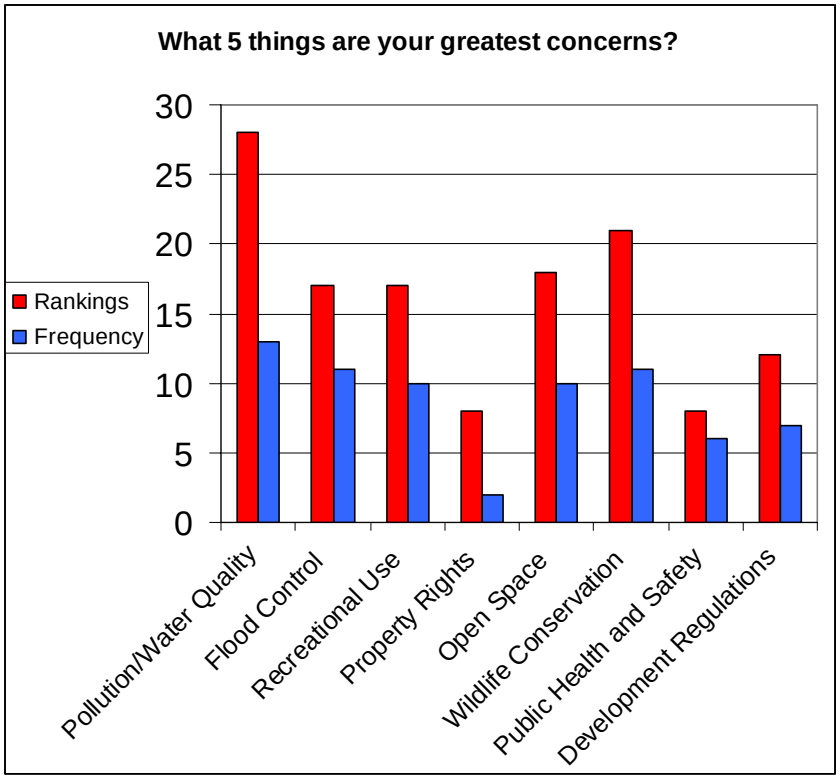


Question 6: If you have a dog, please indicate how its waste is handled?

Of the nineteen respondents, only five had a dog, and one of the five noted that their dog recently passed away. Three respondents 'picked up' the waste, while the other two 'left on the ground'. No one 'buried' their dog's waste.

Question 7: What 5 things are your greatest concerns?

Respondents were asked to rank their five greatest concerns. These were reverse scored, so that the greatest concern received 5 points, and the lowest concern received 1 point. In cases where respondents did not rank, all chosen options were given 1 point. Four respondents did not answer this question at all. At least one person responded to each of the available options, and no one chose to include an 'other' item.



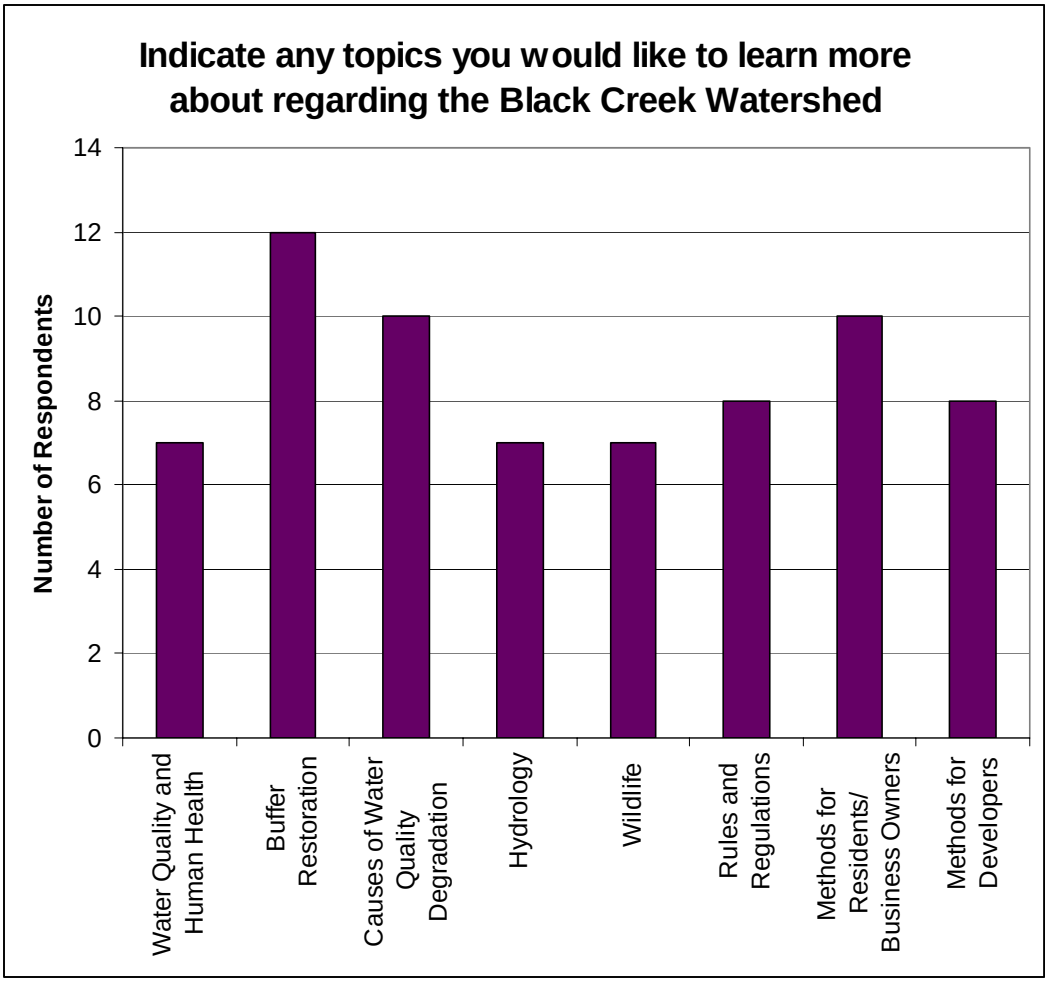
If we look at which items were most highly ranked, 'pollution/water quality' was the greatest concern, with 'wildlife conservation', 'open space', 'recreational use', and 'flood control' also being popular (>15 points). If we look at the frequency at which items were checked, those five items were also the most commonly checked concerns, with over half of the respondents checking each of those items. Over a third of those responding, selected 'public health and safety' and 'development regulations'. 'Property rights' was an outlier, in that only two respondents chose that option, but they both ranked it high.

Question 8: Where do you prefer to get information on local environmental issues?

Of the 19 respondents, 2 did not answer this question. Eleven selected newspaper, with the Raleigh News and Observer and the Cary News being the only two sources named. Nine respondents selected the Town of Cary mailings. Six respondents selected the internet, specifically mentioning grist.org, NC DENR's site, and 'local government sites'. Five respondents selected television, listing the news programs from NBC 17, WRAL 14, and UNC-TV. Three respondents listed civic organizations and four respondents listed volunteering/community workshops. Nobody wrote in an option for 'other'.

Question 9: Indicate any topics you would like to learn more about regarding the Black Creek Watershed.

Of the 19 respondents, 4 did not answer this question. All of our suggested topics were received well by the respondents. The most common response for this question was 'buffer restoration'. Over half of those responding also indicated interest in: 'causes of water degradation', 'methods for home and business owners', 'rules and regulations', and 'methods for developers'. About half of those responding indicated interest in 'water quality and human health', 'hydrology', and 'local wildlife'. Nobody wrote in any other suggestions.



Question 10: Any other comments?

There were three additional comments:

- As a teacher, what can my students and I do to help?
- If there are "good" lawn maintenance companies, I would like to know. Are these companies inspected and/or rated based on environmental and health and safety practices?

How does the health of Black Creek affect Lake Crabtree?

Appendix D:

Stream Walk Flyer

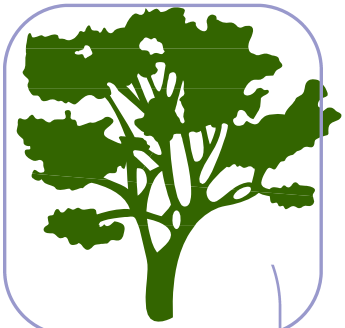
THIS EARTH DAY WEEKEND, GET YOUR FEET WET!

FIRST ANNUAL

BLACK CREEK STREAM WALK

VOLUNTEER TRAINING & STREAM WALK ON SATURDAY, APRIL 21

Call **Christy Perrin**, NC State University, at **515-4542** or email Christy_perrin@Ncsu.edu to RSVP by April 17**.** Teens and adults welcome.



Stream Walk Participants will:

- Learn techniques for assessing stream health in the classroom and the field from 9:00 am– 12.
- In teams of two, participants will be assigned to a tributary or portion of Black Creek to conduct an assessment. Wear stable footwear and clothes that can get wet, since you will be walking in the creek.
- Assessment activity will take 2-3 hours, and can be completed that afternoon or the following weekend if desired
- Breakfast is provided, lunch is on your own.

Sponsored by:

- NC State University
- Town of Cary
- Black Creek Watershed Association
- US Environmental Protection Agency
- NC Division of Water Quality

SATURDAY, APRIL 21

At Page-Walker Cultural Arts Center, 119 Ambassador Loop Downtown Cary behind Town Hall

TRAINING: 9:00 A.M.– 12:00 P.M.
STREAM WALK IS IN AFTERNOON
AM SNACKS PROVIDED

Appendix E:

Stream channel assessment worksheet example

Black Creek Watershed, Cary, NC
Stream Condition Assessment Worksheet

Site Information: Each site consists of the confluence of two streams with two 200 ft stream reaches, each extending upstream of the confluence designated as the site center. Each watershed zone contains two sites. Check the watershed zone. Designate the sites within the zone as numbers 1 and 2, and each reach at each site as numbers 1 and 2 and mark on the zone map.

Date:	Team: 7 - Site A				
Watershed Zone				Site #	Reach #
East Fork, Upstream of Maynard Road		West Fork, Upstream of Maynard Road			
East Fork, Downstream of Maynard Road		West Fork, Downstream of Maynard Road			
Confluence Zone, Upstream of Cary Parkway (A)		Confluence Zone, Upstream of Cary Parkway (B)			
Main Channel Zone, Downstream of Cary Parkway (A)		Main Channel Zone, Downstream of Cary Parkway (B)			

Rain in last 24 hours
□ heavy rain □ steady rain
□ intermittent rain □ none

Present conditions
□ heavy rain □ steady rain □ intermittent rain
□ overcast □ partly cloudy □ clear/sunny

Amount of rain, if known? _____ Inches in last hours/days _____

General Instructions: Walk the reach noting bankfull indicators, channel bottom structure, condition of banks, habitat structure, etc. Identify and mark with pin flags, representative streambanks for assessing streambank stability. Select 2 banks on the outside of meander bends and 2 banks along straight sections of channel. If on the main stem of Black Creek, extend the length of the reach if needed to encompass at least two meander bends. 2 low stress, 2 high stress - to compare

Water Quality: Collect a sample in a pool near the longitudinal center of the reach in a glass jar. Check all that apply. Note any pollutant source in the reach.

Water Odor
□ natural / none
□ sewage
□ rotten egg
□ other
□ gasoline
□ chlorine
□ chemical

Water Surface
□ clear □ natural oily sheen - breaks up when poke finger in it
□ foamy □ other
□ oily sheen (petroleum product) - oil sticks to finger

Water Clarity
□ turbid – suspended matter in water □ sediment □ blue/green algae □ other
50+: can see cloudiness
□ tannic – "clear" water that is naturally stained orange/brownish due to organic acids in water - not in Triangle - (in Coastal areas)
□ no staining / no suspended matter □ other (chemical discharges / dyes)

Notes

_____

_____

_____

Streambank Stability Parameter Scores

Streambank 1

Parameter	Excellent (4)	Good (3)	Fair (2)	Poor (1)	Score
Bank Height Ratio	1.0 – 1.2	1.2 – 1.5	1.5 - 2.0	> 2.0	
Root Depth Ratio	0.6 – 1.0	0.4 – 0.6	0.2 – 0.4	< 0.2	
Root Density %	60 – 100	40 – 60	20 – 40	< 20	
Bank Angle	< 45	45 – 60	60 – 75	> 75	
Surface Protection %	60 – 100	40 – 60	20 – 40	< 20	
Near Bank Stress	Low	Moderate	High	Very High	
Total Score					

Streambank 2

Parameter	Excellent (4)	Good (3)	Fair (2)	Poor (1)	Score
Bank Height Ratio	1.0 – 1.2	1.2 – 1.5	1.5 - 2.0	> 2.0	
Root Depth Ratio	0.6 – 1.0	0.4 – 0.6	0.2 – 0.4	< 0.2	
Root Density %	60 – 100	40 – 60	20 – 40	< 20	
Bank Angle	< 45	45 – 60	60 – 75	> 75	
Surface Protection %	60 – 100	40 – 60	20 – 40	< 20	
Near Bank Stress	Low	Moderate	High	Very High	
Total Score					

Streambank 3

Parameter	Excellent (4)	Good (3)	Fair (2)	Poor (1)	Score
Bank Height Ratio	1.0 – 1.2	1.2 – 1.5	1.5 - 2.0	> 2.0	
Root Depth Ratio	0.6 – 1.0	0.4 – 0.6	0.2 – 0.4	< 0.2	
Root Density %	60 – 100	40 – 60	20 – 40	< 20	
Bank Angle	< 45	45 – 60	60 – 75	> 75	
Surface Protection %	60 – 100	40 – 60	20 – 40	< 20	
Near Bank Stress	Low	Moderate	High	Very High	
Total Score					

Streambank 4

Parameter	Excellent (4)	Good (3)	Fair (2)	Poor (1)	Score
Bank Height Ratio	1.0 – 1.2	1.2 – 1.5	1.5 - 2.0	> 2.0	
Root Depth Ratio	0.6 – 1.0	0.4 – 0.6	0.2 – 0.4	< 0.2	
Root Density %	60 – 100	40 – 60	20 – 40	< 20	
Bank Angle	< 45	45 – 60	60 – 75	> 75	
Surface Protection %	60 – 100	40 – 60	20 – 40	< 20	
Near Bank Stress	Low	Moderate	High	Very High	
Total Score					
Mean Total Score for All Four Reaches					

Notes

Bedform Macrohabitat Scores

Observe condition and density of channel geomorphic features while walking the reach. Rate each macrohabitat feature in the table below in accordance with the conditions along the entire reach.

Macro - Habitat	Excellent (4)	Good (3)	Fair (2)	Poor (1)	Score
Riffles	About half of stream length with long, steep riffles with clean gravel – big & small rocks	Some good riffle features	Few good riffle features	Non-existent	
Pools	About half of stream length with deep pools located in meander bends with stable outside banks sandy & good	Some good pool features	Few good pool features	Non-existent	
Structure-related habitats	Many structure-related features providing flow diversity, refuge, and habitat enhancement	Some good structures	Few good structures	Non-existent	
Total Score					

What we saw - excellent

Riffle habitat - macroinvert. like riffles - fish might hang out in pools near stem

5.

Notes

Cover and Refuge Scores

Walk the stream and note the presence and quality of cover features, including the cover types listed below. For each cover type, score the functional value based on its availability for enhancing habitat. On the last line of this Table, assign a score based on the percent stream length containing some form of cover and refuge to enhance habitat.

Cover Type	Excellent (4)	Good (3)	Fair (2)	Poor (1)	Score
Undercut Banks	Abundant	Moderate	Sparse	None	
Leaf Packs	Abundant	Moderate	Sparse	None	
Overhanging Vegetation	Abundant	Moderate	Sparse	None	
Pools > 2 ft deep	Abundant	Moderate	Sparse	None	
Root Wads	Abundant	Moderate	Sparse	None	
Boulders (too heavy to lift)	Abundant	Moderate	Sparse	None	
Oxbows, backwaters	Abundant	Moderate	Sparse	None	
Aquatic Macrophytes	Abundant	Moderate	Sparse	None	
Logs and Woody Debris	Abundant	Moderate	Sparse	None	
Overall Cover & Refuge	> 50 %	25 – 50 %	5 – 25 %	< 5 %	
Total Score					

Notes

Floodplain Condition

First determine the riparian vegetation structure and density, then walk the reach observing the features noted in the floodplain condition table below and rate each feature based on the average condition along the entire reach. To determine riparian vegetation structure and density, locate four line transects 30 ft long extending outward from the streambank, perpendicular to streamflow. Locate the transects so as to represent the range of riparian vegetation conditions. Estimate the percent bare ground and percent cover of herbaceous vegetation along the transect in a zone 5 ft either side of the transect centerline. Estimate the percent cover of shrubs along the transect in a zone 10 ft either side of the transect centerline. Estimate the percent cover of trees in a zone 20 ft either side of the transect centerline. Note presence of exotic invasive shrubs, trees, or vines.

Riparian Vegetation Cover

Structural Element	Percent Cover				AVG
Trees					
Shrubs – incl. saplings					
Herbs – knee ht.					
Bare Ground					

Notes

Ex

Floodplain Condition

Parameter	Excellent (4)	Good (3)	Fair (2)	Poor (1)	Score
Floodplain Connection	High flows (greater than bankfull) able to enter floodplain. Stream not deeply incised.	High flows (greater than bankfull) able to enter floodplain. Some incision occurring	High flows (greater than bankfull but less than 2X bankfull) not able to enter floodplain. Stream deeply entrenched.	High flows (greater than 2X bankfull) not able to enter floodplain. Stream deeply entrenched	
Vegetated Buffer Width	Width of buffer zone > 50 feet; human activities (i.e. parking lots, roadbeds, clear cuts, lawns, crops) have not impacted zone	Width of buffer zone 25-50 feet; human activities have impacted zone only minimally	Width of buffer zone 10-15 feet; human activities have impacted zone significantly	Width of buffer zone < 10 feet; little or no riparian vegetation due to human activities	
Riparian Vegetation Structural Complexity and Diversity**	All 3 classes of vegetation present, > 70 % tree cover and at least 20 % shrub cover - closed complex	At least one woody class and one herbaceous class present, > 70 % combined cover	At least one woody and one herbaceous class present , 10 – 70 % combined cover	No woody class present, herbaceous cover > 50 %	
Floodplain Habitat	Mix of wetland and non-wetland habitats, evidence of standing/pooling water	Mix of wetland and non-wetland habitats, no evidence of standing/pooling water	Either all wetland or all non-wetland habitat, evidence of standing/pooling water	Either all wetland or all non-wetland habitat, no evidence of standing/pooling water	
Floodplain Encroachment	No evidence of floodplain encroachment in the form of fill material, land development, or manmade structures - incl. grway, scour lines	Minor floodplain encroachment in the form of fill material, land development, or manmade structures, but not affecting floodplain function	Moderate floodplain encroachment in the form of filling, land development, or manmade structures, some effect on floodplain function	Significant floodplain encroachment (i.e. fill material, land development, or manmade structures), significant effect of floodplain function	
Percent Exposed or Bare Ground	10% or less of the site with exposed soil surface	10% to 20% of the site has exposed soil surface	20% to 50% of the site has exposed soil surface	> 50% of the site has exposed soil surface	
Stormwater Outfall Quality (urban projects only)	Excellent Outfalls appear stable. Little evidence of erosion or degradation. Energy dissipation and treatment is evident. - could be pipes, paths - can be good + bad - Should not go directly into stream	Good Outfalls have very few problems and are generally stable. Attention has been paid to the design, and some treatment and energy dissipation is expected	Fair Design appears to consider outfalls. However, exhibits limited ability to either dissipate energy or treat runoff.	Poor Little to no attention was paid to storm outfalls. Outfalls are failing or are a source of stream floodplain erosion. Either energy dissipation or treatment. a lawn	
		Total Score			

excellent
last one we saw floodplain

excell

excell

excell

good

4

before getting to Grway
Cattails, black willow, juncus } flood plain
undigged banks - sparce overhang veg
sparse vascular

near Grway - big pool - Grway does not encroach - not vertical - so does not harm flood plain function
Bank full - look at rock bar top
30% look at
Surface protection - 60% - big tree, big rocks, veg some boulders
Stress - high - 4ft high bank

Notes

Final Assessment Table

Category	Metric	Range of Scores	Score	Divide by	Mean Score
Channel Condition	Streambank Stability	6 – 24		6	
	Bedform Condition	3 – 12		3	
	Cover and Refuge	10 – 40		10	
Riparian Condition	Floodplain and Riparian Vegetation Condition	7 – 28		7	
Overall Mean Score					

Appendix F:

Pollution source survey worksheet example

Pollution Source Survey

Black Creek Watershed, Cary, NC

June 20, 2008

Background

In Section 502 of the Clean Water Act, pollution is defined as *the man-made or man-induced alteration of the chemical, physical, biological, and radiological integrity of water.* Implicit in that definition is the concept of man-caused changes in the characteristics of water in rainfall, soils, streams, freshwater bodies, ground water, and the oceans, i.e. all components of the global water cycle. Water quality means the chemical, physical, biological, and radiological characteristics of water, usually in relation to man's use of a particular source of water. In the Black Creek stream network, pollutants are most likely solids, liquids, and microbes that may enter streams in the watershed from one of two types of sources. *Point source* pollution refers to discharges from a pipe such as discharge of treated effluent from a wastewater treatment plant or the discharge of stormwater from a pipe. The source of the pollution is easily identifiable. *Nonpoint source* pollution is that which enters a stream from diffuse sources and the specific source or source area is not easily identifiable. An example in urban watersheds such as Black Creek is the entry of common turf management pesticides into the stream network. Some of the stormwater that flushes pesticides from lawn surfaces during rainfall may accumulate in stormwater pipes but some may also flow via surface or subsurface routes directly to the stream network.

Additional Reading: The "Stormwater and Runoff Pollution" web page (http://www.ncstormwater.org/) of the NC Department of Environment and Natural Resources provides some excellent educational material on stormwater pollution. Click on "Citizen Resources" and "Stormwater FAQs" on that web page.

<u>Objective</u>

The assessment of water quality in Black Creek being conducted by the Technical Team from the NCSU Department of Forestry and Environmental Resources has focused on two approaches: (1) analysis of water samples for various water quality parameters, and (2) assessment of benthic macroinvertebrate populations. The benthic macroinvertebrate assessments in Black Creek indicate that many types of aquatic insects (i.e. larval aquatic stages) that are sensitive to degraded water quality are lacking. However, the water quality analyses, so far, do not show that water quality, per se, is the culprit in the decimated macroinvertebrate populations. The water quality sampling may have been too infrequent to capture data on short term events that may have had a negative impact on the macroinvertebrates, e.g. flushing of pesticides into the stream network by a large storm. However, our results may indicate that the macroinvertebrate populations have been affected adversely mainly by the very high energy storm flows in Black Creek and its tributaries.

The objective of the Pollution Source Survey is to survey potential *point* and *nonpoint sources* of pollutants in the Black Creek watershed. The only legal point sources are stormwater pipe (storm sewer) discharges to the stream network. Those points were inventoried by the

Town of Cary and that GIS layer is available in the Black Creek geodatabase. The potential for diffuse runoff to collect and discharge pollutants to the stream network is related to land use/land cover in subareas of the Black Creek Watershed. As part of the stormwater assessment by the Technical Team, a digital assessment of land use/land cover in the watershed using high resolution satellite data is ongoing. The land use/land cover assessment will provide insights into the subwatersheds that are most likely to contribute pollutants in stormwater.

Questions still remain about possible sources of pollutants to the Black Creek watershed stream network. Are there unknown point sources such as discharges from business, industry, or institutional sites where pollutants are being discharged to stormwater systems that should be discharged to a treatment system? Does frequent dumping of pollutants into the stream network occur? Examples include dumping of household trash, garbage, and yard refuse. Are there refuse collection points, fuel storage facilities, or pesticide storage facilities, etc. where improper storage results in discharge of pollutants to stormwater. Are there areas where very intensive landscape management results in relatively high discharges of nutrients and pesticides into the stream network? Answering these questions requires on-the-ground surveys by individuals who are familiar with an area within the watershed.

Methods

1) The Black Creek Watershed will be subdivided into a series of survey areas and additional volunteers will be sought via the Black Creek Listserve to conduct a pollution source survey within each area, using this document and filling out a standard survey form. Some BCWA members volunteered for certain areas at the June 9 meeting. If more than one person volunteers for an area, coordinate with each other to divide it up. The Black Creek Technical Team will review the submitted surveys and conduct follow up examinations of suspected pollution sources. Information on potential illicit discharges (see below) will be passed to the Town of Cary Engineering Department for evaluation and action, if needed.

2) Suggested survey approach. Review the GIS map of the subarea and conduct a driving survey to become familiar with the area. Draft a list of potential pollutant sources/sites and examine these sites more thoroughly. Examine sites along the streams within your survey area for evidence of trash dumping, oil slicks, etc. A complete walk of all streams in the survey area is not necessary but try to visit as many accessible sites along the streams in the survey area as feasible. Be thoughtful of private property and stay on publically accessible areas. List and briefly describe the potential point and nonpoint sources on the Pollution Source Survey form. Take digital pictures of the sites/sources that are listed on the survey form. See instructions on the survey form for turning in the complete survey and pictures to the Technical Team.

3) Potential pollution sources

    a) Point sources*:* Illicit discharge – untreated polluted water that is discharged directly to a stream or to a storm sewer. An *illicit connection* is the discharge of pollutants or non-storm water materials into a storm sewer system via a pipe or other direct connection. Sources of illicit connections may include sanitary sewer taps, wash water from laundromats or carwashes, and other similar sources. An *illicit discharge* is the discharge of pollutants or non-storm water materials to storm sewer systems via overland flow or

direct dumping of materials into a storm drain. Some examples of illicit discharges include the overland drainage from a carwash or dumping used motor oil in or around a storm drain. A component of the Town of Cary's stormwater management program is illicit discharge detection and elimination (IDDE). For background reading on IDDE, see http://www.neiwpcc.org/iddemanual.asp.

i) Things to look for:

(1) Small pipes at the perimeter of buildings or parking lots that are discharging water from an unknown source. Often such pipes are discharging condensate from large air conditioning units. Air conditioner condensate is unpolluted and may be legally discharged to a storm sewer.

(2) Continuous flow from a stormwater pipe during rain free periods. Consider the possible sources. Stormwater pipes under areas of pervious surface (lawns, landscaped areas, forested areas, etc.) may receive groundwater discharge through the pipe joints of concrete piping systems in areas where seasonal high water tables rise to the level of the pipes. Burying small intermittent streams in pipes was common in residential and commercial areas in the 1970s-80s and earlier and continuous base flow from such pipes may occur, at least during winter/spring. Storm sewers at the outlet of stormwater collection systems under large commercial, industrial, or institutional sites may collect and discharge air conditioner condensate from several sources.

ii) Survey action – note the type and location of an unknown discharge on the survey form for follow up by the Black Creek Technical Team and the Town of Cary.

b) Potential nonpoint sources*:*

i) *Residential and commercial areas with intensively managed lawns and landscapes.* Such areas often are sources of nonpoint source pollution resulting from over-fertilization and excessive use of pesticides.

(1) Things to look for:
(i) very well maintained lawns and landscaping, often with in-ground irrigation systems, in upscale residential neighborhoods or commercial or institutional sites.

(2) Survey action – note location and briefly describe the site; add any notes about specific activities that seem unusual or unnecessary for routine lawn and landscape management that may be pollution sources.

ii) *Large areas of impervious surface that can potentially deliver pollutants to the storm sewer system.* Shopping centers and large institutional or business sites with large parking lots may be sources of pollutants to the stream network if poorly managed and stormwater retention/detention systems are not working properly.

(1) Things to look for: large building/parking lot complexes with evidence of trash in the parking lot or around buildings, evidence of fuel or oil spills that have not

(2) Survey action – note location and briefly describe the site. Take a picture of the stormwater retention/detention pond for the site, if one is present and accessible.

iii) *Active construction sites with poorly managed erosion and sediment control practices that results in delivery of sediment to streams that receive stormwater runoff.*

(1) Things to look for: freshly deposited sediment in nearby streams or sediment deposits in riparian areas close to streams, evidence of stormwater and sediment being carried over or under poorly constructed/maintained silt fences, detention basins that are more than half-filled with sediment or there is evidence of overwash over the basin berm, etc.

(2) Survey action – note location and briefly describe the site. Take pictures of specific evidence that sediment is being delivered to receiving streams.

iv) *Pollutants in streams*

(1) Things to look for:
(a) Evidence of dumping of yard/landscape management residues such as grass clippings, branches pruned from shrubs, etc. Such material has high nitrogen content and represents a potential source of excess nutrients in the stream.

(b) Evidence of dumping of trash into the stream or trash in the stream that may have been be carried from roadways or parking lots by stormwater runoff.

(c) Evidence of dumping of oily liquids. Note that iron oxidizing bacteria are common during the spring and summer months in quiet water areas of small streams. Such bacteria utilize reduced (i.e. dissolved) iron in ground water discharging to the stream in respiration and in turn, oxidize the iron.

(d) Evidence of the presence of such bacteria is an oily looking sheen on the surface or fluffy orange masses under water. To determine if a sheen is oil or bacteria, poke your finger into the surface. A bacterial sheen will break up, whereas an oil sheen will immediately flow back together. See photos below of typical iron oxidizing bacteria populations.

(2) Survey action – note location and briefly describe the site.

Black Creek Watershed
Pollution Source Survey Form

1. Watershed subarea:

2. Volunteer(s):

3. Date Survey Completed: (please complete by July 16)

4. Instructions
   a. Suggested survey approach. Review the GIS map of the subarea and conduct a driving survey to become familiar with the area. Draft a list of potential pollution sources/sites and examine these sites more thoroughly. Examine sites along the streams within your survey area for evidence of trash dumping, oil slicks, etc. A complete stream walk of all streams in the survey area is not necessary but try to visit as many sites along the streams in the survey area as feasible, depending on accessibility.
   b. Survey report. Since the types and number of potential pollution sources and the space needed to describe them for each survey area is unknown, please follow this procedure to provide a report on your survey. Make handwritten notes about each site while at the site. Describe the location, the type of pollutant source, the potential pollutants, etc. Give the site a unique name or code and list those names below. Then enter those notes into a MS Word file, print those pages and attach to the survey form. Take one or more digital pictures of each site and use a system of notation for the pictures so that the picture files can be matched with the site description. If you do not own a digital camera, please contact Jim Gregory (jim_gregory@ncsu.edu) or Christy Perrin (christy_perrin@ncsu.edu) to arrange to borrow one for your survey. Transfer the digital pictures to a CD. When your survey report is complete, contact Jim or Christy and one of us will arrange to pick up your report.
5. Point sources

_____
_____
_____
_____
_____

6. Nonpoint sources

_____
_____
_____
_____
_____

7. Pollutants in streams

_____
_____
_____
_____
_____

Pictures of typical iron oxidizing bacteria populations

Appendix G:

Geodatabase categories of information

Appendix: Geodatabase categories of information

Data Type	Feature Dataset	Feature Class	File Name	Source	Projection
Vector	Municipal	Existing Greenway	Bcexistinggreenway	Town of Cary	NAD1983 State Plane Feet
Vector	Municipal	Planned Greenway	Bcgreenwayplanned	Town of Cary	NAD1983 State Plane Feet
Vector	Municipal	Water Lines	Carywaterlines	Town of Cary	NAD1983 State Plane Feet
Vector	Municipal	Sewer Lines	carysewerlines	Town of Cary	NAD1983 State Plane Feet
Vector	Municipal	Main Roads	mainroads	Wake County	NAD1983 State Plane Feet
Vector	Municipal	Streets	Streets	Wake County	NAD1983 State Plane Feet
Vector	Municipal	Property	Bcproperty	Wake County	NAD1983 State Plane Feet
Vector	Municipal	Schools	Schools	Wake County	NAD1983 State Plane Feet
Vector	Municipal	River Buffers	CaryRiverBuffers	Town of Cary	NAD1983 State Plane Feet
Vector	Municipal	Parks	CaryParks	Town of Cary	NAD1983 State Plane Feet
Vector	Hydrology	Lakes and Ponds	lakesponds	Wake County	NAD1983 State Plane Feet
Vector	Hydrology	NHD Streams	nhdstreams	National Hydrography Dataset	NAD1983 State Plane Feet
Vector	Hydrology	Stream Origins	StreamOriginsGPSed	Created for BC Project	NAD1983 State Plane Feet
Vector	Hydrology	Streams	ToCstreamsBC	Town of Cary, modified with origins	NAD1983 State Plane Feet
Vector	Research	Extent File	Bcbox	Created from LiDAR grids	NAD1983 State Plane Feet
Vector	Research	Macroinvertebrate Sampling Sites	Bcmacrosites	Created for BC Project	NAD1983 State Plane Feet
Vector	Research	Stream Gauge	Bcstreamgauge	Created for BC Project	NAD1983 State Plane Feet
Vector	Research	Cary Academy Water Quality	CaryAcademysites	Created for BC Project	NAD1983 State

		Sites			Plane Feet
Vector	Research	Stream Gauge Watershed Area	streamgaugewatershed	Created for BC Project	NAD1983 State Plane Feet
Vector	Research	East Fork Watershed Area	eastforkwatershed	Created for BC Project	NAD1983 State Plane Feet
Vector	Research	West Fork Watershed Area	westforkwatershed	Created for BC Project	NAD1983 State Plane Feet
Vector	Research	Upper East Fork Watershed Area	eastforkupperwatershed	Created for BC Project	NAD1983 State Plane Feet
Vector	Research	Upper West Fork Watershed Area	westforkupperwatershed	Created for BC Project	NAD1983 State Plane Feet
Vector	StormwaterSystem	Channel	Channel	Town of Cary	NAD1983 State Plane Feet
Vector	StormwaterSystem	Combo Inlet	ComboInlet	Town of Cary	NAD1983 State Plane Feet
Vector	StormwaterSystem	Culvert	Culvert	Town of Cary	NAD1983 State Plane Feet
Vector	StormwaterSystem	Curb Inlet	CurbInlet	Town of Cary	NAD1983 State Plane Feet
Vector	StormwaterSystem	Grate Inlet	GrateInlet	Town of Cary	NAD1983 State Plane Feet
Vector	StormwaterSystem	Pipe I/O	PipeIO	Town of Cary	NAD1983 State Plane Feet
Vector	StormwaterSystem	Pipes	Pipes	Town of Cary	NAD1983 State Plane Feet
Vector	StormwaterSystem	Yard Inlet	YardInlet	Town of Cary	NAD1983 State Plane Feet
Vector	LandUseLandCover	10 foot contours	10ftContours	Created for BC Project	NAD1983 State Plane Feet
Vector	LandUseLandCover	5 foot contours	5ftContours	Created for BC Project	NAD1983 State Plane Feet
Vector	LandUseLandCover	Soils	soils	NRCS	NAD1983 State Plane Feet
Vector	Research	Black Creek Watershed Area	blackcreekwatershed	Created for BC Project	NAD1983 State Plane Feet
Raster	Research	DEM	tasoutput	Created for BC Project using floodmaps LiDAR	NAD1983 State Plane Feet
Raster	Research	Land Use / Land Cover	lulc_shifted	Created for BC Project	NAD1983 State Plane Feet

Raster	Municipal	Orthophotography	orthoph	Wake County	NAD1983 State Plane Feet
Table	Research	Index Table	Index_Table	Created for BC Project	NAD1983 State Plane Feet

Appendix H:

Black Creek monitoring station sign

Black Creek Watershed Monitoring Station

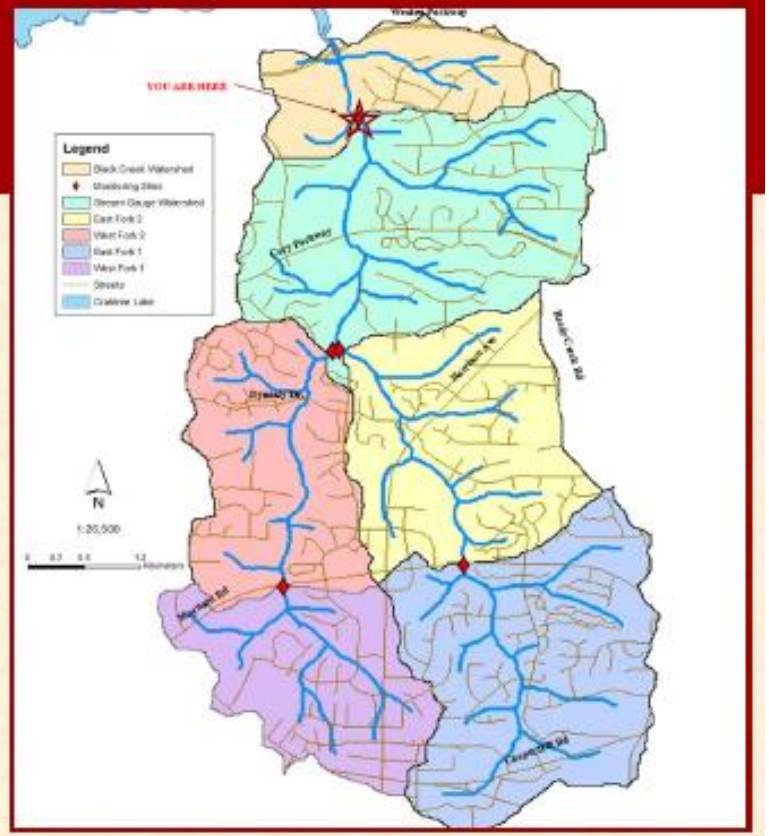
Introducing the Black Creek Watershed Association

Black Creek is considered impaired since it does not meet federal or state water quality standards for healthy aquatic animal life and habitat. A partnership between citizens, the Town of Cary, NC State University (NCSU), Wake County, and other local and state organizations was formed in 2006 to protect and improve the health of the entire Black Creek Watershed. The work is funded by a US EPA Clean Water Act grant, the Town of Cary, and NCSU.

Watershed assessment and monitoring activities conducted by NCSU provide information for the *Black Creek Watershed Association* to better understand reasons for the stream's impairment, and to use the results for developing and implementing a protection and restoration plan.

This red box contains an automated sampling device for recording water and pollutant levels during rain events. After a storm, water runs quickly over rooftops, driveways, parking lots, and roads, picking up pollutants like fertilizer, pet waste, vehicle fluids, and soil. The stormwater carrying pollutants enters creeks, causing erosion, harming wildlife and threatening activities such as fishing and wading. Allowing stormwater to soak into the ground and treatment areas will help rehabilitate Black Creek.

Work on your watershed! For more information visit
www.ncsu.edu/WECO/blackcreek



Appendix I:

Newsletter Examples

THE BLACK CREEK WATERSHED WIRE

News from Black Creek Watershed, Cary, NC Spring 2006

Visit the project website at www.ces.ncsu.edu/WECO/blackcreek

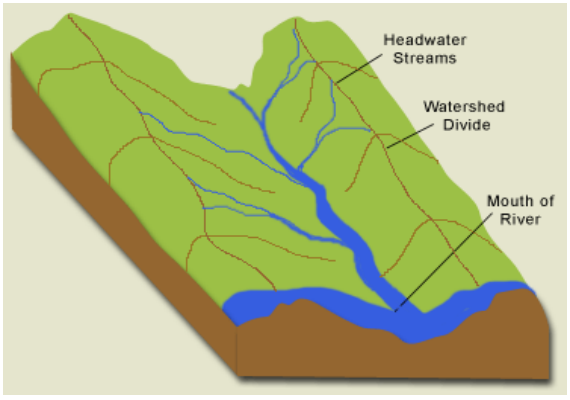
Black Creek EPA Project Begins!

Welcome to the first issue of the Black Creek Watershed Wire! This inaugural newsletter will cover the basics of the new Black Creek watershed planning project, an effort resulting from the partnership of NC State University, the Town of Cary, and citizens, with funding from the USEPA.

We'll also report on feedback received from attendees of a public workshop held to kick off the project in March 2006, and some other project highlights. We have a lot to cover in this issue!

We are very pleased at the high level of interest shown in the Black Creek watershed by citizens, private, and public organizations. If you would like to be added to our mailing list or listserve, please contact Christy Perrin at 515-4542 or Christy_perrin@ncsu.edu. We will be sending out periodic newsletters like this one, meeting notices, and other relevant items. The listserve can also be used for group discussion about the watershed.

Thank you for your interest in working on your watershed!



A watershed is all the land and tributaries that drain to a particular water body

First meeting of Black Creek Watershed Association will be held on Monday, July 24

6:30-9:00 p.m.

(dinner at 6:30)

Herb Young Community Center, corner of Academy St. & Chapel Hill Road

- *The first meeting will focus on introductions, collaborative skills training and a brief update on watershed assessment and monitoring activities.*
- *If you were not contacted for inclusion on the association but are interested in participating, please contact Christy Perrin.*

Where is Black Creek and what are we doing with it?

The Black Creek watershed contains all the land and water bodies from its headwaters along Chapel Hill Road between Reedy Creek Road and Evans Road, and empties into Lake Crabtree. A map of the watershed is on the WECO website. Black Creek is considered impaired by the State of NC and the US EPA, meaning Black Creek is not supporting the aquatic life that would normally live in a Piedmont stream.

Recent citizen concerns about the Black Creek Greenway and the creek have brought to light the high value placed on these resources by the community. A team from NC State University (NCSU), the Town of Cary, and the Black Creek community has obtained an EPA grant to work with citizens to assess the health of the watershed, develop a vision for the watershed, and develop a management plan.

The project involves two components:

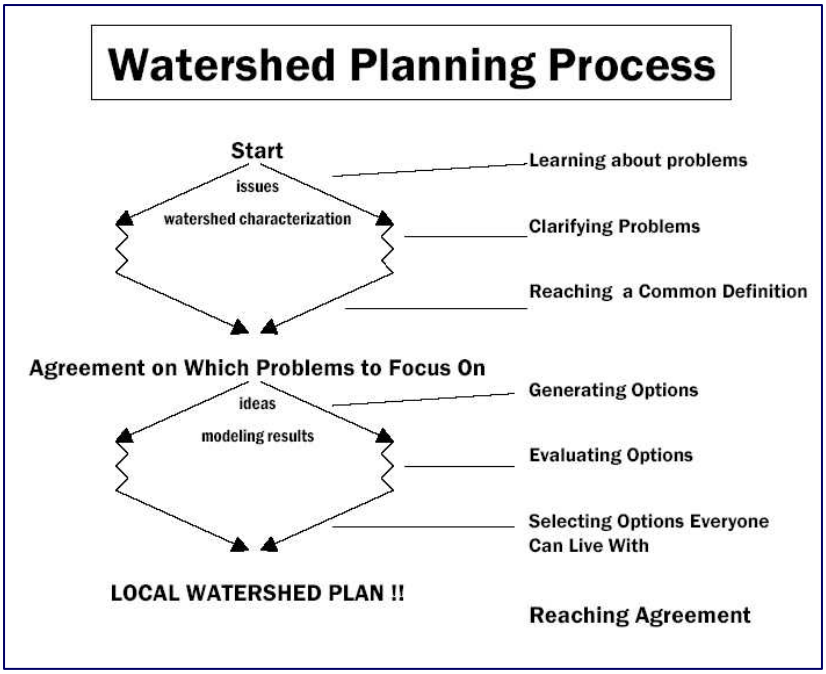
1. *Watershed public involvement:* A coalition of watershed residents and representatives of institutional, commercial, and Town of Cary interests will be convened to involve the community. The coalition will cultivate a vision, educate each other on issues, and develop community supported recommendations for the watershed management plan.

2. *Watershed assessment and monitoring:* NCSU will work to determine the causes of Black Creek's impairment by: (a) conducting a detailed watershed assessment, (b) planning and implementing a monitoring program to detect changes over time in specific indicators and determine the effectiveness of restoration plan implementation, and (c) developing a geodatabase for compiling information to analyze and create maps of the watershed.

Inside this issue:

What is Watershed Planning?

Watershed planning involves assessing watershed issues, environmental health, and local socioeconomic demands, and determining the best possible balance that can be achieved for all. A watershed plan inventories existing conditions, determines issue areas, generates options for protection and growth, and provides guidance for future decision making. The hourglass design pictured here is a visual representation of WECO's watershed planning method. There are two major parts to the hourglass – problem exploration and solution exploration. A Watershed Association will lead this entire process. The Watershed Association consists of people who influence the quality of Black Creek or are impacted by the quality of Black Creek. They will be provided with collaborative, consensus-based decision making skills to help make decisions through the process, and to develop a vision for the watershed.



During **Problem Exploration**, we learn about the issues affecting the watershed and determine what problems exist. A technical watershed assessment is conducted. A *Situation Assessment* (now available online) examines the social issues present through stakeholder interviews. At this stage of the process, we are not looking for the answers, instead we are determining what problems exist and on what problems we will concentrate. Stakeholder input helps direct the support team to find the information needed to clarify the issues and make decisions. Based on all the input, on the problems uncovered, on the vision, on the goals, what will we focus out attentions on?

Next is the **Solution Exploration** phase. Given what we have learned, what can we do about it? What are all the possible solutions that exist? We go back to broad brainstorming to determine all possible opportunities, without rejecting any. At this point, our consensus decision making skills are important. Is there more information that might be needed to make these decisions? What might be the ramifications? How might we enact these solutions? Who can champion our plan? How can we pay for it? Is future monitoring necessary? When should this plan be revisited and reevaluated? Then, we can decide on what solutions should be included in the watershed plan. Recommendations may range from on-the ground projects to manage stormwater, to educational programs, to changes in local policy. The Watershed Association will decide what to recommend in the plan.

Watershed Assessment and Monitoring

Dr. Jim Gregory of NCSU Department of Forestry and Environmental Resources presented the watershed assessment and monitoring component of the Black Creek Watershed Project at the March public meeting. A watershed assessment is a determination of current character and conditions of a watershed, a snapshot. Monitoring refers to ongoing collection of data such as rainfall, streamflow, water quality samples. Initial monitoring data will provide information about current conditions, while continual monitoring will provide data to see how the watershed responds to land use changes or restoration activities that may occur in the future.

The assessment and monitoring team consists of:
Department of Forestry and Environmental Resources: Dr. James Gregory, Dr. Stacy Nelson, Dr. Elizabeth Nichols, Dr. Halil Cakir, Shelby Laird, Diane Norris.
Department of Biological and Agricultural Engineering, Water Quality Group: David Penrose.

The assessment includes mapping the watershed using remote sensing data and on the ground surveys, and incorporating this and other information into a geographic infor-

(Continued on page 3)

Watershed Assessment and Monitoring , continued

(Continued from page 2)

mation system (GIS) program. Remote sensing refers to data collected from afar, such as aerial photography or satellite imagery. This data is then confirmed by on-the-ground assessments – people walk the watershed to determine if the data is correct. All the information will be compiled in a geodatabase, a computer program where both mapping information and other data such as water quality can be combined, mapped, and tracked. We will attempt to make as much data available online as possible.

Data to be collected include:

- watershed geomorphology (physical characteristics such size, shape, terrain),
- the stream network (where are the streams on the map),
- the stormwater drainage system,
- sources of pollution
- cultural features (streets, buildings, etc.)
- sampling station locations (for water quality, rainfall, etc)
- Land use/land cover (the detailed characteristics of the land surface such as driveways, grass, houses, forest.)
- hydrology data (streamflow, rainfall, stream shape, stream stability)
- biological data (what animals, fish and insects live in the stream?)
- chemical data (what pollutants are present?)

A stream gauge that measures flow is being placed in the stream at the downstream end of the watershed. In addition, local volunteers will be needed to measure rainfall, and take samples of water for water quality testing, especially during and right after rainstorms. If you are interested in volunteering, or you would like the technical team to monitor for specific things, please let us know.

A stretch of lower Black Creek

Black Creek Watershed Situation Assessment Online

WECO staff at NCSU conducted a *Situation Assessment* shortly after the EPA grant was awarded. The assessment was conducted by Molly Puente, a graduate student of Public Administration and Entomology , Christy Perrin, and Patrick Beggs. The purpose of the Situation Assessment is to:

(1) identify stakeholders, members of the community with a stake in the Black Creek watershed,

(2) learn what the stakeholders see as problems, and

(3) learn what the stakeholders may wish to gain by participating in a watershed planning process.

WECO interviewed twenty one stakeholders including residents, developers, and government staff, representing a cross-section of interests. The results of the interviews are summarized in the assessment, including the project team's recommendations for moving forward with a watershed association. The results of the Situation Assessment will help determine a public involvement process to best meet stakeholder needs while creating a sustainable watershed management team.

An excerpt from the Situation Assessment reads:

The Black Creek watershed, which begins in downtown Cary, NC and flows into Lake Crabtree through northern Cary, has seen rapid growth in residential and commercial development in recent years. This growth has put various stakeholders at odds with each other. A recent conflict regarding a move of the popular Black Creek Greenway to accommodate a new apartment complex left trust badly strained between lower watershed residents, development interests, and Town of Cary elected officials. However, this Situation Assessment reveals that residents, developers, and other watershed stakeholders are interested in coming together to search for innovative solutions to the problems impacting Black Creek.

Read more online at www.ces.ncsu.edu/WECO or contact WECO for a hard copy, which is available upon request.

Public workshop participants share their interests

Twenty nine participants, including citizens and government agency representatives, attended a public workshop held to officially kick off the Black Creek project on March 21, 2006 at the Herb Young Community Center in the watershed's headwaters. The meeting was covered and reported on by WRAL TV.

The attendees were led through an exercise called *affinity diagramming* to gather and group their ideas. Participants were split into 2 smaller groups to facilitate communication, and were asked "What are the issues to consider in the Black Creek Watershed?" They were instructed to write as many answers as they wanted, one per sticky note. The sticky notes were put up on a wall and attendees were then asked to group the notes by category, then to worked together to title each category. The groups reported out to each other their findings. Overall, there were 89 notes posted ranging from very specific suggestions to broad general statements. Here we have summarized the results of the two groups, using some of the titles the groups came up with to organize the many suggestions. The numbers in parentheses (x) reflect how many people wrote similar responses.

The initial 89 notes and groupings are available on the WECO website.

Vision for the Black Creek as a Public Resource

- Is the creek safe for swimming and fishing, and if not how can we get it there (2)?
- How do we make Black Creek suitable habitat for wildlife (9), specifically birds (1) invertebrates (1)?
- How do we keep Black Creek healthy for people (2) and pets (2)?
- Is Black Creek safe for children to play in (3)?
- Can we preserve the natural beauty and open space in the watershed (4)?
- How can we keep the Black Creek Greenway safe (1), clean/natural (5), and a place people want to visit (1)?
- Is the Black Creek watershed ecologically healthy (1)?
- How can actions in the Black Creek watershed lead to a clean Lake Crabtree (1)?
- How do actions in the watershed affect the long term water quality for Neuse River Basin (1)?

Potential Water Quality Problems

- Is there anything we can do about flooding (3)- especially along Harrison and Chapel Hill Road (1)?
- Is there anything we can do about erosion (1)- more specifically, along Black Creek (1), between Reton Court and Canyon Run (1), and the rock face on Cary Parkway (1)?
- Are there problems with stormwater runoff (4)? acid rain (1)?
- How do we test for and prevent pollution discharges (3) from the dog park (1), housing developments (1), and from North Cary Park hill (1)?

Impacts of Type and Quantity of Development

- What are the economic effects of development in the watershed (2), especially the Town Center Area Plan (1)?
- How is land use likely to change over time (3)?
- What are the current development regulations (1) and are they appropriate for preserving the quality of the watershed (5)?
- How appropriate are the Town of Cary Buffer Ordinances (3)?
- What are the impacts of development, specifically on wildlife (1) and trees (1)?
- How can road construction impact the watershed (1)?
- Are there ways to fill existing strip malls before building new ones (1)?

Potential Water Quality Solutions

- How do we compare with other watersheds in the Cary area (2), and with ideal urban watersheds (2)?
- Can we organize stream clean-ups (4)?
- Can we improve the vegetation around the stream (2)?

The health of our waters is the principal measure of how we live on the land.

-Luna Leopold

(Continued on page 5)

Public workshop participants share their interests, cont.

Public Education, Awareness, and Involvement

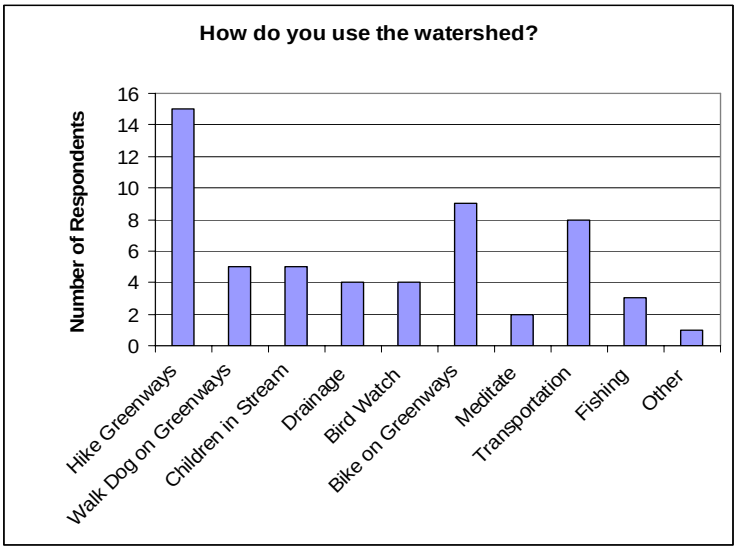
- How do we educate our children about water quality (3) and get them involved in community projects (2)?
- How do we educate property owners (1) about lawn and yard care (3), erosion (1), flooding (1), water quality/pollution (3), and taking actions (2)?
- How will this study's results be presented to the community (2), the Cary Town Council (1), the NC Department of Health (1), and the EPA (1)?

The results of the public workshop exercise have been reviewed by the project team, and will be shared with the Watershed Association for consideration in the watershed planning process.

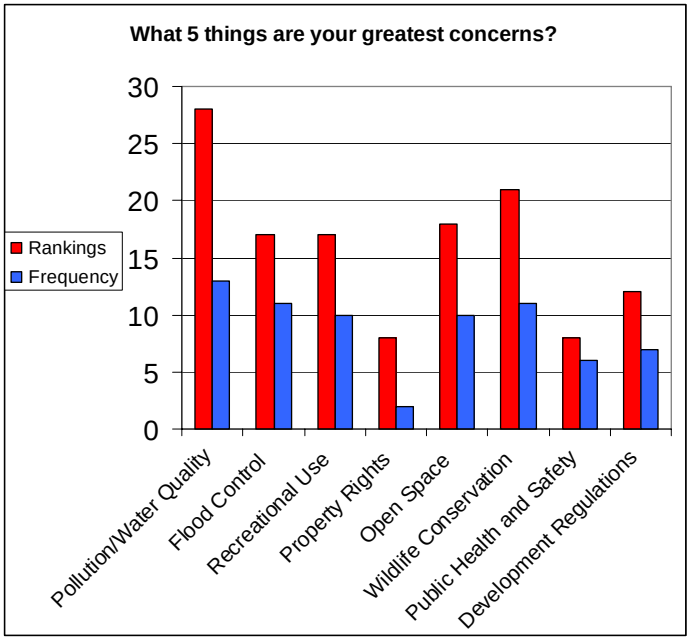
Public Workshop Survey Results

Attendees were asked to complete a preliminary survey to gauge their knowledge and interest. The nineteen completed surveys will help with project guidance. The majority of respondents lived in the watershed. Several salient points came out of this survey:

- Most people consider the greenway system the most visible feature of the watershed.
- Water quality is a major concern, but many think the watershed is healthy enough for all purposes short of ingesting the water.
- People expressed interest in the impacts of development, but it was not the primary concern for most respondents.



Survey respondents use the watershed for many reasons



- The community is interested in taking action, but would like to learn more about specific actions they can take.
- Landscaping practices could be a potential target for action. Most respondents indicated they used chemical treatments for their lawns; a few indicated they used best management practices for rainwater retention; and some expressed interest in learning about better landscaping options.
- Too few pet owners responded to make notable conclusions about how pet waste was handled by residents in the watershed.
- When asked where people got information on local environmental issues, the responses varied, but print information (from newspapers and Town of Cary mailings) was the most common response.

The complete results from the survey are on the project website, titled "March 2006 Public Workshop Survey".

News from Black Creek Watershed, Cary, NC

Watershed Education for Communities and Officials
Dept. Agricultural and Resource Economics, NCSU
Campus Box 8109
Raleigh, NC 27695-8109

Phone: 919-515-4542
Fax: 919-515-1824
E-mail: Christy_perrin@ncsu.edu
Patrick_beggs@ncsu.edu
www.ces.ncsu.edu/WECO

Silverton HOA jumps into Black Creek effort!

Liz Adams of the Silverton Homeowners Association, while waiting for the Black Creek watershed association to get started, took matters into her own hands and organized a successful Earth Day picnic in April for her community at the North Cary Park in the Black Creek watershed. Several families from the Silverton community enjoyed a cook-out and participated in different environmental– themed stations, including recycling activities, skin-savvy sun health, and examining aquatic critters from Black Creek.

Thanks to Rachel Golden, NC Office of Environmental Education, for providing educational materials about aquatic animals, and for helping Christy catch and display animals from Black Creek (which were returned to the creek unharmed, of course!).

The pictures show watershed residents participating in Silverton Earth Day picnic activities.

(pictures provided by Jeff Cox)

THE BLACK CREEK WATERSHED WIRE

News from Black Creek Watershed, Cary, NC April 2007

Visit the project website at www.ncsu.edu/WECO/blackcreek

Black Creek Meeting Highlights

The Black Creek Watershed Association (BCWA) met on March 26 at Page-Walker Cultural Arts center. Thanks to Matt Flynn for securing the location.

The BCWA heard an entertaining presentation by Barbara Doll, NCSU Stream Restoration Institute, Dept. Biological and Agricultural Engineering. Barbara explained how streams function when healthy and impaired, and showed an example of an urban stream restoration project at NCSU. Participants then planned details of the Black Creek Stream Walk to be held on April 21.

The next BCWA meeting is scheduled for May 21 at Bond Park Community Center. During a recent meeting discussion about the proposed swim facility, the BCWA requested information on low-impact development (LID). We present a program on this innovative way to reduce development's impact on water resources at the May BCWA meeting.

We'll hear an overview of what we mean by LID from Laura Szpir, NCSU Water Quality Group, who is leading the development of an NC LID manual. Lee-Anne Milburne, NCSU College of Design, will discuss recommendations for assessing and designing sites for lower impacts. We will also hear from Scott Ramage and Anna Redlin, Town of Cary Planning Dept., about the Town's current LID efforts.

Finally, we are happy to provide extra copies of this newsletter or any past newsletters for you to give to other members of your community or the organization that you represent– just let us know!

Black Creek Stream Walk date: Earth Day weekend!

Are you looking for a way to give back on Earth Day? NCSU Dept. Forestry and Environmental Resources is hosting the first annual Black Creek Stream Walk is on Earth Day weekend– **Saturday, April 21**. Training will start at **9:00 a.m. at the Page Walker Cultural Arts Center at 119 Ambassador Loop**, and will move outside to a stream. Dr. Jim Gregory will lead the training session. Dr. Greg Jennings, NCSU Dept. Biological and Agricultural Engineering, will teach the classroom portion.

Participants will then partner-up to walk along Black Creek and it's tributaries, observing and recording indicators of stream health as they go. This will take 2-3 hours. They will have the option of conducting the stream walk Saturday afternoon or on their own (with their partner) in the week following.

Breakfast will be provided by Grace Lawrence, courtesy of Wake County Cooperative Extension. Lunch will be up to participants– either bring a bag lunch or pick something up on your way to your assigned creek section.

The data will help the technical team and BCWA determine the health of the creek. Please RSVP to Christy at 515-4542 if you would like to participate.

The Black Creek Watershed Association meets on the last Monday of the month, but will meet early in May due to Memorial Day.

Next meeting:

Monday, May 21

6:15-8:30 p.m.

(Social time 6:15-6:30)

LOCATION:

Bond Park , Oak Room at the Community Center

Agenda:

- Low-impact development and conservation site design presented by:
- Laura Szpir, NCSU Water Quality Group; and
- Lee-Anne Milburne, NCSU College of Design
- Anna Readling, Town of Cary Planning Dept. on a Town LID project

Inside this issue:

Introduction to Stream Morphology

Barbara Doll, NCSU Water Quality Group and Stream Restoration Institute, provided an introduction to stream morphology, or stream structure and function. Barbara's powerpoint presentation is posted on the project website in PDF format. Some highlights are included here.

When water flows downhill it creates channels that are influenced by water, sediment and slope. It helps to look at a stream channel 3-dimensionally, by dimension, pattern and profile.

1) Dimension concepts include

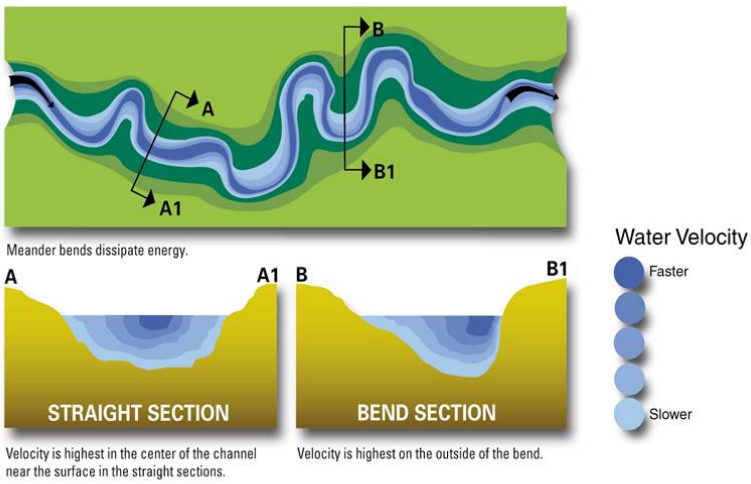
- *Baseflow– how much water is in it daily, which is important for fish and insect habitat*
- *Bankfull flow – channel is full but not overflowing its banks. This is when the most energy is transported - this storm event occurs every 1- 1.5 years. The March 15 rain event was a bankfull event for nearby Swift Creek.*
- *Over Bank flow– when the channel floods its banks, dissipating water and energy out into the floodplain*

2) Channel pattern describes

- *Meanders– these bends in a channel dissipate energy*
- *Straight sections*
- *Water, sediment, and slope influence channel pattern.*

3) Channel profile includes

- Average slope
- Riffles- sections of a stream with fast-moving, turbulent, shallow water with a rocky bottom; important macroinvertebrate habitat
- Pools- sections of a stream with slow-moving, deep water; important fish habitat. In natural streams, pools and riffles alternate.



Channel Pattern

Stream vary greatly in these 3 dimensions. Barbara showed pictures of various streams.

Streams move sediment and energy in addition to water. When you change the parameters, a stream can be thrown out of balance. Instability in streams is visible across the state.

Problems with instable streams include:

- Water quality degradation
- Habitat loss
- Floodplain function degradation
- Land degradation

Causes of instability include:

- Increased runoff
- Increased slope
- Changed sediment load (from development, agriculture, bank erosion, or impoundments)
- Loss of riparian buffer
- Instream modification

Land use changes can lead to:

- More stormwater runoff
- Stormdrain networks, which increase stormwater velocity
- Increased turbidity– a measurement of suspended sediment particles (total suspended solids, or TSS)

Sedimentation discussion: Participants discussed sedimentation problems. Since clay takes a long time to settle out, and current technology can only remove larger particles at reasonable costs, NC requires 80% TSS removal. Adequate erosion and sedimentation control at construction sites is a concern of some participants who have seen clay-colored waters run into Black Creek from sites. The Town of Cary has their own local S&E program– staff inspects sites and responds to concerns. If accumulated sediment washing off a construction site is seen, citizens should call the town. Note that cloudy/discolored water in the stream could have a number of sources.

(Continued on page 3)

Introduction to Stream Morphology

(Continued from page 2)

Editor's note– The Town is very responsive to citizen concerns about erosion & sediment problems. Citizens should call Tom Horstman at 469-4347 if concerned.

Increased stormwater runoff can cause *incision– cutting down into the channel, which is also called a head cut. Head cuts* can be caused by high flow from land use change, increased impervious surfaces or extreme storm events such as hurricanes.

When the incision reaches bedrock, the stream will start to widen, until at some point it reaches a quasi-equilibrium.

What is traditionally done when streams start widening? (and people start losing property as it falls into the stream) Usually solid materials like rip rap, gabions (rip rap in wire cages), are used to stabilize banks and limit erosion.

Natural Channel Design Approach– is *a* newer and improved way to stabilize streams that allows maintains or improves natural functions. The approach can include:

- Adjusting stream channel size and shape
- Connecting the channel and floodplain
- Addingin-stream structures
- Stabilizing streambanks
- Enhancing riparian vegetation

The Rocky Branch Stream Restoration Project

Each stream improvement project will be unique based on the 3 dimension discussed already, and local concerns and goals. Barbara shared her experience leading the Rocky Branch Stream Restoration Project at NC State University. The Rocky Branch watershed contains NCSU and Hillsborough St., is 70% impervious, and had~30 stormwater pipes draining directly into the creek. The project provides an opportunity to determine how natural channel design can be applied in an urban area, and how natural functions of streams can be recovered.

The goals are to:

- Stabilize the creek
- Improve water quality and habitat
- Integrate the creek into the campus environment

Some highlights of this restoration project include:

- Restoration of over 3,300 linear feet of stream
- Stormwater best management practices to reduce runoff and pollutants entering the creek
- "Daylighting" formerly piped portions of the creek (digging up and removing pipe, and re-creating a natural channel)
- Public involvement in determining goals for the restoration
- Use of the project and creek in classroom activities and public education

See Barbara's presentation on our project website for more detail.

The pictures below show before and after shots of restoration on a reach of Rocky Branch at NC State University in Raleigh.

NC STATE UNIVERSITY

News from Black Creek Watershed, Cary, NC

Christy Perrin
Watershed Education for Communities and Officials
Dept. Agricultural and Resource Economics, NCSU
Campus Box 8109
Raleigh, NC 27695-8109

(Continued from page 3)

Questions and comments for Barbara:

A participant commented that most people want to see the creek and walk along it's edges, so there is a conflict between what is ecologically best and what people are used to seeing– this is an educational challenge.

Q: Black creek is bedrock– limited regarding how far down it could incise. Will Black Creek start to widen?

A: Once it hits bedrock, yes, and that can be a positive aspect. In an urban setting, it's best when a stream is low, as that eases some of construction costs if there is a restoration project.

Q: You mentioned that some of the causes of instability are natural, while some are the results of increased runoff. How do we interpret what is natural and what is not?

A: The watershed modeling that will occur as part of our assessment will help us interpret man-made impacts.

How does this information apply to Black Creek?

Participants commented on their observations about Black Creek:

- bank erosion and scouring
- depositional sediment bars
- bedrock outcrops where it can't erode
- has some riparian vegetation
- Green way constrains it on one side
- Greenway is only natural flood plain in area across from N. Cary Park
- Stream is incised
- Bank full events access the floodplain
- It is meandering, has not been channelized
- Some engineering is present
- Sewer line is part of constraint for how stream moves
- Sewer over-flow may contribute to pollution

March 26 Meeting Participants

Liz Adams, *Silverton HOA*
Patrick Beggs, *WECO; NCSU*
Heather Boyette, *NC Div. Water Quality*
Drew Cade, *Wake County Parks*
Nathan Cobb, *Beechtree*
Susan Davenport, *Beechtree, Cary PRCR*
Amin Davis, *Beechtree resident*
Nora Deamer, *NC Div. Water Quality*
Barbara Doll, *NCSU*
Matt Flynn, *Town of Cary*
Jim Gregory, *NCSU*
Amelia Hoyle, *Cary Academy*
Pat Hudson, *Cary Rotary*
Eric Kulz, *North Harrison Trace, DWQ*
Grace Lawrence, *Wake County Cooperative Extension*
Heidi Maloy, *Cary Academy*
Vickie Maxwell, *Wessex HOA*
Tamara Mittman, UNC-Chapel Hill
Bob Morris, *Silverton HOA, Cary Greenways Committee*
Christy Perrin, *WECO, NCSU; Windchase at Beechtree*
Gracie Randall, *Cary Academy*

Phone: 919-515-4542
christy_perrin@ncsu.edu
patrick_beggs@ncsu.edu
www.ces.ncsu.edu/WECO

DEPARTMENT of FORESTRY AND ENVIRONMENTAL RESOURCES
NC STATE UNIVERSITY

NC STATE UNIVERSITY A&T STATE UNIVERSITY COOPERATIVE EXTENSION
Helping People Put Knowledge to Work

THE BLACK CREEK WATERSHED WIRE

News from Black Creek Watershed, Cary, NC July 2008

Visit the project website at www.ncsu.edu/WECO/blackcreek

Black Creek Meeting Highlights

The Black Creek Watershed Association (BCWA) last met on May 19 at Page Walker Center Center, with a special session for orienting volunteers to a pollution inventory exercise on June 9.

In May, Shelby Gull Laird with the NCSU Tech Team discussed an upcoming pollution inventory, and asked for help determining how to divide up the watershed into small sub watersheds.

This discussion and a description of the pollution source inventory are summarized in this month's newsletter.

Please be aware that the next meeting is scheduled at a different place and date. To enable our technical team's participation, the meeting is scheduled for **Tuesday, August 5,** at **Page Walker Community Center** in downtown Cary. There is no July meeting. A meeting is also scheduled on Monday, Sept. 29.

The NCSU technical team will share more monitoring results and the land use analysis results.

If you are not yet on the Black Creek listerve but would like to be, send an email to: mj2@lists.ncsu.edu with the following in the body of the email: subscribe blackcreek J_DOE@ADDRESS.COM

While The Black Creek Watershed Association usually meets on the last Monday of the month, the next meeting is on a Tuesday:

Tues., August 5

6:30-8:30 p.m.

Page-Walker Arts & History Center

119 Ambassador Loop on Town Hall Campus. The campus is off North Academy Street, between Chapel Hill Road and Chatham Street in downtown Cary.

Agenda:

- Overview of new monitoring data & pollution inventory results
- Presentation of land use analysis information
- Discuss prioritizing areas for action based on results
- Discuss potential grant opp.

Second Annual Streamwalk Event

The Tech Team suggested conducting a stream walk/ pollution source inventory in the watershed to see if there were any potential sources that could explain some of the monitoring results they are seeing. This information will be fed into the geodatabase and help the group to determine priority areas for action, and to determine potential management strategies.

Questions still remain about possible sources of pollutants to the Black Creek watershed stream network. Are there unknown discharges from business, industry, or institutional sites where pollutants are being discharged to stormwater systems that should be discharged to a treatment system? Does frequent dumping of pollutants into the stream network occur? Examples include dumping of household trash, garbage, and yard refuse. Are there refuse collection points, fuel storage facilities, or pesticide storage facilities, etc. where improper storage results in discharge of pollutants to stormwater?

Answering these questions requires on-the-ground surveys by individuals who are familiar with an area within the watershed.

Dividing Black Creek Watershed into smaller areas

With feedback from the May 19 meeting attendees, Shelby delineated, or divided up, the watershed into 10 small areas. Initially, the purpose is to divide the watershed up into manageable areas for the pollution source inventory. Having smaller areas delineated also helps is to evaluate the smaller drainage areas more closely, to determine if

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Second Annual Streamwalk

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there are smaller drainage areas that should be prioritized for targeted management efforts. In restoring watersheds, working at smaller levels allows for the potential of more tangible improvements. A map on the opposite page shows the areas as outlined by Shelby. The areas are numbered 1-10 (BCWA members are welcome to suggest names for the areas!).

BCWA members volunteered to perform a pollution source inventory in one of these areas at the June 9 meeting and via the listserve/email. Maps of each of the areas were posted as PDFs on the website, along with the instructions and form to fill out.

The suggested methods are:

- Review the GIS map of the area and conduct a driving survey
- Draft list of potential pollutant sources/sites and examine the sites more thoroughly (stay on publicly accessible areas and be mindful of private property)
- Visit as many accessible sites along stream as feasible
- List and briefly describe potential point and non-point sources on the form
- Take digital pictures of sites/sources

Thanks to our volunteer surveyors: Liz Adams, Bianca Bradford, Susan Davenport, Bob Morris, Amin Davis, the Cobb Family, Vicki Maxwell. NCSU staff also surveyed 2 areas. A volunteer was not found for Area 5. After the results are received in July, they will be evaluated and compiled with the rest of the data the Tech Team has been collecting.

Discussion from meetings

In May participants discussed a few management ideas, including a potential **demonstration project** in a public place. The site would demonstrate a stormwater best management practice to show what types of retro-fit projects may need to be constructed throughout the watershed.

Town of Cary Illicit Discharge Detection

According to Charles Brown, The Town of Cary found approximately 10 illicit storm water discharges when doing their inventory of stormwater pipes (where they looked at outfalls, but not ditches). Illicit discharge detection involves quick screenings for pollution when flows from stormwater pipes continue more than 48 hours after a storm. Charles is now in charge of the illicit discharge detection program with the town and should be contacted if any are suspected.

Next Steps for Black Creek Watershed

The Tech Team is winding down on the data collection and analysis, and will be presenting the final data at the meetings in August and September.

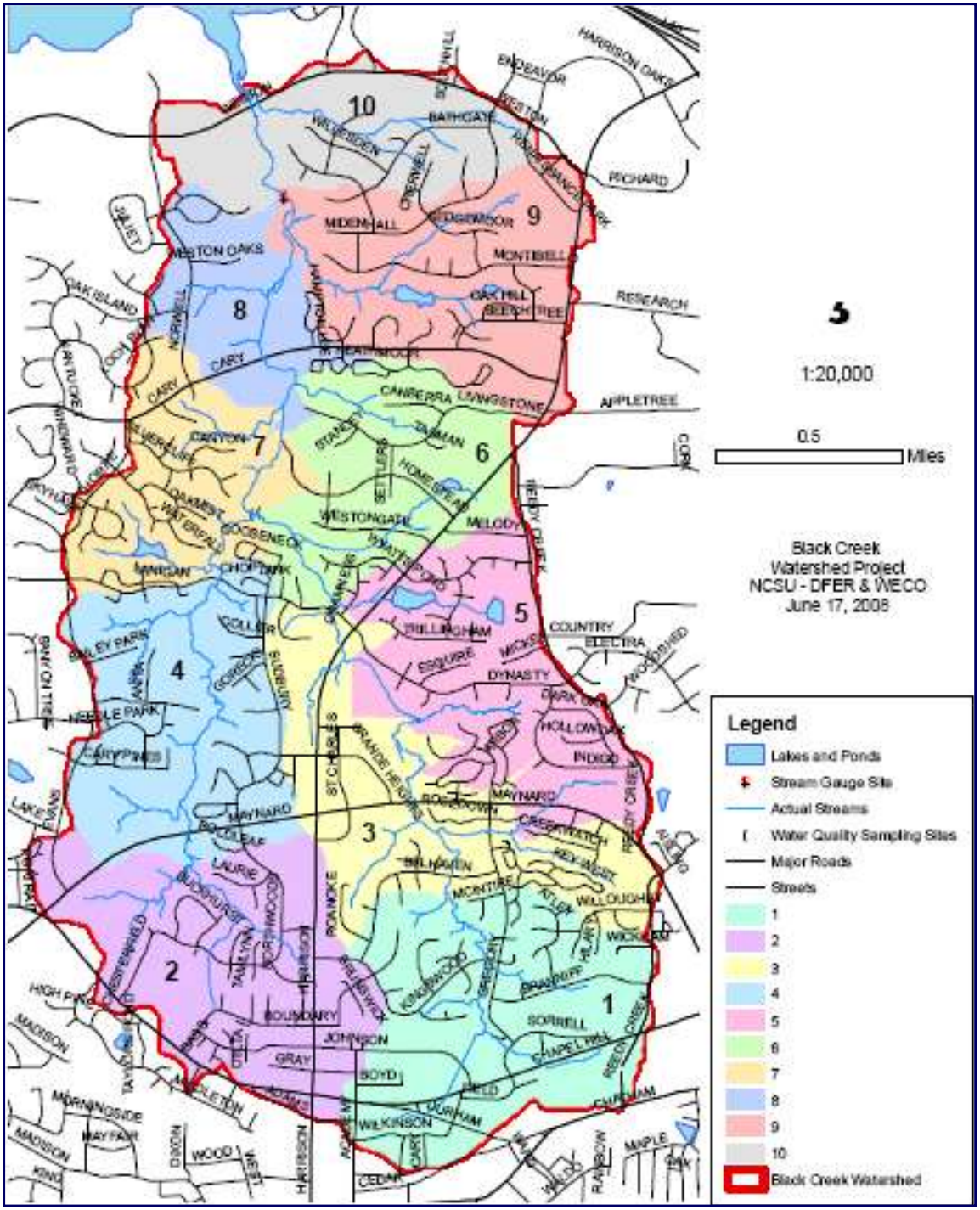
We will ask the BCWA to consider the results and discuss prioritizing potential areas for targeted management efforts, to help identify a demonstration site, to determine reasonable restoration goals for the watershed, and to start identifying specific management actions for achieving those goals.

Regarding potential funding for management strategies, the NC Clean Water Management Trust Fund recently announced a new funding source for stormwater management. We recommend submitting a proposal for this source, and are discussing options with NCSU's Dept. of Biological and Agricultural Engineering to involve them in implementing a management strategy and studying stormwater management efforts. The request for proposals follows. Note the October deadline for proposals:

Request for Proposals for CWMTF Innovative Stormwater Management Technologies

The N.C. Clean Water Management Trust Fund has released a Request for Proposals to fund projects that employ innovative stormwater management technologies, applications, strategies or approaches which are designed to protect and improve water quality in North Carolina. The RFP is available at: http://www.cwmtf.net/stormwaterrfp.doc Deadline for submittal is Oct. 15, 2008. For additional information or answers to questions, contact Kevin Boyer, CWMTF's Project Manager for Restoration and Stormwater Projects.

Black Creek Watershed Areas



NC STATE UNIVERSITY

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Christy Perrin
Watershed Education for Communities and Officials
Dept. Agricultural and Resource Economics, NCSU
Campus Box 8109
Raleigh, NC 27695-8109

Black Creek Public Art Project

Cary Visual Art, Inc. announced that artist Brad Spencer of Reidsville, NC was selected for the Black Creek Greenway Public Art Project. The project will feature art on three locations near the intersection of NW Maynard and Chapel Hill Roads. The primary site is on an easement directly behind and partially bisecting a circular area approximately 30' in diameter at the corner of the intersection. The other two sections are a pedestrian tunnel and a pedestrian bridge, both of which will be located along the nearby Black Creek Greenway Path. As possible art forms, CVA's Black Creek Greenway Committee has recommended the use of a low relief art form, which may take form as seating areas, carved brick, or paving patterns. The project will be funded by Cary Visual Art and the Town of Cary. For questions regarding the Black Creek Greenway Public Art Project, call Michelle Normand at 531-2821..

A tributary in area 9 is swollen with rain and full of sediment after a heavy March rain

Other Updates

PCB Issue

Marilyn reported that PCBs were found in fish living in the Neuse River downstream from Crabtree Creek. The EPA had not yet made a Record of Decision about management actions for Lake Crabtree and Crabtree Creek as of the May meeting.

Falls Lake

Marilyn and Bill also reported that the Falls Lake 319 grant is getting underway. They are putting together a monitoring plan.

Aquatic Center

The only update Susan had to provide in May was that the YMCA may be interested in partnering on this project.

Logo Contest

Christy received a number of entries, including those from an entire 5th grade class. Most of the entries in general were from middle school students. Waterfest was cancelled, so the appreciation event will have to occur some other time. A design student or professional may be hired to "spruce up" a logo, since the logos, while very creative and artistic, were not necessary formatted or designed for use as a logo. BCWA members will need to discuss how they want to recognize logo contest participants.

May 19 Meeting Participants

Patrick Beggs, *WECO; NCSU*
Charles Brown, *Town of Cary*
Susan Davenport, *Beechtree, Cary PRCR Advisory Board*
Amin Davis, *Beechtree resident*
Bill Dupont, *North Raleigh resident*
Marilyn Grolitzer, *North Raleigh*
Shelby Gull Laird, NCSU
Grace Lawrence, *Wake County Cooperative Extension*
Vickie Maxwell, *Wessex HOA*
Bob Morris, *Silverton; Cary Greenway Committee*
Christy Perrin, *WECO, NCSU; Windchase*

Phone: 919-515-4542
Fax: 919-515-1824
E-mail: Christy_perrin@ncsu.edu
Patrick_beggs@ncsu.edu

WATERSHED EDUCATION FOR COMMUNITIES AND LOCAL OFFICIALS

NC STATE UNIVERSITY A&T STATE UNIVERSITY COOPERATIVE EXTENSION
Helping People Put Knowledge to Work

DEPARTMENT of FORESTRY AND ENVIRONMENTAL RESOURCES
NC STATE UNIVERSITY

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February 2009

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Black Creek Highlights Oct. '08- Jan '09

Happy New Year, Black Creek Fans! We have exciting news as lots has been happening since our last meetings in 2008! We have new watershed babies, a new proposal under consideration, new educational materials, and a new funding source for 2009!

Read on to learn more details, and come to our next meeting on March 30 to review and discuss the draft watershed management plan, and help plan for spring activities, including the first Springtime Big Sweep for Black Creek.

The Black Creek Watershed Association (BCWA) met on Oct. 27 at Town Hall and Dec. 8 at Bond Park. Thanks to Charles Brown for securing the locations.

The next BCWA meeting is scheduled for Monday, March 30 at Bond Park Community Center.

The Black Creek Watershed Association typically meets on the last Monday of the month as needed- there is no February Meeting.

Next meeting:

Monday, March 30

6:15-8:30 p.m.

(Social time 6:15-6:30)

LOCATION:

Bond Park Community Center

Agenda:

- Review and discuss draft Watershed Plan
- Plan community events for Spring
- Discuss CWMTF Grant

Watershed Management Plan Update

Goals, Objectives, and Strategies

We define *goals* as the desired medium - long term outcomes. For example, one goal for the watershed plan is:
Provide clean water for safe physical contact with creek

We define objectives as specific measureable impacts. For example, an objective in the plan is:
Reduce fecal coliform bacteria levels in stream to <200 CFU

A strategy to help meet the objective of reducing fecal coliform bacteria is:
Install pet waste stations at entrances to the Black Creek Greenway

A matrix containing potential goals, objectives, and strategies was built based on results from the watershed assessment and feedback from the BCWA over the last 2 years. This matrix has been circulated on the listserve, and handed out at the last 2 meetings for review and discussion.

BCWA members amended the goals and objectives, and added potential strategies. Some members provided feedback via email when they were not able to attend meetings. These changes have been incorporated. The most recent draft of the matrix is posted on the website for public review.

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Inside this issue:

Published by Watershed Education for Communities and Officials (WECO), a program of NC Cooperative Extension

Watershed Management Plan Update

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Evaluating potential impact of strategies

At the December meeting, participants considered the connections between the proposed strategies and the goals the plan seeks to achieve. The Goals were placed on one side of a large piece of paper posted on a wall, and juxtaposed across from the main strategies under consideration. The exercise promoted discussion about the potential impacts of the strategies. Lines were drawn between each strategy and its respective goals. The number of connections were then tallied to determine potential impact.

Strategies that were perceived to have the broadest range of impact across goals scored higher. The scores were as follows:

7 Continue/expand litter removal
6 Protect natural areas adjacent to greenway
5 Design/create BMPs in public spaces as demos
5 Increase forest canopy in developments adjacent to greenway
4 Remove exotic & invasive plants
4 Hold community workshops to educate about BMPs
4 Install pet waste stations
4 Install many residential/HOA BMPs
4 Create view spots of natural areas
3 Present Education & watershed plan to TOC Boards & Council
3 Citizens learn to recognize & report erosion control failure
3 Maintain forest canopy over greenway
2 Educate HOAs & community groups though presentations

Photos of the exercise will be added to the website.

Discussion about moving forward

Source of phthalates?

Participants at the October meeting pondered the source of phthalates found in Black Creek water quality samples. Phthalates are used in beauty products (fragrances) and as plasticizers. Shelby commented that quality control of sampling is important (could plastic sample bottles leach into the samples?).

They reviewed the dates of the Town of Cary's illicit discharge survey of the watershed, since illicit discharges that were found were immediately rectified. The date the phthalates were reported by the Tech Team was November '07, while the Town survey was conducted between Dec. '06- Feb. '07. Participants hypothesized that If the samples were taken after Feb '07, the sources were likely not removed.

Identifying sites: The group discussed how to involve citizens to identify specific stormwater retro-fit sites. With the map resources we have, we should be able to show citizens where to look (where stormwater pipes end, or on the land uphill of concentrated stormwater flow).

Support for implementation: Participants suggested partnering with the development community, such as Crosland Homes, to seek matching for projects. They also wondered if letters of support from Homeowners associations would help with grants.

Town of Cary Citizen Advisory Groups

Vicki explained how the new Town of Cary Citizen Issue Advisory Group process works. The purpose of the process is to help citizens bring an issue before the Town Council. Citizens form a group, then have 60-90 days to research and discuss their issue. They formulate their recommendations and are allowed 15 minutes to speak to the Town Council. The request has to benefit the Town and its citizens. The BCWA discussed the possibility of bringing the finished watershed plan to Council through this method. A potential request is for matching funds for implementation.

Watershed Assessment Report

The Tech Team is finishing their report of results. The draft report will be provided for review in advance of the March meeting.

Funding Black Creek Watershed Improvements

NC Clean Water Management Trust Fund

WECO staff just received notice that the NC Clean Water Management Trust Fund (CWMTF) has decided to partially fund the Black Creek Innovative Stormwater Grant proposal. This is just one of the proposals we worke don together at a meeting. The CWMTF Board chose to remove the portion of the grant that funds large retro-fit BMPs on public property. They suggested approaching them at a future date with specific locations and completed BMP designs.

The funded part of the proposal includes:

- a survey of watershed residents to learn their views about Black Creek in general and how to fund restoration and stormwater retrofits,
- conducting homeowner disconnect campaign, and
- implementing backyard BMPs.

The total amount of the grant will be $122,000.

Environmental Protection Agency (EPA) 319 Grant

A grant proposal (for EPA Section 319 funds for stomrwater runoff) was submitted to the NC Division of Water Quality in January. The grant includes public and residential BMPs, a salamander study to better quantify a baseline for these critters, and hydrologic modeling to follow where the watershed assessment left off. This seeks to better quantify potential improvements that can be made by implementing practices throughout the watershed.

If chosen for the first round, partners will be invited to interview for the grant in May.

Student Logo Winners Honored at Reception

BCWA held a reception on December 8 to thank participants of the student logo contest. The BCWA honored Lizzy Seaquist (below) winner of the high school category of the logo contest, and Cindy Chen (right) winner of the middle school category. They were presented with certificates of appreciation and giftcards to Café Carolina. The logo contest and educational materials developed were funded by a grant from the Cary Community Foundation.

A slideshow of all student logo entries is posted on our website. Special thanks to everyone who participated!

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Welcome watershed babies!

Congratulations to Elena Horvath and her husband on the birth of their second daughter, Addie!

Congratulations to Shelby Gull Laird and her husband Malcom on the birth of Patricia, their first child!

A Springtime Big Sweep for Black Creek?

Based on the high level of interest in keeping Black Creek clean, we propose adding a springtime Big Sweep for Black Creek. Winter storm events have washed more trash into the creek. This will be discussed via email to see if there is interest in rounding up volunteers for a springtime event. If you or your community group is interested in participating, please contact Christy.

Fate of the stream gauge

The stream gauge has been taken offline, as the equipment needs repair, and support for maintaining the equipment and collecting/analyzing data has not been identified yet.

Watershed Swag

Thanks to the grant from the Cary Community Foundation, of the NC Community Foundation, the BCWA has a new logo, and this logo has been printed on stickers and reusable cloth grocery bags. The bags also carry the slogan:

Less Rain Down the Drain!

When folks attendsthe Oscars they get a bag of swag - come to the next BCWA Meeting to get your swag!
With these materials and a new CWMTF grant, we are poised to start a disconnect campaign.

October Meeting Participants

Patrick Beggs, *WECO; NCSU*
Charles Brown, *Town of Cary*
Susan Davenport, *Beechtree, Cary PRCR*
Amin Davis, *Beechtree resident*
Bill Dupont, *North Raleigh*
Marilyn Grolitzer, *North Raleigh*
Elena Horvath, *Silverton*
Shelby Gull-Laird, *NCSU*
Eric Kulz, *North Harrison Trace, DWQ*
Vickie Maxwell, *Wessex HOA*
Bob Morris, *Silverton HOA, Cary Greenways Committee*
Christy Perrin,*NCSU; Windchase*

December participants

Patrick Beggs, *NCSU*
Charles Brown, *Town of Cary*
Cindy Chen & familiy
Nathan Cobb, *Beechtree*
Susan Davenport, *Cary PRCR*
Bill Dupont, *North Raleigh*
Marilyn Grolitzer, *North Raleigh*
Pat Hudson, *Cary Rotary*
Vicki Maxwell, *Wessex HOA*
Heidi Maloy, *Cary Academy*
Bob Morris, *Silverton, Cary Greenways*
Christy Perrin,*NCSU; Windchase*
Lizzy Seaquist & family
Shirley Wasson

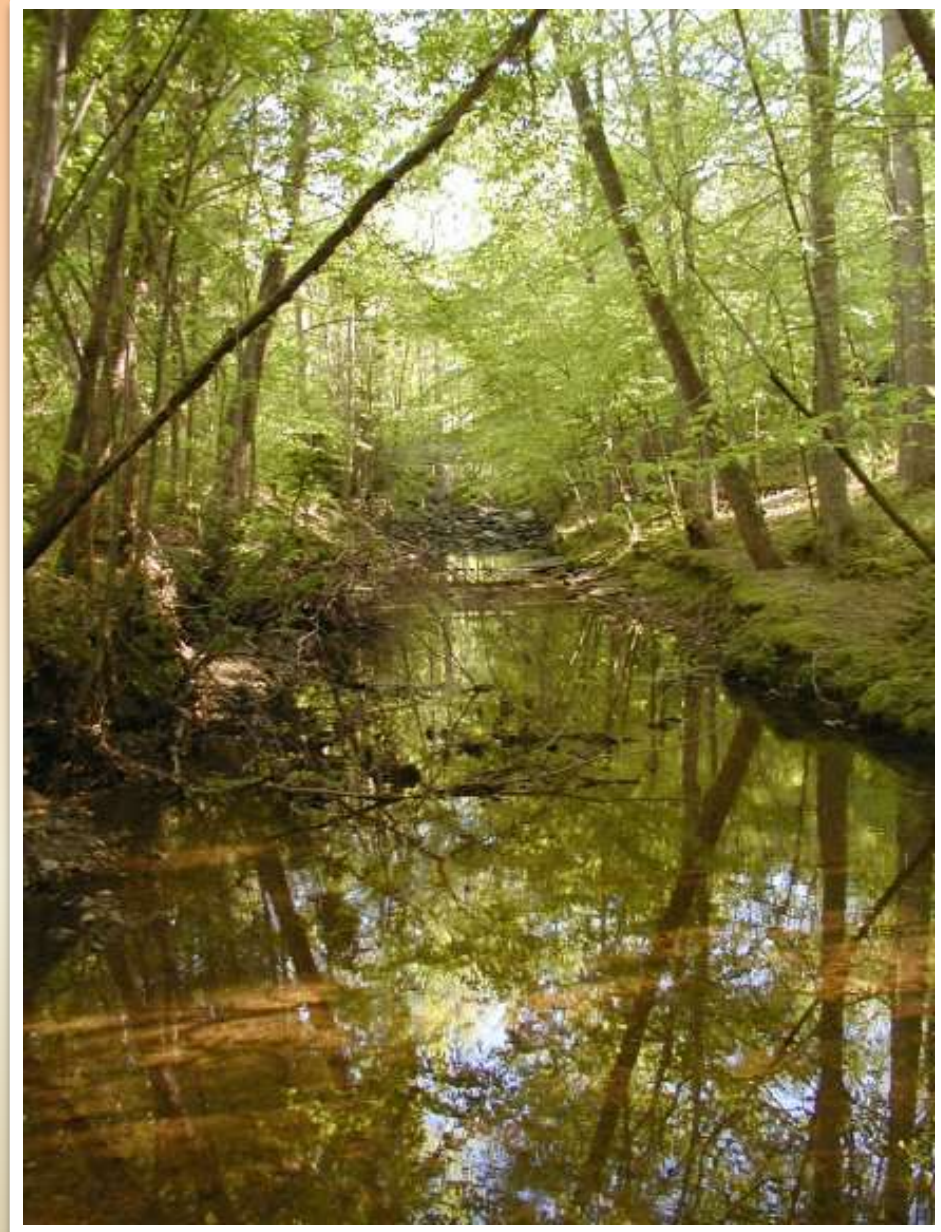
Phone: 919-515-4542
christy_perrin@ncsu.edu
patrick_beggs@ncsu.edu
www.ces.ncsu.edu/WECO

Appendix J:

Black Creek Watershed Association Photo Album

Black Creek Watershed Association Photo Album

2006-2009



Scenes from Black Creek watershed

Storm pictures: March 7, 2008

January 2009

Storm pictures: May 2009

BCWA at work


Mrs. Perrin,
All our best
to you!

Big Sweep for Black Creek, 2006-2009

2007 Stream Walk and Training

Monitoring the watershed