An Eight-Step Approach to Stormwater Retrofitting: How to Get Them Implemented

Richard A. Claytor, Jr. P.E.
Center for Watershed Protection

What are retrofits and why are they important? In the quest for watershed protection and restoration, watershed professionals are constantly seeking new tools for controlling stormwater runoff and associated adverse impacts. Stormwater retrofits are among the most promising of these tools. Retrofits are structural stormwater management measures for urban watersheds designed to help minimize accelerated channel erosion, reduce pollutant loads, promote conditions for improved aquatic habitat, and correct past mistakes. Simply put, these best management practices (BMPs) are inserted in an urban landscape where little or no prior stormwater controls existed.

Retrofits come is many shapes and sizes from large regional retention ponds that provide a variety of controls to small on-site facilities providing only water quality treatment for smaller storms. Usually at least some kind of practice can be installed in almost any situation. But fiscal restraints, pollutant removal capability, and watershed capture area must all be carefully weighed in any retrofit selection criteria.

Retrofitting in a Watershed Context

Stormwater retrofits should be applied along with other available watershed restoration strategies for reducing pollutants, restoring habitat and stabilizing stream morphology as part of a holistic watershed restoration program. While some professionals rightfully assert that true watershed restoration is not feasible, the term is applied here as simply *a concerted strategy to at least partially restore a native biological community to a given stream, lake or river.* Some of the many watershed restoration strategies include:

- Stabilizing stream channel morphology
- Improving aquatic habitat within urban streams
- Replacing or enhancing riparian cover along urban streams
- Promoting pollution prevention source controls within the watershed
- Recolonizing streams with native fish communities

Many, if not most, of these components should be planned in conjunction with an urban retrofit program, and rarely should be considered without one. Without establishing a stable, predictable hydrologic water regime that regulates the volume, duration, frequency, and rate of flow, many of these other strategies may be disappointing failures. To successfully restore a stream's overall aquatic health, stormwater retrofitting is an essential element.

Table 1, below, presents a step-by-step approach to stormwater retrofitting developed by the Center for Watershed Protection staff over the past several years. An eight-step process is briefly discussed with several case studies from the author's experience scattered throughout the discussion to emphasize particular points. At the conclusion of the process two case studies are presented in more detail to illustrate some of the many real world challenges of implementing retrofit projects.

Table 1: Basic Elements of a Stormwater Retrofitting Implementation Strategy		
Step	**Elements**	**Purpose**
1.	Preliminary Watershed Retrofit Inventory	First cut at identifying potential retrofit sites
2.	Field Assessment of Potential Retrofit Sites	To verify that sites are feasible and appropriate
3.	Prioritize Sites for Implementation	To set up a priority for implementing future sites
4.	Public Involvement Process	To solicit comments and input from the public and adjacent residents on potential sites
5.	Retrofit Design	To prepare construction drawings for specific facilities
6.	Permitting	To obtain the necessary approvals and permits for specific facilities
7.	Construction Inspections	To ensure that facilities are constructed properly in accordance with the design plans
8.	Maintenance Plan	To ensure that facilities are adequately maintained

Step 1: Watershed Retrofit Inventory

The first step to getting a retrofit in the ground is the process of locating and identifying where it is feasible and appropriate to put them. This involves a process of identifying as many potential sites as rapidly as possible. The best retrofit sites fit easily into the existing landscape, are located at or near major drainage or stormwater control facilities, and are easily accessible. For example, almost every urban area has some type of existing pond or other existing feature adaptable for retrofitting. In many newer neighborhoods, dry stormwater detention facilities were constructed for flood control. In older neighborhoods there are often aesthetic ponds, or other water features that can make suitable retrofits. Table 2 lists some of the most likely spots for locating facilities, some common applications, and an applicable case study.

Usually the first step is completed in the office using available topographic mapping (a 5 ' contour interval is quite satisfactory), low altitude aerial photographs (where available), storm drain master plans, and land use maps (zoning or tax maps are best). Scouting for potential candidate sites should follow the guidance discussed above in Table 2. Two important tasks need to be undertaken before venturing into the field. First, the drainage area to each retrofit should be delineated and second, the potential surface area of the facility measured. The drainage area is used to compute a capture ratio. This is the percentage of the overall watershed that is being managed by all retrofit projects. The surface area is be used to compute a preliminary storage volume of the facility. A short cut storage volume can be computed by multiplying two-thirds of the facility surface area times an estimated depth. These two bits of information can be used as a quick screening tool. In general, an effective retrofitting strategy must *capture at least 50% of the watershed* and a minimum target storage volume for each retrofit is approximately *½ inch per impervious acre*.

Table 2 Some of the Best locations for Stormwater Retrofits		
Location	**Type of Retrofit**	**Case Study**
Existing stormwater detention facilities.	Usually retrofitted as a wet pond or stormwater wetland capable of multiple storm frequency management	Wheaton Branch, Sligo Creek, Wheaton MD --multi-cell wet pond with extended detention
Immediately upstream of existing road culverts	Often a wet pond, wetland, or extended detention facility capable of multiple storm frequency management	Epsilon Pond, Redland MD --dry extended detention facility
Immediately below or adjacent to existing storm drain outfalls	Usually water quality only practices, such as sand filters, vegetative filters or other small storm treatment facilities	Long Quarter Branch, Towson, MD --gravel based wetland filter
Directly within urban drainage and flood control channels	Usually small scale weirs or other flow attenuation devices to facilitate settling of solids within open channels	Indian Creek, College Park MD --instream concrete weir flow attenuation device
Highway rights-of-way and cloverleaves	Can be a variety of practices, but usually ponds or wetlands	Bear Gutter Creek, Route 22 Armonk, NY --combination wet pond and stormwater wetland
Within large open spaces, such as golf courses and parks.	Can be a variety of practices, but usually ponds or wetlands capable of multiple storm frequency management	Meisner Avenue Retrofit, Staten Island, New York City --micro-pool extended detention facility
Within or adjacent to large parking lots	Usually water quality only facilities such as sand filters or other organic media filters (e.g., bioretention)	Kettering Subdivision, Prince Georges, Co., MD --Bioretention practices

Step 2: Field Verification of Candidate Sites

Candidate retrofit sites from step 1 are investigated in the field to verify that they are feasible. This field investigation involves a careful assessment of site specific information such as presence of sensitive environmental features, location of existing utilities, type of adjacent land uses, condition of receiving waters, construction and maintenance access opportunities, and most importantly, whether or not the contemplated retrofit will actually work in the specified location. Usually a conceptual sketch is prepared and photographs are taken.

One such study that incorporated the principles of this process was the Long Branch Stream Restoration study conducted in Westminster, Maryland in 1994. The Long Branch watershed drains approximately two square miles of moderate to high density commercial and residential land. The area was built prior to stormwater management requirements and consequently, the stream system was suffering the typical urban impacts along much of its reach. This investigation utilized a *retrofit inventory form* that provided field investigators with specific information such as topography, property lines and ownership, storm drain outfall locations, drainage area, mapped utility locations, and other important site design features. This data is vital for the field investigator if sites are to be retained or eliminated from further consideration.

Step 3: Prioritize Sites for Implementation

Once sites have been located and determined to be feasible and practical the next step is to set up a plan for future implementation. Even the best stormwater retrofitting programs have limited capital budgets for individual project design and construction. Therefore it is prudent to have an implementation strategy based on a prescribe set of objectives. For example, in some watersheds, implementation may be based on a strategy of reducing pollutant loads to receiving waters where the priority of retrofitting might be to go after the "dirtiest" land uses first. Whereas if the strategy is oriented more towards restoring stream channel morphology, priority retrofits are targeted to capture the largest drainage areas and provide the most storage. Whatever the restoration focus, it is useful to provide a scoring system that can be used to rank each retrofit site based on a uniform criteria. A typical scoring system might include a score for the following items:

- Pollutant removal capability (storage provided and type of BMP)
- Stream channel protection capability (ability to control subbankful flow events)
- Cost of facility (design, construction and maintenance costs)
- Ability to implement the project (land ownership, construction access, permits)
- Potential for public benefit (education, location within a priority watershed, visible amenity, supports other pubic involvement initiatives)

Step 4: Public Involvement Process

This aspect of the process is critical if a project is ever to be constructed. A successful project must involve the immediate neighbors who will be affected by the changed conditions. Nearly all retrofits require significant modifications to the existing environment. A dry detention pond, for example, is for some a very desirable area in the community. It is a place to walk the dog and only rarely is there any water in the facility. A wet pond or stormwater wetland retrofit, on the other hand, may have large expanses of water and may have highly variable water fluctuations. Adjacent owners may resist these changes. In order to gain citizen acceptance of retrofits they must be involved in the process from the start and throughout the planning, design and implementation process. Citizens who are informed about the need for, and benefits of, retrofitting are more likely to accept projects.

Still, some citizens and citizen organizations will never support a particular project. This is why it is mandatory that there is an overall planning process that identifies projects early and allows citizen input before costly field surveys and engineering are performed. Projects that cannot satisfy citizen concerns may need to be dropped from further consideration.

A good retrofit program must also incorporate a good public relations plan. Slide shows or field trips to existing projects can be powerful persuasions to skeptical citizens. Every site that goes forward to final design and permitting should be presented at least once to the public.

Step 5: Retrofit Design

The design process is for some, including this author, the most rewarding part of the process. Here, the concept is converted from a dream to a construction drawing. Design of retrofit projects incorporate the same elements as any other BMP project including: adequate hydrologic and hydraulic modeling, detailed topographic mapping, property line establishment, site grading, structural design, geotechnical investigations, erosion and sediment control design, construction phasing and staging to name a few. But there is one very big difference. Normal BMP design usually follows a prescribed design criteria (e.g., control of the 2 year storm or sizing for a specified water quality volume), retrofit designers must work backwards from a set of existing site constraints to arrive at an acceptable stormwater control obtainable.

Sometimes this process yields facilities that are too small or ineffective, and therefore not practical for further consideration. One such project in Gaithersburg, Maryland was recently proposed as a major stormwater wetland (upstream from an existing road culvert) to control a 1000 acre watershed. The only problem was that only one-twentieth of an inch of total storage (.05") was obtainable. Clearly this facility would have been a maintenance nightmare and likely would have done little to remove pollutants or control downstream channel erosion. The City of Gaithersburg correctly decided not to pursue the project even though they had already retained a consultant and spent significant time and money on preliminary design.

The key to successful retrofit design is the ability to balance the desire to maximize pollutant removal and channel erosion protection while limiting the impacts to adjacent infrastructure, residents or other properties. Designers must consider issues like avoiding relocations of existing utilities, minimizing existing wetland and forest impacts, maintaining existing floodplain elevations, complying with dam safety and dam hazard classification criteria, avoiding maintenance nuisance situations, and providing adequate construction and maintenance access to the site.

Step 6: Permitting

Perhaps the difficult permitting issues for retrofit projects involve impacts to wetlands, forests and floodplain alterations. Many of these impacts are either unavoidable or necessary to achieve reasonable storage targets. The primary issues that the permitting agencies are looking for is to ensure that the impacts have been minimized to the maximum extent practicable and that the benefits of the proposed project are clearly recognizable.

One recent project in New York City's Staten Island Bluebelt illustrates this point. A larger extended detention facility is being proposed for the Richmond Creek subwatershed to control a 400 acre headwater drainage area. The facility was initially conceived to provide a wet pond with wetland elements and extended detention of runoff from the 1 year storm. The facility is proposed within the Bluebelt park system where impacts to trees and wetlands were a major concern to the park personnel as well as the regulatory agencies.

Several alternative designs were presented to minimize wetland and forest impact while maximizing storage volume to provide downstream channel erosion protection. The real balancing act was to achieve enough storage to provide meaningful downstream channel protection and at the same time minimizing upstream impacts to a mature forest and wetland. The final acceptable solution consisted of a micro-pool wet pond with extended detention for the 1 inch rainfall and a total disturbance limit of about a half acre.

Step 6: Construction Inspections

Like any major design project, proper construction inspection and administration is integral to a successful facility. For retrofit projects, this is even more so. Retrofitting often involves construction of unique or unusual elements, such as flow splitters, underground sand filters, or stream diversions. Many of these practices are unfamiliar to many contractors. Most publicly funded projects are awarded to the low bidder who may be qualified to do the work, but has never constructed projects of this nature before. Therefore, it is almost a necessity to retain the original retrofit designer or other qualified professional to answer contractor questions, approve shop drawings, conduct regular inspections, hold regular progress meetings, conduct construction testing, and maintain construction records.

Step 7: Maintenance Plan

Always the last element to be discussed, and often the least practiced component of a stormwater management program, maintenance is doubly important in retrofit situations. The reasons are simple. Most retrofits are undersized when compared to their new development counterparts and space is at a premium in urban areas where many maintenance provisions such as access roads, stockpiling or staging areas are either absent or woefully undersized.

Designers again must balance maintenance access and storage volumes (for forebays, catch basins, and debris trapping areas) with water quality, flood control, and the other constraints discussed above.

Retrofit Case Studies

1. Example of Retrofitting an Existing Stormwater Detention Facility
Wheaton Branch, Montgomery County, Maryland

The Wheaton Branch facility, located near Wheaton, Maryland, is arguably the best know modification of a former dry detention facility retrofitted to provide water quality and channel protection controls. The facility, constructed in 1990, drains an 800 acre watershed that is over 50% impervious. A unique design feature was the three cell wet pond (constructed around an existing sanitary sewer trunk main) to provide water quality controls. Extended detention controls for the 1½ inch rainfall were incorporated for channel protection. The 3 cell pond has a complex flow path for both baseflows and small stormflows to facilitate maximum settling of solids. Controls for larger storms (i.e., 2, - 100 year events) were balanced against upstream backwater constraints and dam safety considerations. Figure 1 illustrates the key operational and design elements of the project.

The first cell of the facility, or forebay provided almost a tenth of an inch per impervious acre (this is a good target minimum volume for most retrofits). A 25 foot wide access ramp with a level 30' by 30' pad was provided for future dredging. During the design phase it was estimated that dredging of the forebay would be necessary every 5 years of so. The first cleanout of the forebay occurred in July 1997, a little over 7 years after completion of the project.

The Wheaton Branch retrofit facility was also part of the larger Sligo Creek watershed restoration project. Downstream habitat improvement and native fish restocking projects accompanied the retrofit and have proved very successful over their seven year trial period. John Galli (MWCOG), and his colleague Jim Commins (ICPRB) have published several reports and articles on the success of the stream restoration efforts in Wheaton Branch.

Some important design lessons are also illustrated by the Wheaton project. The existing hydraulic characteristics of the facility were first analyzed to assess the types of control originally provided. The original facility provided partial control of the 2, 10, and 100 year storm and safely passed the probable maximum flood (PMF) through a massive emergency spillway. The retrofit required a balancing act to maximize water quality control, while maintaining enough control for larger storms to avoid impacting downstream houses or the 100 year floodplain.

Routing storms through the 3-cell pond was extremely difficult due to the very low head conditions and the unusual backwater created by downstream ponds. The original pond bottom was excavated for much of the permanent pool storage (for pond and wetland components), the emergency spillway was modified to maintain passage of the PMF and the outlet control structure was completely overhauled.

All of these measures added up to quite an expensive project. The total cost for the facility, including engineering, construction, and construction inspection was approximately $800,000. Although this was certainly a healthy sum it equates to approximately $640,000 per square mile of drainage area. This is somewhat less than the typically quoted figure of approximately one million dollars per acre of drainage for average retrofitting (Karouna, 1989).

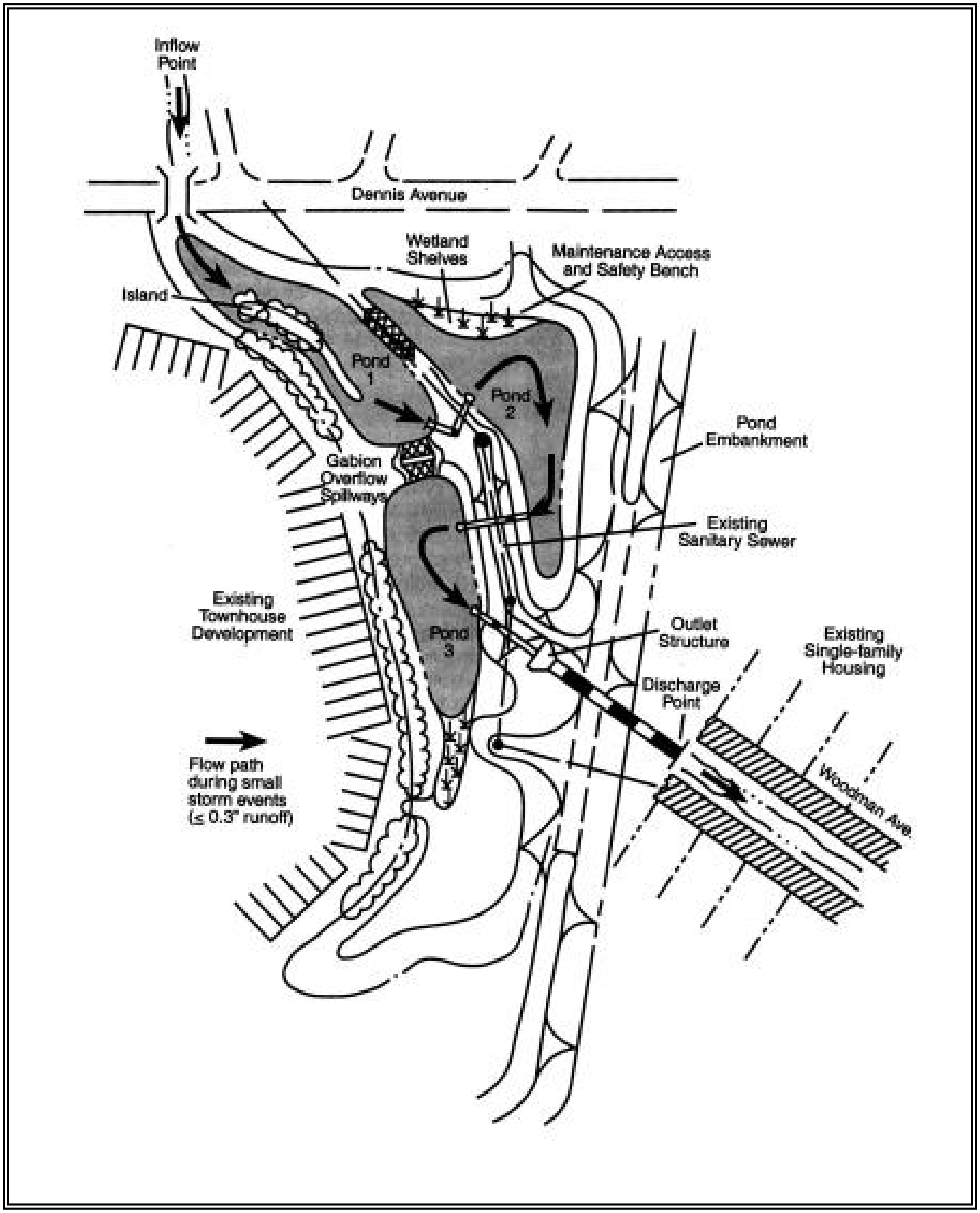

Figure 1. Wheaton Branch Retrofit Key Operations and Design Elements, Montgomery County, MD

2. Example of a Retrofit in a Highway Right-of-Way
Bear Gutter Creek, Westchester County, New York

The Bear Gutter Creek Retrofit is one of many BMPs recently designed to protect the Kensico Reservoir (one of the principle components of New York City's drinking water system) from impacts of stormwater runoff. The Bear Gutter watershed is approximately a square mile in area and drains a mixed land uses of approximately 30% impervious area directly into the Kensico Reservoir. Note that this is an unfiltered drinking water system that serves millions of New Yorkers. The retrofit is located immediately below a state road culvert and within the NY Route 22 Right-of-Way.

Interesting design features include a flow diversion weir at the downstream end of an existing large diameter road culvert that diverts baseflow and stormflow for up to the 1½ inch rainfall into a primary settling area. Storms larger than the 1½ inch rainfall are diverted to a stabilized downstream channel below the facility. The primary settling chamber is sized for about a third of an inch per impervious acre and has both a wet component and storm storage above the wet pool. An existing 1½ acre emergent wetland, adjacent to the facility receives runoff as a polishing treatment below the primary settling chamber. See Figure 2 for an illustration of the facility and representation of design features.

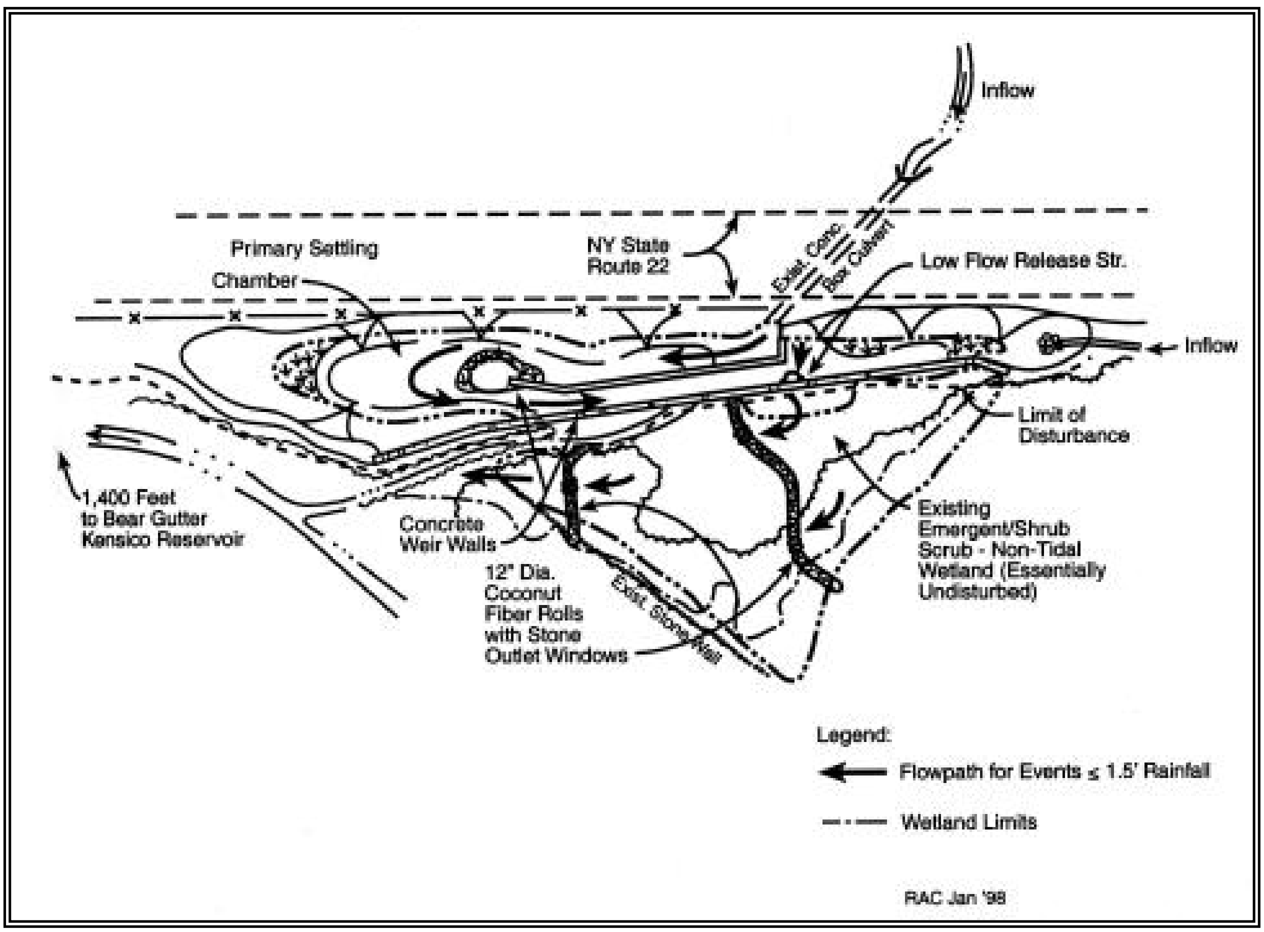

Figure 2. Bear Gutter Creek Retrofit – Illustration and Representation of Design Features

The design criteria for the Bear Gutter Creek (as well as all of the Kensico BMPs) was to provide a facility with a minimum storage volume necessary to maximize particulate settling, and provide long detention times to allow for fecal coliform die off. An original design concept called for the siting the facility within the middle of the 1½ acre wetland. Unfortunately very little space was available within the road right-of-way or anywhere else outside of the existing wetland. The solution was to use a flow diversion structure coupled with a concrete weir and baffle to maximize a flow path within the primary settling chamber and then utilize the wetland as a "polishing" treatment. Coconut rolls were specified within the wetland to encourage additional detention for controls of larger storms.

Summary -- Is Retrofitting Really That Complicated?

The answer to this question might seem elusive. Retrofitting can be a daunting task, and usually *not* an inexpensive one. The key to a successful local program is to follow a systematic and straightforward process toward implementation. The eight step process, presented above, is certainly not the only way to get projects built. Some jurisdictions identify and construct pilot projects first and then expand a program from there. Others spend much more time on planning and public involvement. Whatever the focus, one thing is for sure, retrofitting is still more of an art than a science and planners and designers who take an approach geared toward innovation will go a long way towards successfully planning, designing, and building stormwater retrofit projects.

References:

Commins, J. and J. Stribling. 1992. Wheaton Branch Retrofit Project: 1990-91 Biomonitoring Project. *ICPRB Report No. 92-1*. Interstate Commission on the Potomac River Basin, Rockville, MD

Galli, J. and T. Schueler. 1992. Wheaton Branch Stream Restoration Project. In: *Watershed Restoration Sourcebook.* Metropolitan Washington Council of Governments, Washington, DC.

Hazen and Sawyer, Inc. and Center for Watershed Protection. 1997. *Final Site Plan for BMP 67, Sub-Basin BGC-5.* Kensico Watershed Stormwater Best Management Facilities. Westchester, NY

Karouna, N. 1989. Cost Analysis of Urban Retrofits. Unpublished Report. Metropolitan Washington Council of Governments. Washington, DC.

Watershed Protection Techniques, Vol. 1, No. 4. 1995. Center for Watershed Protection. Ellicott City, Maryland.