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APPENDICES

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1.0 INTRODUCTION

This Watershed Management Plan for the Cathey's Creek watershed is the product of a multi-phase study conducted for the Ecosystem Enhancement Program (EEP) of the North Carolina Department of Environment and Natural Resources. The Cathey's Creek watershed (Hydrologic Unit 03050105070020), within the Broad River Basin of North Carolina, is one of several watersheds across the state selected by EEP for a comprehensive planning effort to investigate sources of pollution and degradation in a local watershed (14-digit hydrologic unit) and to recommend comprehensive strategies for improving or maintaining water quality and other watershed functions. These local watershed plans also serve to identify potential stream and wetland restoration projects to help meet the future compensatory mitigation needs of the North Carolina Department of Transportation. It is EEP's hope and intention that the watershed management plans will be used by local stakeholders as a framework for linking EEP restoration projects with other watershed improvement projects initiated at the local level. In the Cathey's Creek watershed, the management plan was written in way that should provide guidance for local stakeholders such as county and municipal officials, natural resource professionals, and community leaders to identify the areas of greatest need, what types of projects are needed, who are the potential collaborators and funders, and where to obtain more detailed information and technical assistance for project implementation.

The following approach to local watershed planning includes new methods of watershed assessment that focus on ecological functions of the watershed. The phases of the planning process include characterizing the watershed, identifying types and locations of degraded ecological function, and developing a plan that provides specific solutions to the problems.

In collaboration with local stakeholders and resource professionals, EEP, Watershed Education for Communities and Officials (WECO), and Earth Tech have conducted a public meeting, several Technical Advisory Committee (TAC) meetings, a GIS analysis, and field sampling, resulting in two preliminary reports over the past two years. The TAC provided input at critical points during the watershed assessment process to ensure that watershed problems were accurately characterized and that issues under evaluation were important to the community. A detailed account of the stakeholder involvement process and TAC proceedings is included in **Appendix A**. Brief summaries of the purpose and findings of the reports leading up to this watershed management plan are given below, followed by specific management recommendations for four sub-watersheds.

1.1 Results of Initial Watershed Characterization

The *Initial Watershed Characterization and Sampling Plan* (Earth Tech, 2004) was a compilation of existing published data in Geographic Information Systems (GIS) and other databases regarding land use, water quality, ecosystem functions, current management measures, and existing restoration and protection needs. The current conditions and functional status of the watershed were evaluated and stressors were identified. The watershed evaluation included interviews with local stakeholders and resource agencies, visual observation of the watershed, and analysis of existing data. Sub-watersheds were identified and classified for future field studies and monitoring. Extensive field studies were not included in this phase of the watershed

evaluation. The full report was completed in February 2004 and may be viewed on WECO's website at the following address:

http://www.ces.ncsu.edu/depts/agecon/WECO/Catheys_Creek/techassess.html

This report addressed three main watershed functions -- Water Quality, Hydrology, and Habitat. The actual analysis was limited to data currently available in GIS or other databases. Indicators were developed for each of the functions and values were used to rank the sub-watersheds in terms of functional capacity. Examples of some function indicators used in the analysis include length of stream protected by a forested buffer (water quality), total area of wetlands (hydrology), and total area of forested land cover (habitat).

The Cathey's Creek watershed was delineated into 14 sub-watersheds (**Figure 1)** and a ranking system was developed to classify the sub-watersheds by functional status. The functional degradation concerns identified through this analysis were summarized as follows:

Water Quality

- Water quality monitoring results consistently indicative of stressed stream biota
- Urban runoff and sediment suspected to be causes of degradation
- Spindale Waste Water Treatment Plant (WWTP) discharge
- Possible mercury contamination from historic mining operations

Hydrology

- Historic mining and farming practices have altered stream morphology resulting in reduced ability to handle peak flows in a stable manner
- Straightened, entrenched streams seeking equilibrium are remeandering and causing in-channel erosion
- Increased impervious surface, loss of forest cover, and changes to soil permeability in upland areas have caused increased runoff volumes and peak flows
- Flood control lakes have altered sediment balance

Habitat

- Straightened and entrenched streams lack aquatic habitat variety
- Increased sediment load and sandy substrates create hostile environment for aquatic species
- Terrestrial habitat is threatened by deforestation and fragmentation
- Species richness is low and exotic species are common in terrestrial systems
- Flood control lakes appear to have a negative effect on downstream aquatic communities

The sub-watershed (SW) functional status classification results from the Initial Watershed Characterization were as follows:

- High - SWs 02, 03, and 10
- Moderately high - SWs 01, 05, and 06
- Moderately low - SWs 04, 07, 11, 12, and 14
- Low - SWs 08, 09, and 13.

Based upon these findings, a Sampling and Analysis Plan was developed to gather additional data through field sampling and GIS updates. This plan was incorporated into the Initial Watershed Characterization Report. Earth Tech conducted stream and landscape assessments during March 2004 and DWQ conducted water quality and biological sampling throughout the summer and fall of 2004 (NCDENR 2004a). The findings of these studies were described in the Critical Area Analysis Report.

1.2 Results of Critical Area Analysis

The Critical Area Analysis Report summarized the data and findings of the water quality and biological monitoring and field assessment activities in the Cathey's Creek watershed. The Critical Area Analysis was designed with the goal of further elucidating the causes of functional degradation in the watershed and determining the critical areas on which to focus for the future watershed management plan and restoration efforts. The report was completed in February 2005 and a summary may be viewed on WECO's website at the following address:

http://www.ces.ncsu.edu/depts/agecon/WECO/Catheys_Creek/Critical_Summary_Feb2005-1.pdf

The following objectives for the detailed field assessment were selected to address the watershed functional deficiencies and concerns identified through the GIS analysis:

- Assess the sources, severity, and causes of sedimentation and erosion
- Assess the causes and severity of habitat degradation
- Assess water quality degradation due to urban runoff
- Evaluate the Spindale WWTP discharge to determine its contribution to water quality degradation
- Assess potential mercury contamination from historic gold mining operations
- Identify the most critical areas for stream stabilization and restoration.

The data collected from this detailed assessment was used to refine the preliminary ranking that was based on the GIS analysis. Critical areas were identified where functional deficiencies were the greatest and where implementation of watershed improvements such as stream or wetland restoration and best management practices would have the greatest impact on water quality and watershed functions.

The data were analyzed on a sub-watershed basis as in the Initial Watershed Characterization, and a scoring and ranking system was developed to classify the sub-watersheds by functional status. The sub-watershed functional status classification results from the Critical Area Analysis were as follows:

- HIGH – SWs **02, 03**, 04, 05
- MODERATE - SWs **01, 06, 07, 12**
- LOW - SWs **08, 09**, 10, 11, **13,** 14

Sub-watersheds listed in bold font are those that retained the same functional status classification as they were assigned in the Initial Watershed Characterization.

The findings of this study confirmed that the Cathey's Creek watershed as a whole shows signs of moderate functional degradation in terms of water quality, hydrology, and habitat. All of the sub-watersheds offered some opportunity for better management of land and water resources, although the degradation was not particularly extreme in any one sub-watershed.

The assessment showed that sedimentation is a significant problem throughout the Cathey's Creek watershed. Fish monitoring results from Hollands and Catheys Creeks indicate that fish were more abundant and diverse at sites with better habitat (clean riffles, good pools, woody debris, and vegetated banks). A certain amount of sand in the system is not unexpected, given the typical geology and soil types of the area. However, the large amounts observed in this study demonstrate the sensitivity of the system to in-stream or landscape disturbances such as mining, agriculture, forestry, or urban development.

During the field assessment, it was noted that several large forested tracts in both the upper and lower ends of the watershed (SWs 01, 02, 11, 13, 14) have been cleared **(Exhibit 1**) since the 1998 aerial photography was obtained. Decreases in the amount of forested cover have the potential to significantly degrade water quality and other watershed functions even further by increasing the volume of stormwater runoff and sediment pollution, especially if the land use conversion results in increased impervious surface (*e.g.*, buildings, roads, parking lots). This was reflected in the scores of individual sampling points located downstream of these disturbances.

Exhibit 1. Forest clearing.

Exhibit 2. Kudzu on streambanks.

The study confirmed a degree of terrestrial habitat degradation as well. Plant species richness was observed to be low and invasive exotic species such as kudzu (*Pueraria lobata*) (**Exhibit 2**), Japanese honeysuckle (*Lonicera japonica*), mimosa (*Albizia julibrissin*), Japanese grass (*Microstegium vimineum*), multiflora rose (*Rosa multiflora*), and Chinese privet (*Ligustrum sinense*) are well established in the watershed. Forested habitat that is marginally suitable for two species listed as Threatened under the Endangered Species Act, dwarf-flowered heartleaf (*Hexastylis naniflora*) and/or small whorled pogonia *(Isotria medeoloides*), was found in small areas adjacent to 10 sampling points. White irisette (*Sisyrinchium dichotomum*), a Federal Species of Concern (FSC), was found along the

headwaters of Cathey's Creek in SW 02. The Diana fritillary butterfly (*Speyeria diana*) and the cerulean warbler (*Dendroica cerulea*), also FSC, are known to occur in the watershed. Some state watchlist species also have been identified, along with a Significant Natural Area along Cathey's Creek in SW 02.

Exhibit 3. Colored discharge.

Photo by Earth Tech

All five sites sampled for fecal coliform bacteria by the NC Division of Water Quality were above the NC water quality standard of 200 colonies/100ml as a geometric mean during baseflow conditions. Drainage from large pasture areas with livestock, faulty or vandalized sewer collection and septic systems, and straight piping were believed to contribute to these high fecal coliform levels. Also, a colored discharge and dead fish (**Exhibit 3**) were observed in Reynolds Creek by Earth Tech personnel, and several citizens have reported a colored discharge in Case Branch. Treatment plant personnel suggested that this occurs from time to time as a result of sewer system overflows or bypasses.

Sites within and downstream of Spindale were characterized by higher metals, nutrients, fecal coliform bacteria, and turbidity than the upstream rural comparison site on Cathey's Creek. Fecal coliform, turbidity, residue, total phosphorus, total Kjeldahl nitrogen, ammonia nitrogen, copper, zinc, manganese, iron, and aluminum levels were all higher in stormflow samples than in baseflow samples. Stormflow values for specific conductance, pH, sodium, and nitrate plus nitrite nitrogen were usually lower than baseflow values, reflecting a dilution effect of rainwater. Total phosphorus at baseflow was much higher at the lower Cathey's Creek site in SW 12 than at any other site. A possible source is the effluent from the Spindale wastewater treatment plant (WWTP). The plant is in compliance with regulations, but permitted phosphorus levels may still have an effect on biological communities.

Sediment samples were taken upstream and downstream of an historic gold mine and downstream of the Spindale WWTP. The highest overall levels of metals were found in sediment samples from a tributary draining the old Wolverine gold mine and from Cathey's Creek below this tributary in SW 07. However, the highest mercury levels were found at the downstream Cathey's Creek site in SW 12. The sources of mercury at this lower site may include not only historic gold mining, but urban sources and the Spindale WWTP. Mercury levels at this site approached values expected to cause biological impacts. Chromium and copper may be of concern in the vicinity of the gold mine.

In the Critical Area Analysis Report, the functional status of each sub-watershed was discussed and recommendations were provided for focusing management and restoration efforts. These recommendations were presented to the Technical Advisory Committee, which ultimately selected four sub-watersheds for further study. This discussion and the selection process are summarized later in Section 3.0.

2.0 STRATEGIES FOR FUNCTIONAL IMPROVEMENT AND STABILITY

Based on the findings of the preceding reports, strategies were developed for dealing with the sources of functional degradation of most concern in the watershed. In accordance with guidance provided by the Watershed Needs Assessment Team (NCDENR, *et al., 2003*), the *Watershed Management Plan* is directed toward restoring and maintaining three main watershed functions:

- **Water quality** - the ability of the water to support aquatic life and other designated uses, such as drinking water or recreation.
- **Stable hydrology** - the occurrence, distribution, and movement of water in a way that supports other watershed functions.
- **Habitat** - the physical, chemical, and biological characteristics necessary for an organism's viability.

A more detailed explanation of these watershed functions (derived from NCDENR *et al., 2003*), is provided in **Appendix B.**

Functional degradation comes about through a chain of events initiated by some change in land or stream corridor use or through some specific human activity. Resulting changes in hydraulics, morphology, or other factors precipitate changes in functions such as habitat, sediment transport, and storage. These functional degradations may result in numerous direct and indirect effects, such as changes in fish populations and changes in stream morphology that perpetuate erosion, down-cutting of the stream, and even lowering the water table. In short, watershed processes are highly interrelated and effects can reach far beyond the initial point or area of stress.

The goal of a watershed management plan, therefore, is to recommend specific watershed projects and management actions that achieve a balance in these interrelationships, thereby maintaining or improving key watershed functions. There are eight commonly employed strategies for **protection** and **maintenance** of watershed function. The first four strategies listed below are all strategies that fall under the purview of local, state, or federal agencies. Technical and funding support may be available for the implementation of these strategies. Possible sources of technical support and funding for these recommended watershed projects and management actions are presented in **Tables 8 and 9** in **Section 4.0** of this Plan.

- Riparian buffers
- Erosion and sediment control practices
- Stormwater management
- Regulation of non-stormwater discharges

The remaining four strategies are more suited to local initiatives, either private or governmental.

- Land use planning
- Land conservation
- Better site design and low-impact development practices
- Watershed stewardship programs

Restoration of watershed function may be accomplished by bioengineering and natural channel design techniques for stream and wetland restoration, which may be eligible for funding by the EEP and other state and federal agencies. Retrofitting existing sites with stormwater controls and remediating or removing polluting discharges can be restorative also. **Appendix C** describes activities that can qualify as compensatory mitigation for environmental impacts and could be eligible for EEP funding. A separate document, the *Project Atlas* (Earth Tech, 2005b), lists and maps specific potential watershed restoration projects identified through this watershed assessment process. The *Project Atlas* is a companion document for technical use, and copies will be available at the offices of the Cooperative Extension Service and the Natural Resources Conservation Service.

The implementation of all or some of these strategies is vital to maintaining and/or restoring watershed health. Just as the watershed's functional processes are interrelated, so are the human activities required to maintain them. Multi-agency collaboration and stakeholder involvement in all phases of strategic implementation are also vital.

Sedimentation, point source pollution, stormwater, and historical mining have been identified as the primary factors affecting watershed functions in the Cathey's Creek watershed. The following sections discuss each of these functional degradation factors and describe the multi-disciplinary, collaborative practices and techniques proposed for improving function and stability in the watershed.

2.1 Sedimentation

Sedimentation in the stream channels was identified as a problem throughout the entire Cathey's Creek watershed, with the exception of the uppermost headwater reaches. The sediment appears to originate mainly from land clearing operations and eroding agricultural fields and streambanks.

Sediment originating from land being used for urban and residential development, agricultural fields, forestry, and mining is transported in rainwater runoff to streams. Once in streams, some of the sediment settles out of the water column to the stream bed or along streambanks. Excessive amounts of sediment on stream beds can cover woody debris or fill in the spaces between rocks and thereby destroy or degrade the in-stream habitat for aquatic insects and fish. This embedded stream condition was documented during biological monitoring by DWQ at all three sites sampled on Cathey's Creek (US 221 in SW 01, SR 1547/Old Ballpark Rd. in SW 13, and SR 1549/Rock Corner Rd. in SW 12) as well as numerous sites from the field sampling. See Figures 1 and 3 and Appendix B of the Critical Area Analysis Report (NCDENR, 2004b; Earth Tech, 2005a).

Sediment can also deposit in ponds and lakes such as those on Mill (SW 04) and Cherry (SW 06) Creeks, which reduces their storage capacity and adversely affects prime fish spawning areas. In addition, phosphorus, metals, pesticides and other pollutants are readily attached to sediment particles and therefore are transported with the sediment.

Sediment export from road building and development activities is regulated by the NC Sedimentation Pollution Control Act of 1973. The NC Division of Land Resources enforces the provisions of the Act across the state, except where local entities have been granted control. Neither Rutherfordton nor Rutherford County are included in the Delegated Local Programs that are responsible for their own sediment and erosion control regulations and enforcement (NCDENR. 2005b). While agricultural and forestry activities are exempt from this act, there are state and federal programs involving incentives for reducing sediment export from these land uses.

Because about 18% of the watershed land is used for agricultural production (both row crops and livestock), sediment originating from farmland is a primary concern. Many Best Management Practices (BMPs) have been developed to minimize the soil erosion and subsequent sedimentation resulting from various sources and land use practices, but only those most applicable for the Cathey's Creek watershed are listed below.

2.1.1 Agricultural BMPs-Row Crops

Row crop fields are dispersed throughout the Cathey's Creek watershed, with perhaps the greatest acreage located in the middle reaches of the watershed (SWs 05, 06, 07, 08, and 10). Several BMPs for controlling erosion from fields are listed below.

Contour farming involves orienting a field such that the crop rows are on the contour.

Conservation tillage (Exhibit 4) involves a range of practices that leave plant residues on or near the soil surface to reduce the erosive effects of rainfall and runoff.

Exhibit 4. Conservation Tillage

Strip cropping (Exhibit 5) is the practice of planting the side of a hill in relatively narrow strips along or near the contour so that the whole hillside is not tilled or cropped at one time, which insures that some of the soil is protected by vegetation.

Exhibit 5. Strip cropping.

Grassed waterways (**Exhibit 6**) are channels planted and maintained in close-growing grasses that safely convey concentrated flow off of a field. These waterways are usually constructed where runoff concentrates, such as swales or hollows.

Exhibit 6. Grassed waterway

Field borders are relatively narrow (on the order of 10-30 feet) strips of grass planted around downslope edges of the field to filter sediment and other pollutants out of the runoff before it leaves the field.

The effectiveness of each of these BMPs varies with site conditions; however, each has been shown to be effective at reducing erosion and sediment export when implemented appropriately. Some of these practices have the additional benefit of reducing nitrogen and phosphorus loss from cropland along with the sediment. Information and assistance in implementing the cropland BMPs is readily available from the local office of the NC Cooperative Extension Service, Natural Resources Conservation Service, or the Soil and Water Conservation District. See **Tables 8** and **9** in Section 4.0 for additional information.

2.1.2 Agricultural BMPs-Livestock

About half the agricultural land in the Cathey's Creek watershed appears to be pastures for livestock. These pastures are dispersed throughout the watershed, but the majority are located in SWs 05, 06, 07, 08, and 10. Severely eroding stream channels have been observed in most of the pastures visited. This indicates that sediment control measures for pastures must be considered a high priority for the watershed. Because pastures consist mostly of close-growing grasses, they are protected from erosion; however, trampling of streambanks, overgrazing, and heavy use around feeding area can reduce or eliminate the grass in areas. Minimizing sediment yield from these pastures involves maintaining vegetation and protecting waterways. Specific BMPs are listed below:

Livestock exclusion fencing (**Exhibit 7)** prevents continuous livestock access to streambank areas. The fencing needs to be a minimum of 15 feet from the streambank for effective filtering of nitrogen, phosphorus, and sediment (Osmond *et al*., 2002). Trampling of streambanks can impede plant growth and increase potential erosion.

Exhibit 7. Livestock exclusion fencing and stream crossing.

Riparian buffer revegetation can stabilize streambanks, filter sediment and remove pollutants from runoff, thereby improving water quality.

Pasture rotation allows time for revegetating livestock feeding areas that may have been denuded due to trampling.

Technical and financial assistance in implementing these BMPs on pastures can be obtained from the local Soil and Water Conservation District, NC Cooperative Extension, or USDA NRCS office. See **Tables 8** and **9** in Section 4.0.

Exclusion and revegetation is effective at reducing nitrogen, phosphorus, and fecal coliform bacteria inputs to streams. Since monitoring has documented relatively high fecal coliform bacteria levels in watershed streams, this reduction may be as significant as the sediment reductions. Another benefit of excluding livestock from streams is that of reducing the chance of

young animals being caught in the mire or standing water of a stream bottom or leg injuries from navigating steep stream banks. Along with the fencing, providing alternate sources of water and stable stream crossings are often necessary to make the pasture useable. The erosion problems associated with overgrazing (**Exhibit 8**) and heavy use areas can be addressed by dividing the pasture into sections and rotating the livestock from one area to another thereby maximizing the growth of grass and hence soil cover. Detailed design standards for the above mentioned BMPs can be found at the national NRCS website. See **Tables 8 and 9** in Section 4.0 for the website address and other information.

Exhibit 8. Overgrazing.

2.1.3 Forestry BMPS

Because more than 74% of the watershed is wooded, attention to minimizing sediment export from forest harvesting operations is recommended, especially since clearcutting was observed in several locations throughout the watershed. The relative infrequency of harvesting operations (15 or 30 year rotations for pine pulpwood or sawtimber, 60- to 80-year rotations for hardwood sawtimber) makes sediment export from this activity less of an immediate concern in terms of overall functional degradation factors, but when harvesting does occur it can be a significant source of sediment. The often large extent of the area affected can require an extensive network of roads and skid trails, which are the most significant source of sediment from clearing operations. There is the potential for large amounts of sediment from these sites to enter streams, especially when the Forest Practices Guidelines, as promulgated in 15A NCAC II.0100-.0209, are not followed.

Several common BMPs that help minimize sediment yield from forest harvesting operations are listed below. Details on these and other forestry BMPs can be obtained from the NC Division of Forest Resources (NCDFR) Best Management Practices Manual (NCDEHNR, 1989) and the NCDFR website. See **Table 8** in Section 4.0 for the website address. An updated BMP manual is expected to be published in late 2005.

Streamside management zones (**Exhibit 9)** leave or enhance a forested corridor along a stream channel so that it acts as a filter for sediment and nutrients released from upslope harvested areas. (**Exhibits 9 and 10** from NCDFR).

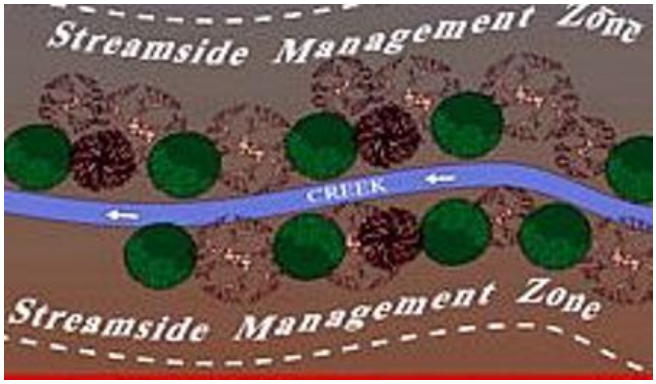
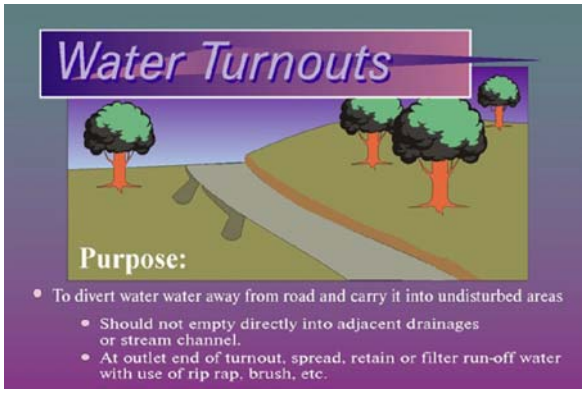


Exhibit 9. Streamside management zone.

Water bars or diversions, **turnouts, (Exhibit 10) and timely seeding of cuts and fills** control sediment yield from forest roads. See further explanation under roadway BMPs.



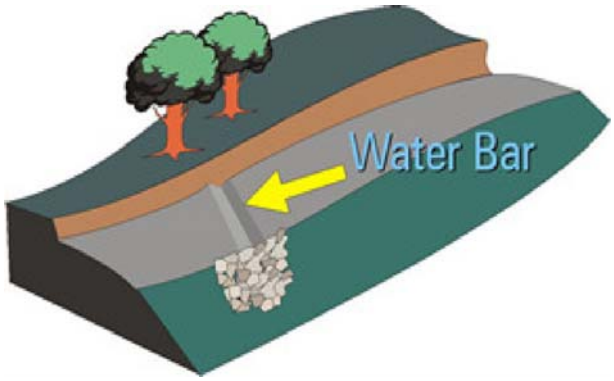


Exhibit 10. Water bars and turnouts

Stream crossing stabilization is accomplished by orienting the crossing perpendicular to the stream. The use of stone, erosion control fabric, or other materials further stabilize streambanks and bed at sites that are frequently crossed with heavy equipment.

Skid trail rotation is the practice of changing locations of skid trails to avoid rutting.

Removing the furthest timber first, using water bars on trails, establishing trails on the contour, avoiding wet weather logging, and reshaping and vegetating trails after use are other practices that, if used appropriately and extensively, can minimize sediment yield from silviculture operations. An established program, administered by the NCDFR, is in place to provide assistance to landowners in the use of and track the use of these BMPs. The NCDFR is responsible for enforcing the Forest Practice Guidelines, which are necessary to maintain the forestry exemption from state sediment and erosion control regulations.

2.1.4 Roadway BMPs

A large area of the Cathey's Creek watershed retains a rural to semi-rural character; as such, a number of unpaved roads, driveways, and roadside banks and ditches, particularly in SWs 01, 02, and 03, may be a significant source of sediment. Minimizing sediment yield from these sources may be accomplished by the following practices:

Water bars are primarily used on unimproved roads or driveways where travel speeds are slow. A raised berm is built across a road to divert water off the road surface to a roadside ditch. This prevents water from gathering velocity and concentrating as it runs down the surface causing gullying and erosion. See **Exhibit 10** above.

Turnouts are places where the roadside ditch is directed away from the road to keep runoff from building up in the roadside ditch. Minimizing the amount of water in the roadside ditch helps reduce the erosive energy of concentrated flow. See **Exhibit 10** above.

Crowned or graded cross-sections also direct road surfaces runoff to either or both sides of the road into a stable roadside ditch, thereby minimizing erosion of the road surface.

Stabilizing roadside ditches involves designing and vegetating or armoring the ditches to safely transport runoff water to another water body.

Diversions (Exhibit 11) are small channels cut along a slope to prevent water from flowing over a highly erodible area further downslope. Diversions can be installed upslope of steep roadside banks to keep water from flowing over and eroding them.

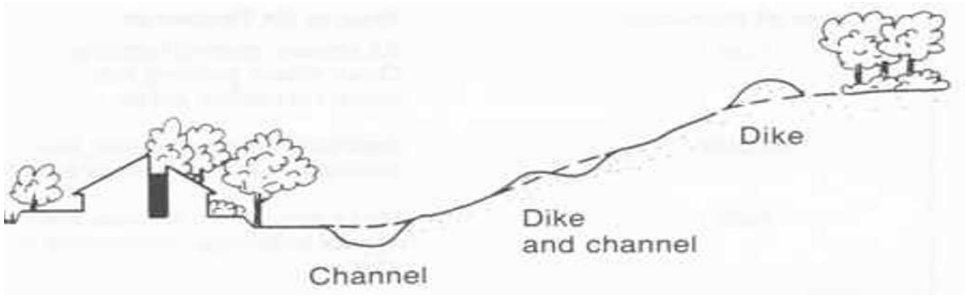


Exhibit 11. Permanent Diversion (NC Sedimentation Control Commission *et al.*, 1988)

2.1.5 Stream Restoration

Accelerated stream channel erosion was observed at many sites in the watershed as documented in the Critical Area Analysis report (Earth Tech, 2005a). Erosion scores from field sampling are discussed in Section 3.1 and narrative descriptions of individual site conditions are included in Section 3.6 of that report. In the upper reaches of the watershed, the erosion is mainly attributed to past channelization and cattle access. In the lower reaches, high-velocity flows from stormwater runoff are the likely cause. In addition to the livestock exclusion and riparian buffer revegetation already discussed, a variety of practices and techniques are available for controlling

erosion of stream channels. Techniques appropriate for streams in the Cathey's Creek watershed are listed below:

Restoring sinuosity (Exhibit 12) to streams that have been channelized slows the velocity of flow and can reduce scouring of the streambanks.

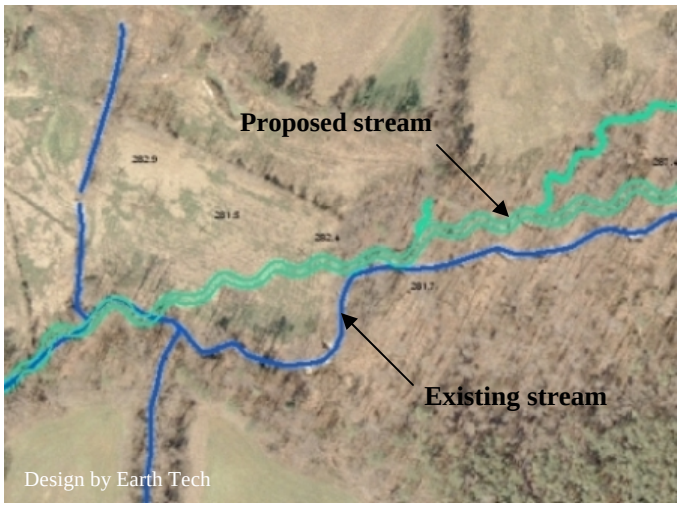


Exhibit 12. Conceptual stream restoration plan
(EEP Little Beaver Creek Restoration, Wake County, NC)

Rock cross-vanes, J-hooks, root wads, (**Exhibit 13**) or other structures direct the flow energy to stable parts of the stream channel. They may be required in streams that have been highly destabilized by channelization, surrounding development, or livestock access. These structures are often used in conjunction with restoring sinuosity and raising bed elevation. They have the added benefit of providing habitat for aquatic insects and certain fish species as well as providing an aesthetically pleasing appearance to the stream.

Exhibit 13. Root wad (left-EEP Cross Creek stream restoration, Fayetteville, NC) and Cross Vane (right-NCSU Rocky Branch stream restoration, Raleigh, NC)

Raising the bed elevation of streams that have been channelized allows the water to overflow the banks and access the floodplain in a more stable manner during rain events. This also reduces the velocity of flow, reduces scouring, and allows the deposition of sediment on the floodplain rather than retaining it within the channel.

Relocating the channel to its original position in the floodplain can provide greater floodplain access and more even distribution of overbank flows. Historically, streams were often relocated to follow the toe of a slope at the edge of the original floodplain. This is an unstable position and contributes to erosion.

2.2 Stormwater

Stormwater runoff (both the volume and associated pollutants) was identified as a problem mainly in the lower reaches of the Cathey's Creek watershed where concentrations of impervious surface are the highest (SWs 09, 13, 14). Residential neighborhoods, large industrial or institutional facilities, and commercial districts are the main sources of excess stormwater runoff and associated pollutants.

Developing forests and farms into urban and residential land creates areas of impervious surfaces that prevent precipitation from soaking into the ground. Consequently, this increases the amount of precipitation that runs over the land surface and becomes stormwater runoff. To convey the increased runoff quickly and safely to streams, stormwater systems with pipes, ditches, and channels are built. The combination of the increased amount and transport speed of stormwater creates short-term bursts of water to streams, which often results in accelerated erosion of the stream channels. The short-duration bursts of stormwater also cause stress on aquatic insects and fish by washing rocks, submerged logs, and other structures downstream. In addition to its physical effects, stormwater can also carry nitrogen, phosphorus, metals, and toxic organic pollutants washed from developed areas such as parking lots, industrial plants, roads, and residential subdivisions.

There are both federal and state programs, administered by the NC Division of Water Quality, that determine when stormwater controls are required by law (NCDENR, 2005a). See **Table 8** in Section 4.0 for additional information. The federal rules primarily apply to large industrial facilities and to municipalities of at least 50,000 people (40CFR 122.32). The state rules focus on new development and construction activities in sensitive watersheds. There are eight industrial facilities including the Broyhill Furniture and Four Leaf Textiles plants in the Cathey's Creek watershed that fall under the federal stormwater rules through the National Pollution Discharge Elimination System (NPDES). No municipalities in the Cathey's Creek watershed currently fall under the stormwater rules, although the rules are expected to be modified to eventually include smaller municipalities such as Rutherfordton and Spindale (NCDENR, 2005a).

The NPDES stormwater management program regulates point source discharges of stormwater from specific activities that have been identified as having significant pollution potential. Pollutants on impervious surfaces associated with the facility may wash off during significant rain events and reach surface waters through storm drains. The eight general stormwater permits that have been issued in the Cathey's Creek watershed include car lots and junk yards, an

equestrian facility, and large industrial complexes. The pollutants of concern associated with these facilities include gas and oil, fecal coliform, sediment, and toxic chemicals and metals. More detailed information about these permits is given in Table 12, Section 3.5.4 of the *Initial Watershed Characterization* report (Earth Tech, 2004).

All of the permitted stormwater discharges in the Cathey's Creek watershed are located in the lower half of the watershed (SWs 08-14) and are concentrated in the more urbanized sub-watersheds (09 and 13). In sub-watersheds where stormwater discharges are a concern, a review of NPDES permits, local ordinances, and inspection schedules would be the first course of action. If a pollution source is identified and regulatory action is not sufficient to promote compliance, a targeted program of education and incentives may be useful. Owners of facilities similar to the facilities of the offending discharger (*e.g.*, all gas station owners) could be identified through trade associations or other means and provided with information regarding the impacts of non-compliance, *e.g.*, fish kills, endangerment of human health, increased costs for additional inspections, or aesthetic concerns. Incentives may be offered such as certification and recognition programs or on-site technical assistance.

The following non-permitted sources of pollution are included under this discussion of stormwater pollutants because they are often exacerbated by rain events, but they may cause pollution independent of rain events. Some may originate from a defined, identifiable source, but are not considered regulated point sources under the current terminology and rules.

Leaky or clogged sanitary sewer pipes can be a significant source of pollution to streams. The leaking sewage often drains into storm drains and then to streams. This is not an uncommon occurrence in urban streams. Straight-piping of raw sewage from homesites was not specifically identified as a problem in the Cathey's Creek watershed, although grey water discharges (any water that has been used in the home, except water from toilets) to streams were observed in a couple of locations during this study. Prior to this study, the Concerned Citizens of Rutherford County were organizing to investigate straight-piping, although the area of concern is not known. Some of the colored discharges and fish kills observed in streams were attributed by municipal employees to clogs caused by individuals dumping items through manholes into the sewer lines, although illegal direct discharges generated by an unknown facility were not ruled out during field investigations. Educational material included as inserts in utility bills may serve to dispel common misconceptions about the structure and function of sewer lines, storm drains, and treatment facilities. Information about the hazards of straight-piping may also be disseminated in this way. Assistance such as free repair permits and low-interest loans and grants for installing or repairing residential septic systems may be explored if the problems are found to be widespread.

The prevention and regulation of stormwater discharges falls mainly under the purview of specific state regulatory agencies and local governments. Funds for implementation of educational or assistance programs similar to those described in the preceding paragraphs are unlikely to be funded by EEP, at least given current regulatory guidance regarding what constitutes mitigation for permitted impacts. State and federal grant monies have been obtained to support assistance programs in other watersheds where illicit point-source discharges threatened water quality. Grass-roots campaigns financed by grants or local benefactors may also be effective. See **Table 9** in Section 4.0 for information on funding programs.

Stormwater management BMPs are installed in urban and residential areas to control peak and cumulative runoff rates as well as sediment, nitrogen, phosphorus, metals, and other pollutant export from development. There are many stormwater BMPs and each must be designed to the specific site conditions for maximum effectiveness. Structural and preventive stormwater BMPs appropriate for use in the Cathey's Creek watershed are discussed below. Pollution from non-permitted or accidental discharges, such as residential straight-piping or vandalism to sewer lines, are more difficult to identify and prevent. They may best be handled through the state and local regulatory programs.

2.2.1 Structural Stormwater BMPs

Structural stormwater BMPs can be employed in a variety of developed areas, including urban areas with concentrated areas of rooftops and pavement, industrial or institutional facilities such as factories and schools, residential neighborhoods, and major roadways. Some BMPs are suitable in any of these settings, and may only vary in terms of scale or specific choice of plant materials. Details on the practices listed below may be found in a number of sources, including Arnold *et al.,* 1993; NCDENR, 1999; and Center for Watershed Protection, 2004. Additional sources may be found in **Table 8** of Section 4.0.

Wet retention/detention ponds (**Exhibit 14**) or basins are designed to retain a small permanent pool of water to enhance pollutant removal, while having the capacity to temporarily retain a much larger volume of runoff water that is released over several days. These ponds are used commonly for the treatment of large volumes of potentially polluted runoff associated with parking lots, gas stations, highway interchanges, and large buildings such as schools, factories, shopping centers, and hospitals.The most important function of these ponds is the retention and slow release of water, which helps to reduce peak runoff rates and subsequent downstream flooding and stream channel erosion. The retention of water also facilitates settling of sediment and associated pollutants in the pond, thereby treating the runoff.

Exhibit 14. Detention pond.

Bioretention areas (**Exhibit 15**) are designed to retain and treat a smaller volume of runoff than retention ponds; therefore, they usually treat runoff from a smaller area and are less effective at reducing peak runoff rates. Bioretention areas are commonly located on the lawns of commercial

facilities, along sidewalks and greenways, or in other locations where stormwater can be intercepted and aesthetics are important (Hunt and Moran 2004). Traffic and parking lot islands are excellent locations for retrofitting this technique. The typical bioretention area has a small depression on the surface where runoff ponds up to 9 inches before it flows over a yard inlet and into the storm drain system. Runoff water that does not leave via the overflow soaks through a surface mulch or vegetation and then through 2-4 feet of a sandy soil material, often imported or mixed on-site, to an underdrain before exiting back into the storm drain system. As water soaks through the soil, sediment and associated pollutants are filtered leaving treated water to reenter the storm drains. The vegetation in the bioretention areas can be an array of plants that tolerate extreme conditions and thus provide an aesthetically pleasing addition to urban areas.

Exhibit 15. Bioretention areas.

Rain garden is another name for small-scale bioretention areas used in residential areas. They can be easily constructed and maintained by the homeowner. Functions and benefits are the same as described above for larger facilities.

Level spreaders (Exhibit 16) divert the runoff from channels or storm drains and spread it out over a larger, vegetated area. They are commonly used where roadside ditches empty into streams or where concentrated flow comes off of a slope. The diversion can be as simple as a relatively small (<1 foot deep and <3 feet wide) channel constructed mostly on the contour in the existing soil with the end of the channel blocked. Stormwater runs into and fills the channel until the water spills over the downslope edge of the diversion in a thin uniform sheet. Although urban areas contain large amounts of impervious surface, there are often patches of vegetation left, especially along streams. Many of these areas can provide effective treatment of urban runoff. Spreading the water over a large area causes more water to soak into the soil where it can be used by the vegetation or percolate to the groundwater, thereby decreasing runoff volume and peak discharge. The level spreader-vegetated strip is generally not effective at peak runoff rate reductions for larger storms because there is limited storage of stormwater. Nitrogen and phosphorus in the runoff can be used by the vegetation which prevents it from entering nearby streams. The vegetation can be anything from weeds to ornamental plants as long as adequate ground cover is maintained to prevent erosion. Hence the practice is very effective at reducing nitrogen and phosphorus in stormwater if the rate and volume of runoff are relatively low.

Exhibit 16. Level spreaders at Umstead Park, Raleigh, NC (left) and Orange County, NC (right)

Constructed stormwater wetlands (**Exhibit 17**) are similar to wet retention ponds except they are much shallower (water depth 1-1.5 feet) and more heavily vegetated with wetland plants. Stormwater wetlands can be used in the same applications as the wet retention/detention ponds discussed previously. The shallow water depth limits the amount of retention of the wetland and hence its effectiveness at reducing peak runoff and runoff volume. Wetlands often have varying water depths throughout to facilitate treatment of stormwater via several different natural processes and the growth of an array of wetland plants. As stormwater flows through the treatment wetland, pollutant removal occurs through settling or sediment, adsorption to plants, and plant uptake. These wetlands can be very effective at reducing both peak runoff rates as well as nutrient levels, if properly designed. Additional benefits of wetlands include wildlife habitat and aesthetics depending on the wetland plants involved.

Exhibit 17. Stormwater wetland at Hillandale Golf Course, Durham, NC.

Rainwater collection systems, also called **cisterns** or **rainbarrels (Exhibit 18)** involve storing roof runoff in above- or underground storage structures and then releasing this water sometime after the rainfall event has ended. Large cisterns with pumps can be designed for large commercial or institutional buildings, either as a retrofit or for new construction. Rainbarrels are designed and sized for smaller buildings and residential use. The stored water can be used to irrigate grass or ornamental plants or dumped into the storm drain system. Reductions in peak and overall discharge volume depend on the capacity of the storage structures and how the stored water is released. For example, if the water is simply stored to the end of the rainstorm and then released into the storm drain system, peak flow will be reduced, but overall runoff volume will not. If the stored water is used for irrigation, reductions in nitrogen export can also be achieved, given that rainwater has been shown to contain an average of 1.0 mg/L of total nitrogen in studies from Wake County, NC (Line *et al*., 2002). Reductions in other pollutants such as metals that originate from roofs can also be significant. The NC Legislative Building was recently retrofitted with a cistern system to collect the 2.3 million gallons of rainwater that flows off the roof annually. About 80% of that volume will be captured. Some of the water will be used for irrigation, saving $2,500 annually in irrigation expenses, and the excess will be released to the storm sewer system.

Exhibit 18. Rain barrel

"Green" roofs (Exhibit 19) are vegetation-covered roofs that retain up to 60% of the water from a rain event. Green roofs can be installed on flat or sloping rooftops of residential and commercial buildings. Some structural reinforcement may be required depending on the size of the planted area and the original structure of the building. Green roofs consist of the usual layers of structural support, insulation, and waterproofing of conventional roofs, with additional layers for drainage, a planting medium, and the vegetation. They cost more than conventional roofs for the initial construction, but the plant coverings can extend the roof life by up to 100% by blocking damaging ultraviolet rays and can reduce heating and cooling costs by 25% annually. In addition to retaining stormwater runoff, the vegetation can also remove nitrogen from the water (Hunt and Moran 2004).

Over half of the streams in the watershed have a forested buffer greater than 30 feet wide along both sides of the stream. Several of the streams in cleared areas in the lower end of the sub-watershed lack adequate buffers and cattle have free access. Some streams also have been channelized or moved to the edge of the valley to increase the area of land available for building and agricultural use.

The bottom substrate material in streams sampled in this sub-watershed is mostly homogenous, either all bedrock, all cobble, or predominantly sand depending upon the location within the watershed and stream order. Many of the streams have sandy banks with low root densities and lack surface protection by vegetation.

A flood control lake is present in this watershed. During field work, Earth Tech observed an abundant population of bivalves just downstream of the dam, as well as heavy sand deposition.

Exotic species cover an average of approximately 16% of the riparian area at the sites that were sampled. No potential habitat for Threatened or Endangered species was observed.

There are no permitted discharges located in this sub-watershed. One DWQ benthic monitoring point is located in this sub-watershed on Mill Creek below the lake. In June 2003, the bioclassification was Fair, and results suggested the input of organic particulates from the lake (NCDENR, 2003).

3.1.1 Causes and sources of degradation

Sedimentation is the functional degradation factor of most concern in SW 01. Sources of sediment include unpaved roads and recently cleared land associated with logging operations, eroding streambanks caused by cattle access, and in-stream erosion caused by historically straightened streams that are remeandering.

While sediment yield from mature forests is relatively low, erosion and sediment export on land cleared during harvesting operations in mountain areas has been estimated to be considerable (**Table 1**). Most of the land that has been cleared for many years is in agricultural production with the dominant use being pastures for livestock. Sediment yield from pastures in the Piedmont region of NC has been documented to range considerably depending on the stocking density or degree of grazing (**Table 1**). Given the extent of the land uses and the potential erosions rates, efforts to control upland sources of sediment should be focused on livestock pastures and forestry operations.

Instream sources of sediment such as bed and bank erosion cannot be overlooked, as they may be greater than upland sources. Five stream channel observation sites documented bank erosion of varying severity. From the qualitative assessment, it can be surmised that there is moderate streambank erosion which indicates an average erosion rate of 150 tons/acre (SCS, 1977). Thus, stream channel erosion is potentially a significant source of sediment in the sub-watershed.

Table 1. Estimated Potential Sediment Export Rates for Various Land Uses.

Land Use	Export (ton/ac-yr)	Source
Forest		
Mature, undisturbed	0.1-0.4	Hill (1991)
Clear cut harvesting	2-32	SCS (1977)
Select harvesting	0.01-0.02	USEPA (1993)
Forest roads	6.8-33.7	USEPA (1993)
Pasture		
Light to moderate grazing	0.1-0.7	Line *et al*. (2002)
Heavy grazing	1.3-17	Line *et al*. (2000)
Cropland		
High residue	3-5	Mud Creek WRC (2003)
Low residue	5-20	Mud Creek WRC (2003)
Urban		
Construction	25	Line *et al*. (2002)
Completed	1-6	Line *et al*. (2002)
Highways		
Construction	2-21	Line, unpublished
Completed	0.1-1.0	Wu *et al*. (1998)
Unimproved roads/driveways	35	SCS (1977)
Streambank Erosion		
Slight	50	SCS (1977)
Moderate	150	SCS (1977)

3.1.2 Sub-watershed restoration goals

Goal: **Reduce the upland and instream sediment load to Mill Creek and its tributaries by 30**%. A minimum 30% reduction is needed in most watersheds to document a statistically significant change in nonpoint source sediment loads over time (Spooner *et al*., 1990). Goals are somewhat arbitrary, but the 30% reduction has been shown to be both attainable and significant in improving water quality. The real goal is to restore the streams to a healthy, balanced state that supports a diverse aquatic biota and sustainable human use.

Strategy:

- Employ sediment and erosion Best Management Practices (BMP) on all land clearing operations
- Plant forested buffers along cleared streambanks
- Install fencing to exclude cattle from streams
- Restore the natural morphology of altered streams where feasible

Implementing these strategies will result in the improvement of both aquatic and terrestrial habitat functions, hydrologic functions, and water quality functions. The specific management

measures recommended to achieve the sediment reduction goal are described below along with some suggested locations for implementation. Management measures described for SW 01 generally would apply also in SWs 04, 05, 06, 07, 10, 11, and 12. Cattle access, land clearing, and sedimentation are concerns in these sub-watersheds as well.

3.1.3 Management measures

General management techniques recommended for various sites in SW 01 are summarized in **Table 2** below. More detailed explanations are given in the following sections.

Table 2. Sub-watershed 01 Management Recommendations

Site	Proposed Techniques
a	Forestry BMPs, Harvesting Plan, Maintain wooded buffers on streams
b	Buffer restoration, Livestock exclusion, Stream restoration
c	Buffer restoration, Livestock exclusion, Stream restoration
d	Agricultural or Livestock BMPs
e	Agricultural or Livestock BMPs

Forestry BMPs

The upper third of the Mill Creek sub-watershed is dominated by forests; therefore, the focus of sediment control activities should be on timber harvesting and possibly unimproved roads and driveways. There are BMPs designed to reduce sediment export associated with forestry operations and an established program, administered by the NC Division of Forest Resources, to track compliance. Excellent sediment control on a forest harvesting site such as the clear cut area off Painters Gap Road about 0.7 mi. north of SR 1332 (**Site 01-a** on **Figures 3a and b** and **Figure 4** in *Project Atlas*), should have several components, including the following:

- **Develop a harvesting plan** that considers weather, soils, topography, surface waters, and access to trees.
- **Locate and design access roads to minimize erosion** by such practices as locating on the contour, crossing as few streams and dry washes as possible, and stabilizing places where crossing streams is unavoidable. Studies have shown that careful planning of access roads can reduce erosion by 50%.
- **Maintain streamside management zones** of at least 35 to 50 feet along Mill Creek and any perennial streams in the harvested area. The zones should be left undisturbed. Rip-rap and wash stone check dams should be placed across significant streams where the stream enters the management zone to help filter sediment from runoff.
- **Orient skidder trails on the contour** throughout the clear cut and retire them following use by installing water bar diversions or seeding to reestablish vegetation.

There are many other practices that should be implemented such as leaving tree debris scattered over the site, but the focus on roads and skidder trails has been shown to reduce the majority of sediment export from forest harvesting.

Stormwater BMPs

Uncontrolled runoff from the airport terminal and parking lots can erode stream channels and destroy aquatic habitat by the force of the water as well as carrying sediment and other pollutants to the streams (**Site 08-c** on **Figures 4a and b** and **Figure 30** in *Project Atlas*). From the aerial photograph, it appears that there is a large area (4.6 acres) of unbroken impervious surfaces around the main terminal building. Such a large area of impervious surface requires the use of a wet detention pond or a very large bioretention area to treat the runoff from the area (**Exhibit 20**). There is an area of undeveloped land to the south of the complex of buildings, which receives runoff from part of the complex that could be used to construct a stormwater detention pond. Effluent from the pond could be further treated by a bioretention area, a constructed wetland, or wooded or grassed buffer with a level spreader along the upslope edge. The pond and other BMP systems associated with the runway and new expansion facilities would provide control of stormwater flows and filter pollutants from the water. See **Table 5** for removal efficiencies of these BMPs.

Exhibit 20. Stormwater BMPs at airport.

Table 5. Pollutant Reduction Efficiencies and Costs of BMPs.

		Drainage Area	Pollutant Reductions			Construction Cost	Maintenance Cost (20 yrs.)
Site	**BMP**		**TSS**	**TN**	**TP**		
		acres	**%**	**%**	**%**		
1	Bioretention	4	77[2]	45[1]	71[1]	$45,900[1]	$5,250[1]
2	Bioretention	3	77[2]	45[1]	71[1]	$33,600[1]	$4,060[1]
3	Rainwater collection system	4	NA	NA	NA	NA	NA
4	Level spreader	4	82[2]	62[2]	48[2]	$8,000[2]	$1,000[2]
5	Wetland	10	61[1]	22[1]	33[1]	$11,740[1]	$6,403[1]

[1] Wossink and Hunt (2003).
[2] Unpublished data collected by Line (2005).

3.3 Sub-watershed 09

SW 09 includes the headwater reaches of Holland's Creek and some unnamed headwater tributaries. Fifty-three percent of the watershed area is cleared. The land uses are a mixture of residential, industrial, and institutional with a small amount of pasture and row crops. Approximately 19% of this cleared area is impervious surface. The remaining area consists of small patches of mixed deciduous forest, covering 47% of the total watershed area. Although located in the lower end of the Cathey's Creek watershed, the topography remains somewhat hilly in this sub-watershed. A small amount of recent land clearing was observed within this sub-watershed.

Close to three-quarters of the streams have forested buffer widths greater than 30 feet. A few short reaches through pasture, agricultural fields, industrial sites, and recently cleared land have no forested buffer at all. Some streams have been altered to accommodate agricultural activities or construction of buildings and roads. Livestock access to streams was not observed in this sub-watershed.

Most of the reaches are straightened systems dominated by runs and sandy bottoms. Bank failure was common at the sites sampled. This is restoring sinuosity to some extent but also causing in-stream erosion. There is also evidence of flash flow events.

There is one DWQ benthic monitoring site in the sub-watershed at Rock Road (SR 1520). The stream there is too small to assign a bioclassification according to DWQ protocols, but sampling results indicated a severely impacted benthic macroinvertebrate community, likely because of scour at high flows. There is one stormwater discharge permit issued within this sub-watershed for Broyhill Furniture Industries Incorporated and one wastewater permit discharge for Little Cubbard/Thomas Petro GW.

Exotic species cover an average of 58% of the buffer areas at the sampling sites. No potential habitat for Threatened or Endangered species was observed in this sub-watershed.

3.3.1 Causes and sources of degradation

Sedimentation and **stormwater runoff** are the functional degradation factors of most concern in SW 09. Sources of sediment include eroding streambanks caused by flashy storm flows, in-stream erosion caused by historically straightened streams that are remeandering, and upland erosion caused by stormwater runoff. The principal sources of stormwater runoff are three large facilities with significant impervious surface areas—the high school, the Broyhill Furniture Industries facility, and the Tanner Companies facility. A couple of residential neighborhoods also constitute a significant concentration of impervious roofs and streets that may contribute significantly to increased runoff and altered hydrological cycles.

Stormflow sampling at five sites within the Cathey's Creek watershed documented that Holland's Creek had the highest suspended sediment concentrations of the entire watershed (>400 mg/L). Stormflow sampling off Old Ball Park Road indicated elevated levels of several metals including copper, lead, and zinc. Given that much of the sub-watershed is either forested, pasture, or stabilized residential areas, a significant amount of the suspended sediment could be originating from channels formed by concentrated flow. These channels can be anything from the small feeder drainageways in pastures to the main stream channel of Holland's Creek itself. Sources of sediment along Holland's Creek itself were documented by the observation of bank failures at several sampling points as reported in previous documents. Some metals can originate from natural sources; however, most of the metals likely originate from commercial or residential areas.

The uppermost reach of Holland's Creek (sampling point 09-01) was observed to be relatively stable, while at the next several reaches (sampling points 09-02 and 09-03) undercut banks and bank failures were observed. This indicates the need for mitigating stormwater discharges between sites 09-01 and 09-02, because simply attempting to stabilize the stream channel without addressing the peak flows would be problematic. An unnamed tributary enters Holland's Creek between the two stations, which transports runoff from a High School campus. Thus, this campus with its considerable impervious area from the building and parking lots should be a focus of the mitigation effort. The added benefit of mitigation in the uppermost reaches of the sub-watershed is that the reductions in peak flow translate to all of the reaches downstream.

3.3.2 Sub-watershed restoration goals

Goals:

- **Reduce the sediment load to Holland's Creek by 50%**
- **Reduce stormwater runoff volume and peak flows from industrial/institutional facilities by 30%.**
- **Reduce nitrogen, phosphorus, and metals export from developed areas by 20-30%, so that metals concentrations are less than NC standard/action levels.**

Strategy:

- Retrofit the existing industrial/institutional facilities with stormwater BMPs
- Coordinate neighborhood efforts to employ residential stormwater BMPs such as rainwater collection to reduce stormwater volume and careful selection of landscaping material and appropriate fertilizer application to reduce nutrients.
- Employ sediment and erosion BMP's on all land clearing operations
- Plant forested buffers along cleared streambanks
- Restore the natural morphology of altered streams where feasible
- Install fencing to exclude cattle from streams if needed

Sediment reduction must be done in concert with reducing stormwater volume and peak flows to be successful. Implementing these strategies will result in the improvement of both aquatic and terrestrial habitat functions, hydrologic functions, and water quality functions. The specific management measures recommended to achieve the sediment and stormwater reduction goals are described below, along with some suggested locations for implementation.

3.3.3 Management Measures

General management techniques recommended for various sites in SW 09 are summarized in **Table 6** below. More detailed explanations are given in the following sections.

Table 6. Sub-watershed 09 Management Recommendations

Site	Proposed Techniques
a	Bioretention areas, Level spreaders, Rainwater collection, Constructed wetlands
b	Bioretention areas, Rainwater collection, Constructed wetlands, Wet detention ponds
c	Bioretention areas, Rainwater collection, Constructed wetlands, Buffer restoration
d	Livestock exclusion, Buffer restoration
e	Stream bank stabilization, Buffer restoration
f	Buffer restoration, Stream enhancement and bank stabilization, residential stormwater BMPs

Industrial/Institutional Stormwater BMPs

There are several industrial/institutional campuses in the sub-watershed including the High School (**Site 09-a** on **Figures 5a and b** and **Figure 32** in *Project Atlas*), the Broyhill Manufacturing plant (**Site 09-b** on **Figures 5a and b** and **Figure 33** in *Project Atlas***)**, and the Tanner Companies facility (**Site 09-c** on **Figures 5a and b**). The High School complex will be used to illustrate the use of BMPs to control stormwater runoff from these sites (**Exhibit 21)**. The High School campus encompasses about 48 acres with parking lots, athletic fields, buildings, and grassed areas making up the land cover. Impervious surfaces make up about 30% of the land cover. A small detention pond is located on the unnamed tributary that receives runoff from the school campus, but it does not appear to be large enough to mitigate the flows from the site. Hence, the elevated peak flow and volume of runoff.

Exotic species cover approximately 54% of the buffer areas at the sampling sites. One industrial area had 85% cover of kudzu. No potential habitat for Threatened or Endangered species was observed in this sub-watershed.

3.4.1 Causes and sources of degradation

Point source pollution, **stormwater runoff** and associated pollutants, and **sedimentation** are the functional degradation factors of most concern in SW 13. The principal pollution sources include the dumps and runoff from various urban sources. The source of the colored discharge has not been identified, but further work in this sub-watershed should include that determination. The automotive facilities holding stormwater permits may also be considered potential sources of gas and oil pollution. The principal sources of stormwater runoff are the paved road network throughout this largely developed sub-watershed, as well as the high and low intensity residential areas and commercial/industrial areas that drain to Reynolds Creek and Case Branch. Low-intensity development draining to Holland's Creek also exists between Whiteside Road and Rock Road. These areas constitute a significant concentration of impervious roofs and streets that may contribute significantly to increased runoff and altered hydrological cycles. Sources of sediment include streambank erosion caused by flashy storm flows and upland erosion caused by stormwater runoff.

As reported above, elevated suspended sediment, metals concentrations, and fecal coliform bacteria were found in storm samples collected from Holland's Creek at Old Ball Park Road. The sub-watershed encompasses some agricultural and forest land, but the largest area of land is in residential and commercial developments. Sources of sediment along Holland's Creek itself were documented by the observation of bank failures at several sampling points. Some metals can originate from natural sources; however, most of the metals likely originate from commercial/industrial or residential areas.

3.4.2 Sub-watershed restoration goals

Goals:

- **Eliminate pollution caused by illegal dumping in streams**
- Minimize potential pollution from sources such as chemical storage and automotive facilities.
- Eliminate fecal coliform contamination caused by leaky sewers, faulty septic systems, or cattle.
- Reduce stormwater runoff volume and peak flows by 30%
- Reduce nitrogen, phosphorus, and metals export in stormwater runoff from developed areas by 20-30%, so that metals concentrations are less than NC standard/action levels.
- Reduce the sediment load to Hollands Creek which is most likely caused by erosive storm flows.

Strategy:

- Employ stormwater BMPs at commercial and industrial facilities and along streets and bridges.

- Coordinate neighborhood efforts to employ residential stormwater BMPs such as rainwater collection to reduce stormwater volume and careful selection of landscaping material and appropriate fertilizer application to reduce nutrients.
- The nutrient and metal reduction goal can be achieved upon implementation of the stormwater BMP's in both residential and commercial settings.
- Employ sediment and erosion BMPs on all land clearing operations.
- Plant forested buffers along cleared streambanks.
- Restore the natural morphology of altered streams where feasible.
- Install fencing to exclude cattle from streams.
- Enforce local dumping ordinances and initiate community education and cleanup efforts.

Sediment reduction must be done in concert with reducing stormwater volume and peak flows to be successful. Implementing these strategies will result in the improvement of both aquatic and terrestrial habitat functions, hydrologic functions, and water quality functions. The specific management measures recommended to achieve the sediment and stormwater reduction goals are described below along with some suggested locations for implementation.

3.4.3 Management Measures

General management techniques recommended for various sites in SW 13 are summarized in **Table 7** below. More detailed explanations are given in the following sections.

Table 7. Sub-watershed 13 Management Recommendations

Site	Proposed Techniques
a	Livestock exclusion, Conservation tillage, Buffer restoration
b	Bioretention basins, Rainwater collection, Buffer restoration
c	Bioretention basins, Rainwater collection, Buffer restoration
d	Bioretention basins, Rainwater collection, Buffer restoration
e	Bioretention basins, Rainwater collection, Buffer restoration, Livestock exclusion
f	Stream bank stabilization, Buffer restoration
g	Stream enhancement, Buffer restoration
h	Stream bank stabilization

Agricultural and Livestock BMPs

The reach of Holland's Creek down to the confluence with Reynolds Creek drains an estimated 200 acres of agricultural land. Livestock exclusion fencing and conservation tillage should be the focus of management measures in this area (**Site 13-a** on **Figures 6a and b** and **Figure 47** in *Project Atlas*). It was observed that for some of the reach livestock had unlimited access to Holland's Creek and that streambanks showed evidence of excessive erosion indicating the need for livestock exclusion fencing and perhaps stream restoration.

Stormwater BMPs

The extensive residential and commercial areas of the sub-watershed present a unique challenge because of the number of landowners involved (**Sites 13-b**, **c**, **d**, **e, f, g,** and **h** on **Figures 6a and b** and **Figures 48-54** in *Project Atlas*). Control and treatment of stormwater runoff can be handled with the same industrial and residential BMPs recommended for SW 09. With so many landowners to deal with, the most efficient way to implement stormwater control is to have the municipality lead the effort through the development of ordinances or a stormwater utility. A model stormwater ordinance is currently being written by a contractor to the DWQ and could be used for any municipality. Cost-sharing programs developed for commercial districts and neighborhoods have been successful at providing education and implementing stormwater and nutrient management practices on a large scale.

Stream Restoration

At least two of the observation sites (**13-f** and **13-h**) in the sub-watershed had severely eroding streambanks indicating the need for stream channel restoration/stabilization. Stream restoration in urban areas often presents difficult challenges due to factors such as limited space, utilities, and flooding issues. Any stream restoration design must take into account the possibility of increased flows because of additional buildout upstream in the sub-watershed.

Table 8 continued

Management Practice	Program	Links	Level
Stream Watch	Delaware Nature Society – Delaware Stream Watch	http://www.delawarenaturesociety.org/nrc/SW/aboutstreamwatch.htm	State
	Ellerbe Creek Stream Watch Association	http://www.ellerbecreek.org/streamwatch.htm	Local
	NC DENR Office of Environmental Education – Stream Watch	http://www.ee.enr.state.nc.us/edresources/denrprograms/streamwatch.htm	State
Stream Restoration	North Carolina Stream Restoration Institute, NCSU Department of Agricultural and Biological Engineering	http://www5.bae.ncsu.edu/programs/extension/wqg/sri/	Region
	US EPA's River Corridor and Wetland Restoration	http://www.epa.gov/owow/wetlands/restore/	Federal
	USDA Forest Service	http://www.stream.fs.fed.us/	Federal
	NC Ecosystem Enhancement Program	http://nceep.net	State
	USDA-NRCS	http://www.wsi.nrcs.usda.gov/products/stream.html	Federal

Table 8 continued.

Management Practice	Program	Links	Level
Stormwater BMPs	Center for Watershed Protection, Stormwater Manager's Resource Center	http://www.stormwatercenter.net	Region
	NCSU Biological & Agricultural Engineering	http://www.bae.ncsu.edu/bae	Region
	EPA, Post-Construction Stormwater Management in New Development & Redevelopment	http://cfpub.epa.gov/npdes/stormwater/menuofbmps/post.cfm	Federal
	International Stormwater Best Management Practices (BMP) Database	http://www.bmpdatabase.org	Federal
	NCDENR BMP Manual	http://h2o.enr.state.nc.us/su/PDF_Files/SW_Documents/BMP_Manual.PDF	State

Table 9. Potential Funding Sources

Agency/Source	Program Name	Description	Dollar Value FY 2005	Webpage
Bureau of Land Management, U.S. Fish and Wildlife Service, and USDA Forest Service	Bring Back the Natives Grant Program	Provides funds to restore damaged or degraded riverine habitats and their native aquatic species through watershed restoration and improved land management.	$1.1 million	www.nfwf.org/programs/bbn.htm
Corporation for National and Community Service	Learn and Serve America Program	Provides students and youth with opportunities to serve America by connecting community service with academic learning, personal growth, and civic responsibility. Typical projects address local needs in the areas of education, the environment, and other human needs.	$43 million	http://www.learnandserve.org/
EPA	Drinking Water State Revolving Fund (DWSRF)	To help protect public drinking water supply	$14.5 million	www.epa.gov/safewater/dwsrf.html
EPA	Five-Star Restoration Program	Funds for community-based wetland and riparian restoration projects with a preference given on-the-ground habitat restoration and projects that involve larger watersheds.	$500,000	www.epa.gov/owow/wetlands/restore/5star/
EPA	Nonpoint Source Implementation Grants (319 Program)	Provides formula grants to implement nonpoint source projects and programs in accordance with section 319 of the Clean Water Act (CWA) such as BMP's. Nonpoint source pollution reduction projects can be used to protect source water areas and the general quality of water resources in a watershed.	$207 million	http://h2o.enr.state.nc.us/nps/
National Fish and Wildlife Foundation	National Fish and Wildlife Foundation General Matching Grants	Conservation grants awarded to projects that: (1) address priority actions promoting fish and wildlife conservation and the habitats on which they depend; (2) work proactively to involve other conservation and community interests; (3) leverage available funding; and (4) evaluate project outcomes.	$4 million	www.nfwf.org/programs/grant_apply.htm

Table 9 continued.

Agency/Source	Program Name	Description	Dollar Value FY 2005	Webpage
National Fish and Wildlife Foundation	Southern Rivers Conservation	Projects are funded that help to restore and enhance riparian and riverine habitat in twelve southeastern states including North Carolina. Projects fall into one of the three categories: (1) Stream Restoration (Restore Our Southern Rivers), (2) Freshwater Mussel Conservation , and (3) Southeastern Imperiled Fishes Management.	Not yet Available	http://www.nfwf.org/programs/ROSR.htm
NCDENR	Clean Water Management Trust Fund (CWMTF)	The Clean Water Management Trust Fund makes grants to local governments, state agencies and conservation non-profits to help finance projects that specifically address water pollution problems, including repair of waste treatment equipment, riparian protection easements, restoration of degraded lands, and stormwater control.	$100 million	www.cwmtf.net
NCDENR	Ecosystem Enhancement Program	Program that combines previous stream, buffer, and wetland restoration and or enhancement work from NCDOT and an existing NCDENR program to offset unavoidable environmental impacts from transportation-infrastructure improvements.		www.nceep.net
NCDENR	NC Ag Cost Share Program	Reduce agriculture nonpoint pollution and improve the water quality in North Carolina	Local SWCD determines	http://www.enr.state.nc.us/DSWC/pages/agcostshareprogram.html
NCDENR	North Carolina Parks and Recreation Trust	To improve or establish public parks	$500,000	www.ils.unc.edu/parkproject/partfund/home/index.html
NCDENR-SWCD	Rutherford County Soil and Water Conservation District	To protect North Carolina surface waters		http://www.rutherfordcountync.gov/dept/soil_and_water/Main.php
State of NC	Natural Heritage Trust Fund (NHP)	To acquire and protect the state's ecological diversity and cultural heritage and to inventory the natural areas of the state.	$12 million/year	http://ils.unc.edu/parkproject/heritage/nhtf.html

Table 9 continued.

Agency/Source	Program Name	Description	Dollar Value FY 2005	Webpage
U.S. Department of Commerce Economic Development Administration, Public Works Division	Public Works and Development Facilities Program	This program provides assistance to help distressed communities attract new industry, encourage business expansion, diversify local economies, and generate long-term, private sector jobs. Specific activities may include demolition, renovation, and construction of public facilities; provision of water or sewer infrastructure; or the development of stormwater control mechanisms (e.g., a retention pond) as part of an industrial park or other eligible project.	$164 million	http://www.eda.gov/InvestmentsGrants/Investments.xml
U.S. Department of Transportation	Transportation Equity Act for the 21st Century Funding Programs	Funds numerous transportation programs to improve the nation's transportation infrastructure, enhance economic growth, and protect the environment. Funds include those for transportation enhancement projects, which can include acquisition of conservation and scenic easements and the mitigation of highway stormwater runoff water quality, as well as scenic beautification, pedestrian and bicycle trails, archaeological planning, and historic preservation. These varied project types can be used to protect source water areas during construction of transportation corridors.	$5.06 billion (National highway system), $5.9 billion (Surface transportation program).	www.fhwa.dot.gov/tea21/
U.S. Fish and Wildlife Service	Private Stewardship Grants Program	Provides grants and other assistance on a competitive basis to individuals and groups engaged in private conservation efforts that benefit species listed or proposed as endangered or threatened under the Endangered Species Act of 1973, as amended, candidate species, or other at-risk species on private lands within the United States. Examples of the types of projects that may be funded include managing nonnative competitors, restoring streams that support imperiled species, fencing to exclude animals from sensitive habitats, and planting native vegetation to restore a rare plant community.	$6.5 million	http://www.fws.gov/endangered/grants/private%5Fstewardship/
U.S. Fish and Wildlife Service	State Wildlife Grant Program (Non-Tribal)	Provides grants for wildlife conservation. The SWG program provides funds to help develop and implement programs that benefit wildlife and their habitat, including species that are not hunted or fished.	$63 million	http://offices.fws.gov/statelinks.html

Table 9 continued.

Agency/Source	Program Name	Description	Dollar Value FY 2005	Webpage
USDA	Watershed Processes and Water Resources Program	The program sponsors research that address two areas: (1) Understanding fundamental processes controlling a) source areas and flow pathways of water, b) the transport and fate of water, sediment, nutrients, dissolved matter, and organisms (including water-borne pathogens), within forest, rangeland, and agricultural environments as influenced by watershed characteristics and contaminant origin, and c) water quality. (2) Developing appropriate technology and management practices for improving the effective use of water (consumptive and non-consumptive) and protecting or improving water quality for agricultural and forestry production, including the evaluation of management policies that affect the quantity and quality of water resources.	$4.3 million	www.csrees.usda.gov/funding/rfas/nri_rfa.html
USDA-Farm Agency Service	Conservation Reserve Program	CRP is a voluntary program that offers long-term rental payments and cost-share assistance to establish long-term, resource-conserving cover on environmentally sensitive cropland or, in some cases, marginal pastureland.	$1.95 billion	http://www.fsa.usda.gov/dafp/cepd/crp.htm
USDA-Forest Service	Cooperative Forestry Assistance Programs	Through its Forest Legacy Program (FLP), the USDA Forest Service supports state efforts to protect environmentally sensitive forest lands. The program helps fund the acquisition of forest land or partial interests in privately owned forest lands. It encourages and supports the acquisition of conservation easements..	Not yet Available	www.fs.fed.us/spf/coop/flp.htm
USDA-Natural Resource Conservation Service	Environmental Quality Incentives Program	Established to provide a voluntary conservation program for farmers and ranchers to address significant natural resource needs and objectives. It provides technical, financial, and educational assistance.	$992 million	www.nrcs.usda.gov/programs/eqip/
USDA-NRCS	Conservation Reserve Program (CRP) Continuous	To protect soil, water, wildlife, and to improve water quality	$50,000 a year per person	www.nrcs.usda.gov/programs/crp/

Table 9 continued.

Agency/Source	Program Name	Description	Dollar Value FY 2005	Webpage
USDA-NRCS	Wetlands Reserve Program	Provides landowners with financial incentives to restore and protect wetlands in exchange for retiring marginal agricultural land on a volunteer basis. To participate in the program landowners may sell a conservation easement or enter into a cost-share restoration agreement	154,500 acres nationwide.	www.nrcs.usda.gov
USDA-NRCS	Wildlife Habitat Incentives Program (WHIP)	Develop and enhance wildlife habitat	$10,000 (higher amounts for special projects)	www.nrcs.usda.gov/programs/whip/

Source: http://cfpub.epa.gov/fedfund/

5.0 TIME FACTORS

Implementation of the Watershed Management Plan is dependent on a number of factors such as the availability of local leaders and resource agency personnel to further customize the plan and set schedules and milestones according to local priorities. Other factors include grant funding cycles, state and local budget priorities, and complexity of design and construction of the various practices.

The Clean Water Management Trust Fund is a major grantor to municipalities and conservation organizations seeking to restore and protect surface water quality. Grant applications are accepted for projects such as improvements to wastewater treatment & collection systems; stormwater management; repair of septic tanks and removal of straightpipes; wetlands, riparian buffer and stream restoration; acquisition of buffers, floodplains, wetlands, and greenways; and agricultural best management practices. Applications are received twice a year.

The USEPA Clean Water Act Section 319(h) funds are administered by DWQ. These funds are available for non-point source pollution management, including stormwater control. Types of projects funded include demonstration of innovative BMPs, water quality monitoring and modeling, environmental education and technology transfer, and restoration of waters impaired due to NPS pollution. Grant applications are received once a year.

Other potential grantors, such as private foundations, may be considered as well. Funding cycles vary, and would have to be investigated on an individual basis.

Once projects are defined and funding is obtained, designers and contractors can provide timeline estimates for individual projects. For a typical stream or wetland restoration project funded through EEP, the design and permitting process usually takes about one year. Construction may take from 2-6 months depending on the size of the project, and revegetation of the project would be restricted to the winter dormant season. Typical stormwater BMPs do not require permits. Design may take 2-4 weeks, and construction may take 1-2 months. The contacts for EEP projects in the Cathey's Creek watershed are listed below:

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