The North Carolina Geographer
Vol. 3, Summer, 1994

MERGING STORM WATER MANAGEMENT WITH STREAM HABILITATION: GREENSBORO'S LAKE DANIEL PILOT PROJECT

Michael E. Lewis, John R. Jezorek and Parke Rublee

Introduction

Michael E. Lewis is an Assistant Professor of Geography, John R. Jezorek is a Professor of Chemistry, and Parke Rublee is an Associate Professor of Biology. All are at the University of North Carolina at Greensboro

In spite of progress controlling discharges of industrial pollutants from discrete points, many urban drainage basins continue to suffer from heavy loads of sediment and pollutants in the form of storm water runoff from lawns, streets, driveways, parking lots, and other dispersed sources (Arnold et al., 1993; Riley, 1992; Ferguson 1991; Horak, 1988). Altered geomorphic and soil conditions, leaking or broken sewer lines, and structural responses to flooding also contribute to the degraded natural condition of many urban streams. City governments and local environmental groups are attempting to restore natural vitality to such streams and wetlands through cooperative, integrated efforts to reduce storm water borne pollution (DeWitt, 1994).

Stream rehabilitation efforts can be merged with the National Pollutant Discharge Elimination System (NPDES). Under authority of the Water Quality Act of 1987 NPDES requires local governments to devise plans for reducing sediment and pollutants carried by storm water runoff directly to streams or water treatment plants. State and local governments are also providing grants to fund community-based stream restoration projects that serve multiple goals, including storm water management (Riley, 1992). Greensboro, North Carolina, exemplifies the process of meeting the NPDES requirements to plan for storm water management with local public involvement. This article reviews the parallel histories of stream greenway rehabilitation and storm water management and describes the ongoing process of merging the two goals in a Southern Piedmont context.

Volunteer citizens and cooperating city departments are involved in restoring vitality to stream and wetland environments suffering from heavy loads of sediments and pollution from lawns, driveways, streets, and parking areas

Past Approaches

Urban landscape planners have long recognized the amenity value of clean running water, and also the practical reduction in flood hazards that comes from reserving floodplains within parks and greenways. Olmstead's emerald necklace around Boston in the 1880's was one of the earliest examples of a system of riparian public parks. Greenway corridors along streams and rivers have subsequently emerged in cities around the country. The National Capital Park System along Rock Creek in Washington D.C., Denver's Platte River Greenway, Oregon's Willamette River Greenway through Portland, and the Chattahoochee River Corridor near Atlanta, are a few national examples. The Capital City Greenway in Raleigh, North Carolina, dating from the early 1970s, is one of the earliest greenways acquired through public acquisition of private floodplain land. In addition to directing development away from some 1,000 acres of active floodplains, the greenway is traversed by 30 miles of multipurpose trails within the Raleigh metropolitan area. The city of Charlotte, in cooperation with Mecklenburg County, has set aside the McAlpine floodplain greenway, while Guilford County links the City of Greensboro's water supply lakes with a series of greenway corridors and public recreational trails (Field, 1981; Ferguson, 1991; Flink and Stearns, 1993).

An ongoing problem has been that the amenities sought after in greenway reserves — a vigorous growth of riparian trees and shrubs, aesthetically pleasing stream morphology with meandering sequences of pools and riffles, including pockets of wetlands — have been at odds with engineered solutions to the flooding problems that also come with urban development. Hydraulic engineers recognize that land use changes associated with urban development produce forceful changes in stream hydrology and basin morphology. Total runoff and peak flows, bank erosion, and sedimentation all increase as houses, commercial buildings, parking lots, and roads replace natural vegetation and soil covers with a more impervious and environmentally toxic surface. Groundwater regimes are also altered as more water runs off surfaces rather than moving as soil through flow or infiltrating into subsoil levels (Leopold, 1968).

Stream channelization became a common solution to problems of accelerated storm water runoff and local flooding as housing projects proliferated around urban centers following the end of World War II. From the perspective of individual developers, straightening channels, clearing vegetation, and encasing banks in concrete or rip-rap to produce uniform trapezoidal cross-sections provided an efficient means of moving both water and pollutants out of local areas. More recently, the impaired natural environment of such streams, along with collective downstream increases in flooding and pollutant loading, has prompted efforts to identify alternatives to channelized streams (Nunnally and Shields, 1985; Nunnally and Keller, 1979; Nunnally, 1978).

Contemporary storm water management plans are replacing earlier designs emphasizing rapid discharge of floodwater through dredged channels with techniques for delaying its movement and spreading peak flows over longer time periods. Detention ponds, infiltration trenches, and porous parking lots, all designed to detain sediment and pollutants associated with storm water, have emerged as a favored set of "best management practices" recommended in hydrologic engineering and planning literature (Whipple, 1991; Schueler, 1987). Such "pipe and pond" structures are a common response to sedimentation control ordinances in plans for new residential and commercial developments. While they can be effective as sediment traps, they do little to correct the unsightly legacy of channelized streams in established neighborhoods.

Flood stage detention ponds also give little attention to storm water that reaches streams during non-flood precipitation events. Pollutant conveyance is especially significant when a storm follows a period of dry weather. A flush of motor oils, grease, and other petroleum based pollutants are moved directly into streams from streets, parking lots, and driveways in heavy concentrations during such events, producing a severe strain on riparian and aquatic habitats (Silverman and Stenstrom, 1982). Rapid discharge of runoff from low intensity rainfall, and reduced bank storage when culverts are piped directly to streams, also limits the establishment and growth of riparian vegetation and aquatic life. That is a serious limitation because under favorable conditions of topography and soil character, riparian vegetation buffers aid the break down of organic pollutants and increase bank storage of storm water, which can consequently augment stream flow during low water periods (Holder and Mayfield, 1993; Phillips, 1989). In summary, there is a need for stream rehabilitation plans designed to soften the relic imprint of channelization, reduce or assimilate the flush of storm water pollutants during frequent, low intensity storm events, and improve natural stream habitat for aquatic and riparian plants and animals.

> ***Engineering solutions to urban flooding problems are found to be at odds with amenities provided by aesthetically pleasing greenway environments***

The Federal Mandate

The catalyst for bringing storm water management to the urban environmental planning agenda was a new interpretation of the scope of the National Pollutant Discharge Elimination System (NPDES). Discharge permits have been a federal tool for controlling and cleaning up water pollution since passage of the Federal Water Pollution Control Act Amendments of 1972, which was refined by adding the specific goals found in the Clean Water Act of 1977. Section 401 of the Clean Water Act created NPDES to meet the goal of controlling the discharge of effluent containing specific pollutants from discrete point sources.

When the Clean Water Act of 1977 was reauthorized by the Water Quality Act of 1987 a new goal was added. That goal was directed at reducing the introduction of pollutants to rivers and streams from dispersed, non point sources. Motivated by the new non point source pollution goal, the EPA successfully argued before

Congress that though urban storm water runoff originated from dispersed sources, its conveyance through urban gutters, culverts, and storm sewer pipes fell under the legal definition of point source pollution, and was therefore subject to NPDES. The strongest evidence for the need for action was taken from biennial assessments of water quality submitted by the states to EPA under rules of the Clean Water Act of 1972. Those assessments concluded that the effects of pollutants from diffuse sources, primarily urban storm water and non point agricultural runoff, were the leading causes of water quality impairment in the United States (EPA, 1990).

Municipal urban quality assessments have shown that diffuse source pollution is the leading cause of water impairment in the United States

With the broadened authority of NPDES, EPA requires municipalities with separate storm water and sanitary sewer systems to submit plans for management of urban storm water runoff as a condition for renewal of waste water discharge permits. The purpose of the EPA rules is to encourage cities to develop individual approaches that allow for variations in physical settings, and also greater public involvement in identifying and implementing effective planning for storm water management. EPA's policy differs from large scale flood control and multi-purpose water projects of the past in that it encourages preventative and source reduction methods in combination with built structures, and seeks to foster joint efforts between citizen based environmental advocacy groups and governmental agencies. It relies less on the federal government for design, funding, and implementation, finding earlier federally directed water projects plagued with long delays, rising construction and maintenance costs, and unacceptable demands on local property owners (EPA, 1990).

The EPA delegated authority to administer NPDES to the state of North Carolina in 1975. North Carolina's Department of Environment, Health, and Natural Resources is the primary agency responsible for statewide oversight of the storm water planning mandate, while city governments in urban areas exceeding 100,000 residents are responsible for drafting their own storm water discharge permit applications. Six North Carolina municipalities are currently required to develop storm water management plans to qualify for NPDES permits: Charlotte, Durham, Raleigh, Greensboro, Winston-Salem, and Fayetteville. At the beginning of 1994 only Charlotte had completed the application process and been granted a permit, while the other cities' applications were in various stages of development. Other federal and state legislation and regulations affect storm water management programs in other parts of North Carolina. They include floodplain management ordinances required under the National Flood Insurance Program administered by the Federal Emergency Management Agency and the North Carolina Coastal Area Management Act of 1974, which applies in 20 coastal counties (Eaker, 1994).

Paying the cost of implementing and maintaining storm water management plans without heavy federal subsidies has led some 60 cities across the U. S., including Raleigh, Charlotte, and Greensboro to adopt a public utility approach to storm water management. The justification used to create storm water utilities is that provision of storm water drainage facilities and their repair and maintenance are a public service provided to property owners. Property owners are assessed the fee based on a property's potential for producing runoff, including such criteria as the size and use of the tract, the roof area of buildings, extent of guttering, and the area of impervious surfaces. Fee collection is typically administered through a public works utility working in conjunction with water and sewer systems (Eaker, 1994; Lindsey, 1990).

Greensboro Case Study

Situated near the head of the Cape Fear River on the rolling dissected topography of the Southern Piedmont, Greensboro, North Carolina is approaching 200,000 urban residents. Local annual precipitation averages 43 inches and is distributed throughout all seasons of the year. Approximately 90 percent of precipitation events produce surface runoff and through flow to streams. Heavy clay textured soils in many areas, combined with the various impervious surfaces of built-up areas, provide generally poor subsurface drainage and slow infiltration to ground water. Greensboro streams also have small local catchment areas and receive small amounts of ground water base flow. As a result, city streams experience generally low flow levels, except for short periods after storms when rapid runoff can produce localized flooding. Repeated channel dredging and straightening in response to small floods has increased scouring and bank collapse with associated sediment loading. Greensboro streams also carry heavy loads of salts, fertilizers, pesticides, and petroleum based chemicals, conveyed to them from streets, landscaping, and commercial/ industrial areas (City of Greensboro, 1993).

The city took the first step in preparing its NPDES permit application by hiring a consulting firm, which divided the urban drainage network into 12 watersheds, each covering approximately six square miles or less (Figure 1, Table 1). Public meetings revealed a predisposition among city councilmen towards a structurally engineered approach to storm water controls, but also a political sensitivity to the cost that would be borne by city taxpayers. The local chapter of the National Audubon Society saw the situation as an opportunity to demonstrate the fiscal attractiveness of stream restoration and rehabilitation. They responded by establishing the Streamgreen Committee composed of interested Audubon members and local academicians with professional expertise in water resources, aquatic ecology, water chemistry, and public relations. Streamgreen's mission is to encourage city officials to take an integrative approach to storm water management, one that includes restoring the amenity, recreational, and natural habitat functions of urban

Watershed	Area (acres)	Composite Imperviousness	Runoff Coefficient	Runoff (acre-ft/year)
East Fork Deep River	2912	45.8	0.46	4297
Bull Run Creek	982	15.6	0.19	596
Horsepen Creek	5169	26.2	0.29	4721
South Buffalo Creek 1	5271	36.9	0.38	6435
South Buffalo Creek 2	4998	36.1	0.38	5986
South Buffalo Creek 3	5317	42.2	0.43	7298
South Buffalo Creek 4	3659	33.6	0.35	4118
Lake Jeanette	3861	21.4	0.24	2986
North Buffalo Creek 1	6122	37.0	0.38	7481
North Buffalo Creek 2	3578	50.2	0.50	5730
North Buffalo Creek 3	3790	33.5	0.35	4252
North Buffalo Creek 4	6400	35.4	0.37	7529
Citywide	52059	35.5	0.37	61,429

Table 1. Major Characteristics of Greensboro Watersheds
Source: City of Greensboro NC, Stormwater permit Application, Part 2

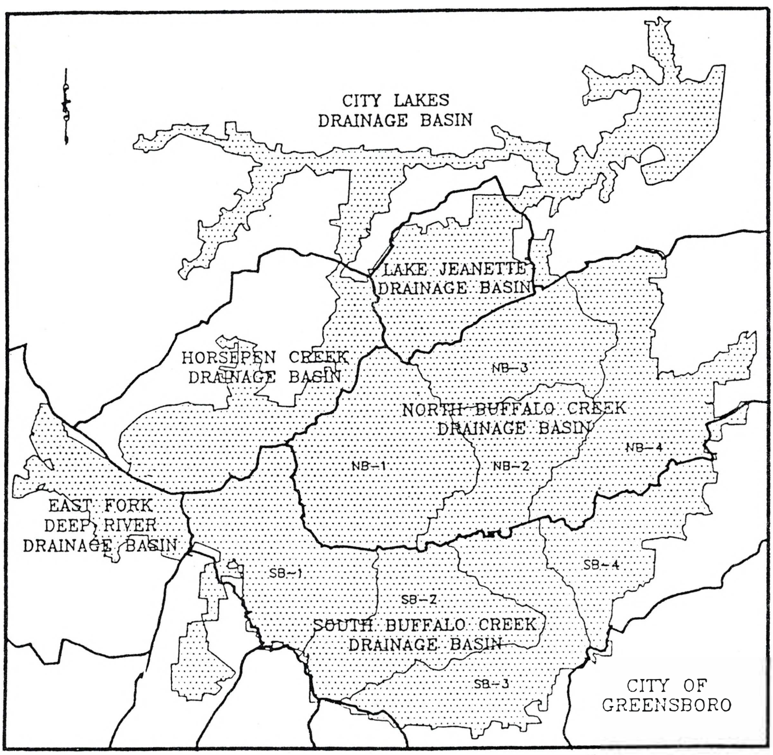

Figure 1. Major Drainage Basins and Sub-basins of Greensboro

streams, in addition to their storm water conveyance function. The initial working goals were to provide public educational information about the benefits of naturally flowing streams, establish linkages to city government officials with responsibility for streams, and involve local neighborhood groups in stream monitoring and restoring riparian vegetation.

Streamgreen is a committee of local citizens interested in restoring the more natural landscapes to the city's stream and wetland environments

The committee first produced a slide / lecture program describing the ecological functions and amenity values of natural stream greenways and wetlands, including their ability to break down some pollutants and absorb small floods. The program was shown to school classes and civic groups in targeted neighborhoods with local streams. Neighborhood outreach also took the form of "adopt-a-stream" projects involving churches, civic groups, and neighborhood associations in regular clean-up of trash and debris washed into streams. Adopt-a-stream was able to generate television and newspaper coverage of conditions at local streams and also the broader issue of storm water management.

While neighborhood outreach and educational efforts proceeded, Streamgreen worked to establish linkages with Greensboro Beautiful, a private-public consortium primarily concerned with landscaping in the city's public parks and natural areas, but increasingly interested in restoring more natural landscapes. Obtaining the support of Greensboro Beautiful was a crucial step in Streamgreen's effort to identify and reach key city officials in departments involved with streams. Responsibility for planting and bank mowing, as well as ditching, piping, and bank grading, all with major effects on riparian vegetation and stream morphology, fall to different city departments. The Greensboro Parks and Recreation Department is responsible for mowing and planting vegetation within stream corridors, and provides part of the funding for Greensboro Beautiful. The Department of Transportation handles channel dredging, repair of drainage culverts and piping, and grading collapsed or eroded banks. Furthermore, any proposals to change the flow or morphology of streams on floodplains mapped by the Federal Emergency Management Agency requires approval from the Environmental Programs department (formerly Greensboro's Public Works department). Meetings were held to explain Streamgreen's mission with staff from each of those departments. The consulting firm contracted by the city to draft the NPDES permit application and design a set of best management practices was also kept informed of Streamgreen activities and made written comments on Streamgreen proposals.

The Lake Daniel Pilot Project

After two years of educational neighborhood outreach, political advocacy, and informal stream surveys, Streamgreen approached the city of Greensboro with a proposal to begin a demonstration project in Lake Daniel park (Figure 2). The park's name is actually a misnomer, because the reservoir once called Lake Daniel was drained over fifty years ago. Since then North Buffalo Creek and its unnamed tributary flowing through the former reservoir site have been channelized several times, with the banks kept graded at a steep 1:1 slope gradient that encourages accelerated bank collapse.

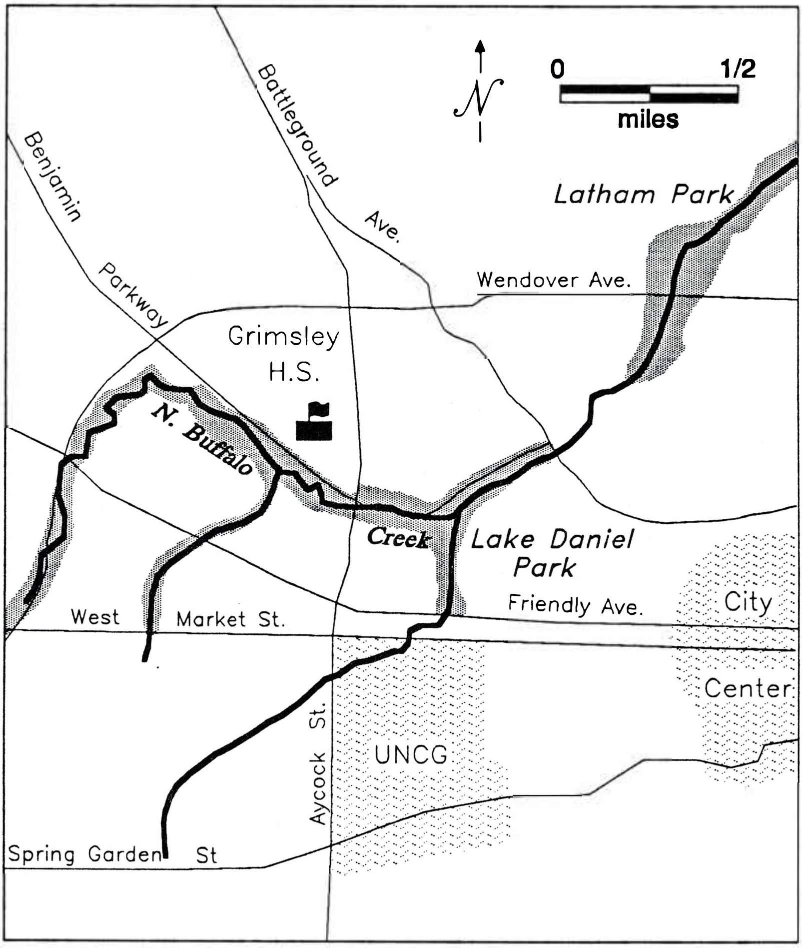

Figure 2. Lake Daniel Park and Vicinity

The city agreed to allow a cooperative group composed of Audubon (Streamgreen) and the Lake Daniel Neighborhood Association to propose changes along the streams of Lake Daniel Park. A long term goal is to have the park serve as a model of low cost stream rehabilitation and preservation practices that the city can implement on other streams within the city. Two elements defined the work carried out in Lake Daniel, each of these addressed by a subcommittee: restoration of native vegetation, and modifications of local drainage and channel morphology.

During channelization episodes in the 1980s the park's riparian zone had been cleared of all shrubs and trees, with the cleared channel banks initially allowed to grow up in volunteer vegetation. A single citizen complaint about "weeds in the park" prompted the Parks and Recreation Department to begin a biweekly regimen of mowing both the inside and upper channel banks. The mowing program prevented the growth of trees or shrubs, and left the stream channel exposed to the summer sun, prompting frequent algal blooms as runoff from local lawns brought in nutrients. Streamgreen lobbied the Parks and Recreation Department to end the mowing program and shade the stream with native shrubs and trees for both aesthetic and practical reasons. Empirical research has shown that vegetation serves to uptake excess fertilizer runoff in storm water as well as providing a measure of bank stabilization, while shading provides lower water temperatures and improves oxygenation for fish and aquatic organisms (Smith and Hellmund, 1993; Dawson and Haslam, 1983). Vegetative buffer zones along streams also provide substantial natural filtering of storm water borne pollutants and retard storm water movement so that contaminants can be decomposed by micro-organisms, or settle out into temporary storage on the primary floodplain (Phillips, 1989).

Given past complaints about the unkempt appearance of unmowed grassy stream banks in the park, Streamgreen and the Lake Daniel Neighborhood Association produced a brochure and posted signboards outlining the reasons for the revegetation project. Neighborhood Association members also sponsored morning and evening stream side walks to discuss the potential appearance of the vegetation over the long term while dampening fears that a lack of mowing would encourage rats and other "vermin" to invade the park. Reassured of public acceptance from the Lake Daniel Neighborhood Association, Greensboro Parks and Recreation agreed to suspend its mowing program along a riparian strip 20 - 100 feet wide along North Buffalo Creek and its tributary within the park.

A grant of $5,000 from Greensboro Beautiful allowed the Lake Daniel Neighborhood Association to purchase some 200 native shrubs and trees for planting in the unmowed riparian buffer. Several planting days were held, and 40-50 neighborhood and Audubon volunteers assisted with the work. In the three growing seasons since the mowing program was suspended, suppressed willows have sprouted along the narrow primary floodplain within the channelized banks. Red maples, sycamores, and mulberry trees are reestablished on the upper banks, and along with a profusion of wildflowers are adding to the stock planted by the neighborhood association. The growth of this emerging vegetation has noticeably improved wildlife habitat. Long time Audubon birders have sighted several songbirds not documented in the park while the mowing program was in effect. Fully documenting the effects of the planting program will require several years, but early signs of improvement are clearly encouraging.

In addition to planting native shrubs and trees in the riparian zone, Streamgreen sought to slow the discharge of storm water runoff into and from the park streams and reduce bank slumping and erosion. Producing an idealized meandering stream would involve an expensive reconfiguration of the existing channel using heavy earth-moving equipment inside a popular city park. Instead, the committee attempted to identify less invasive alterations with moderate or low financial costs, that when implemented collectively across the city could produce significant improvements in rates of storm water runoff and stream flow.

The modifications finally accepted by the city had several components. First, the city agreed to grade the stream banks back to a more gentle 2:1 slope ratio, augmented by plantings of willows to stabilize the bank and transpire some surplus moisture. Revegetating and reshaping the banks also provides a safety benefit in that people are less likely to slip off a steep bank and find themselves trapped in an entrenched rain-swollen stream channel.

Several years of volunteer work in cooperation with the Parks and Recreation Department has provided an excellent example of stream environment rehabilitation

Modifications were also made to the channel morphology through additions of rock. The city provided several truck loads of rough native granite stones ranging between 6-24 inches in greatest dimension. Neighborhood residents and Audubon volunteers placed as rock steps across the channel, or built rock flow deflectors upstream from several undercut and collapsed banks along straightened stream segments. Pools created behind the rock steps are intended to provide a refuge for fish during low water conditions, and delay movement of sediments and trash until clean-up crews can remove it. Stepped pools and rock deflectors also dissipate or redirect the hydraulic energy of stream flow, thus reducing bank erosion and channel scouring, and promoting development of meanders in the primary floodway of North Buffalo Creek. Turbulence created as water flows over the rock steps also improves aeration, which increases dissolved oxygen levels so that microorganisms can break down organic pollutants detained in sediments (Nunnally and Shields, 1985; Riley, 1992; Smith and Hellmund, 1993).

One severely collapsed and eroded bank threatened to cut into a popular walking path. Because of the imminent loss of the walkway, the city decided to construct a gabion wall along the affected bank. Gabions consist of a porous set of rock baskets made from wire fencing fabric. The baskets are wired together and embedded into the eroding bank. Under favorable conditions, soil and sediment collect in the open spaces within the baskets, allowing naturally propagated plants to become established. Construction of the gabion by city workers proved to be the most expensive element of what was otherwise a very inexpensive volunteer labor project.

Phase three of the Lake Daniel Park plan calls for direct intervention in the movement of storm water from street curb drains and piped culverts. Streamgreen is urging the city to remove sections of cut stone street curbing along lightly traveled residential streets bordering gently sloping grassy areas of the park. Excavation of shallow pocket marshes at the outfalls of larger piped culverts are also being proposed. The intent of the curb cuts is to reduce the flow of storm water into drainage culverts and allow sheet flow across grassed areas and the unmowed buffer zone to provide temporary storage of storm water. In a similar fashion, small pockets of wetlands located at cut backs near culvert outfalls are intended to absorb and slow the movement of pollutants from frequent small magnitude storm events. At this time, city engineers in the Department of Transportation have cut back the banks along culvert outfalls on the tributary in the park. Construction of pocket marshes has been delayed on the main stem of North Buffalo Creek because of the need for approval from the Federal Emergency Management Agency for a permitted floodplain modification of the kind involved in the pocket marsh. The Department of Transportation has also committed to further study and public comment on the use of curb cuts to redirect storm water from residential streets.

Concluding Remarks

The Lake Daniel project is not a true empirical experiment given the lack of baseline data on stream flow, water chemistry, or plant and animal surveys on North Buffalo Creek. It is instead an attempt to apply the general results of empirical geomorphological research in a specific demonstration of stream rehabilitation. Audubon has encouraged the city to extend the modifications to Lake Daniel park to other city streams. When applied throughout the Greensboro urban area and integrated with storm water detention ponds and repair work on broken or leaking sewer and storm water lines, we believe the techniques demonstrated in this urban greenway park can contribute to a reduction in stream pollution loading while improving an important urban amenity. Not all of our recommendations were accepted and some remain under consideration, however the experience gained in Greensboro illustrates an alternative to the litigation and adversarial relationship that often characterizes relationships among city officials, development interests, and environmental groups. A locally designed set of practices for managing storm water can serve the best interests of all three groups by providing low cost, low impact, and attractive solutions to a federal mandate for improved water quality in urban areas.

The techniques shown here can contribute to reduction in urban stream pollution when applied throughout the Greensboro region

References

Arnold, J., D. E. Line, S. W. Coffey, and J. Spooner (eds.) (1993). *Storm Water Management Guidance Manual*. Raleigh: North Carolina Cooperative Extension Service and North Carolina Division of Environmental Management.

City of Greensboro (1993). *Storm Water Discharge Permit Application* Part 2. Greensboro: Ogden Environmental and Energy Services.

Dawson, F. H., and S. M. Haslam (1983), "The Management of River Vegetation With Particular Reference to Shading Effects of Marginal Vegetation," *Landscape Planning*, 10:147-169.

DeWitt, J. (1994). *Civic Environmentalism: Alternatives to Regulation in States and Communities.* Washington: Congressional Quarterly Press.

Eaker, W. E. (1994). *Storm Water Management in North Carolina*. Asheville: Land of Sky Regional Council.

Environmental Protection Agency (1990), "National Pollutant Discharge Elimination System Permit Application Regulations for Storm Water Discharges," *Federal Register*, 55 (222):47990-48074.

Ferguson, B. K. (1991), "Urban Stream Reclamation," *Journal of Soil and Water Conservation*, 46:324-328.

Field, Ralph M. (1981). *State and Local Acquisition of Floodplains and Wetlands.* Washington: U. S. Water Resources Council, Government Printing Office.

Flink, C. A. and R. M. Searns (1993). *Greenways*. Washington: Island Press.

Holder, W. J. and M. W. Mayfield (1993), "GIS based Determination of Effective Stream Buffers," *The North Carolina Geographer* 2: 12-20.

Horak, G. (1988), "An Integrated Approach to Storm Water, Wetlands, and Riparian Habitat," In *Urban Wetlands* (Proceedings of the National Wetlands Symposium, June 26-29). Berne, NY: Association of Wetlands Managers.

Leopold, L. B. (1968). *Hydrology for Urban Land Planning*. Washington, DC: U. S. Geological Survey, Circular No. 554.

Lindsey, G. (1990), "Charges for Urban Runoff: Issues in Implementation," *Water Resources Bulletin*, 26:117-125.

Nunnally, N. R. (1978), "Stream Renovation: An Alternative to Channelization", *Environmental Management*, 2:403-411.

_______and E. Keller (1979). *Use of Fluvial Processes to Minimize Adverse Effects of Stream Channelization*. Chapel Hill, NC: Report No. 144, Water Resources Research Institute, University of North Carolina.

_______and F. D. Shields (1985). *Incorporation of Environmental Features in Flood Control Channel Projects*. Vicksburg, MS: Technical report E-85-7, U. S. Army Corps of Engineers, Waterways Experiment Station.

Phillips, Jonathan D. (1989), "An Evaluation of the Factors Determining the Effectiveness of Water Quality Buffer Zones," *Journal of Hydrology*, 107:133-145.

Riley, A. L. (1992). *Restore with Nature: Urban Stream Restoration Alternatives to Conventional Engineering*. Washington: Island Press.

_______ (1988), "A New State Role in Flood Damage Reduction: Low Cost, Timely Stream Restoration Projects. In *Urban Wetlands* (Proceedings of the National Wetlands Symposium, June 26-29). Berne, New York: Association of Wetlands Managers.

Schueler, T. R. (1987). *Controlling Urban Runoff: A Practical Manual for Planning and Designing Urban BMPs*. Washington: Metropolitan Washington Council of Governments.

Silverman, G. S. and M. K. Stenstrom (1982). *The Use of Greenbelts to Control Oil and Grease in Urban Storm Water Runoff*. Berkeley: Technical Memorandum No. 87, Water Quality Treatment Program, Association of Bay Area Governments.

Smith, D. and P. Hellmund (1993). *The Ecology of Greenways*. Minneapolis: University of Minnesota Press.

Whipple,W. Jr. (1991), "Best Management Practices for Storm Water and Infiltration Control", *Water Resource Bulletin*, 27:895-902.

_______, R. Kropp, and S. Burke (1987), "Implementing Dual Purpose Storm Water Detention Programs," *Journal of Water Resources Planning and Management*, 113:779-792.