Article 142

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Assessing the Potential for Urban Watershed Restoration

After many years of neglect and abuse, urban streams and rivers have recently become the focus of restoration efforts throughout many parts of the country. For example, Barth *et al.* (1994) identified over 50 urban watershed programs that have been organized in the last few years. Communities increasingly recognize the value of healthy aquatic systems within urban areas and are taking steps to improve the quality of degraded streams. The motivating factors underlying each program vary. For some, the goal is to improve water quality to receiving waters. In others, the objective is to enhance the urban environment and provide recreational areas. Others seek to recover aquatic diversity within urban streams. These emerging urban watershed restoration efforts are unique in that they target stormwater treatment and habitat enhancement to rehabilitate urban streams.

While many communities now share the goal of urban watershed restoration, they may not always be sure how to go about it, or whether it is really an achievable goal. This article summarizes some of the experience of the last five years in the Mid-Atlantic region. We present a detailed method to assess and identify restoration opportunities and analyze, at subwatershed scale, whether restoration is possible.

Watershed Restoration Feasibility

Before spending millions of dollars and countless hours of staff time, watershed managers must ask a simple question: *Can the watershed really be restored?* We can always do some things to improve water quality to the receiving waters or enhance stream corridor aesthetics, but we must also realize that certain constraints exist within the urban environment that may make complete restoration extremely difficult, if not impossible.

For example, in the ultra-urban setting, where impervious cover exceeds 60 to 70%, most streams may have been previously piped. These areas are going to be next to impossible to restore. Other key criteria that must be considered are identified in Table 1. Although a negative response to a single criteria probably will not make restoration infeasible, a negative response to several criteria may well signal that watershed restoration is not feasible.

In our view, there are essentially three types of urban stream restoration possible. The first is a watershed where it is feasible to at least partially restore a native biological community within the stream. The second is a watershed that acts primarily as a conduit for stormwater runoff, where it is only possible to reduce pollutants to the receiving water body, and few opportunities exist to restore the stream. The third is a watershed where both pollutant load reductions and stream restoration are not feasible, and restoration is limited to stream corridor management. This article presents a restoration process for the first type of system. For those areas where meaningful stream restoration is not attainable, some of the following process may still be useful.

Before discussing a watershed restoration process, it is useful to establish the concept of watershed scale (Figure 1). An urban watershed may be several square miles in area and consist of several major stream systems. A subwatershed usually encompasses first or second order tributaries to the main stream and has a drainage area of approximately 1,000 to 1,500 acres (this can vary depending on regional differences). A subwatershed then consists of several catchments, which usually have drainage areas between 50 and 500 acres.

Meaningful watershed restoration must be conducted at the subwatershed scale for several reasons. First, not all subwatersheds within an urban watershed will have the same level of impervious cover, and therefore impacts and restoration opportunities often

Table 1: Subwatershed Restoration Screening Criteria: Is Restoration Feasible?

- Are stream valley parks present within the subwatershed?
- Is there available public or military land?
- Are the streams and waterways open channels?
- Is prior biological data available for the stream?
- Does the local government have a small-scale GIS database of watershed information?
- Does the subwatershed have a moderate impervious cover (i.e., less than 60 %)?
- Does the local government have a stream buffer program?
- Have stormwater detention structures been historically installed in the subwatershed?
- Are there existing floodways within the subwatershed?

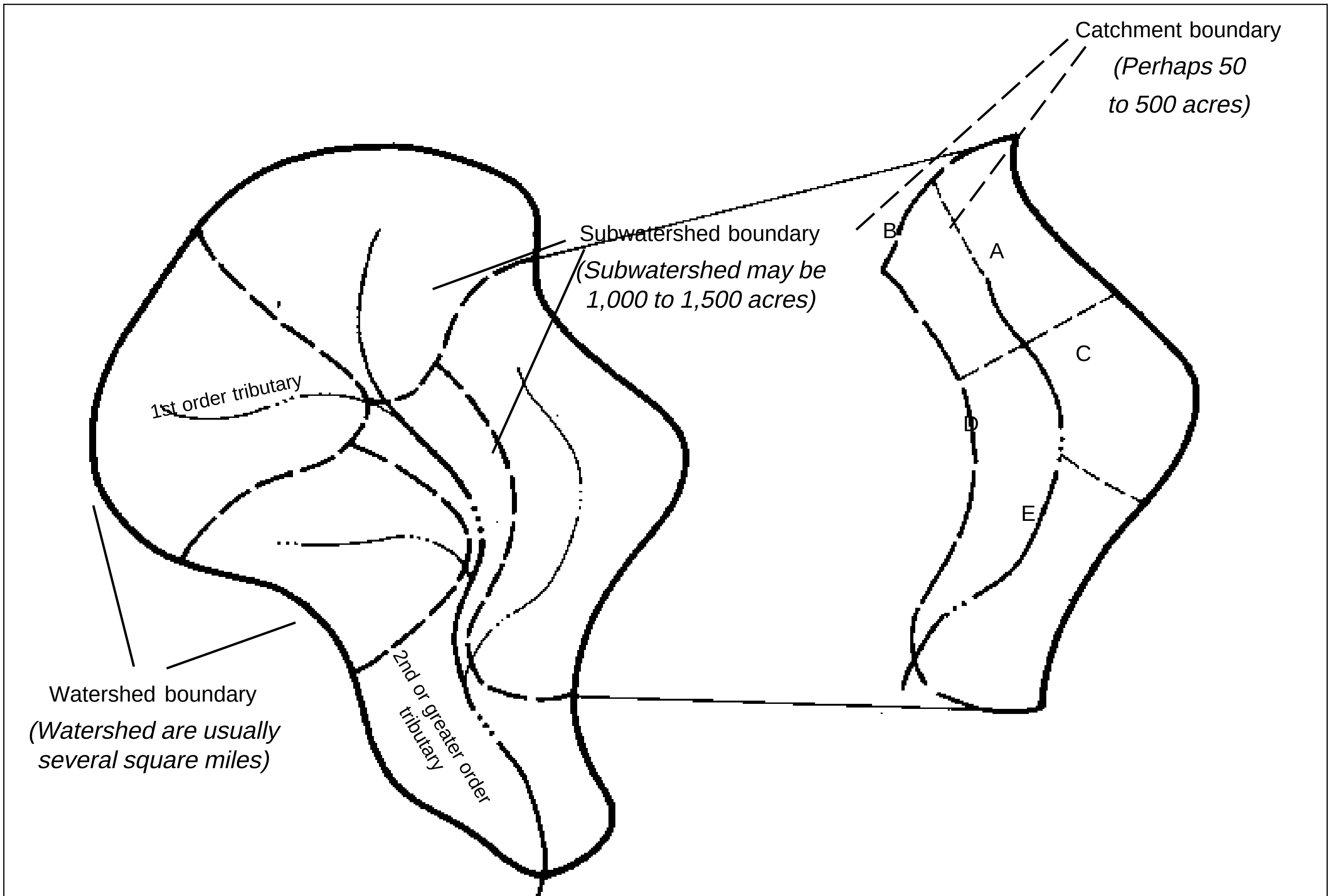

Figure 1: Watershed Scale: Watershed, Subwatershed, and Catchment

differ between subwatersheds. Second, it is easier to identify structural restoration sites and other opportunities at the subwatershed level. Third, local neighborhoods often fall within the scale of the subwatershed, making it easier to target pollution prevention efforts. Finally, and perhaps most importantly, the subwatershed scale is small enough to accurately measure the percentage of subwatershed area that can be treated by stormwater retrofits. We refer to this as the "control area." This concept is extremely important when choosing priority subwatersheds for restoration.

Watershed restoration usually takes decades to implement, whereas subwatershed efforts can be accomplished in shorter time periods. Some subwatersheds may receive stream restoration, while others may receive only corridor management measures. Therefore, by concentrating on one subwatershed at a time, we can measure improvement to that aquatic system while still contributing improvements to the watershed as a whole.

Watershed managers should keep several principles in mind when embarking on a watershed restoration effort. First, urban watershed restoration is primarily a question of what is possible. When striving to restore basic ecological functions to the aquatic environment, watershed managers need to look at current and past land use and stream quality to set realistic and achievable goals for the future. Another prerequisite is to establish a partnership approach. Many different agencies, organizations, and professionals will need to coordinate together to implement projects. A successful restoration plan will require strong fiscal and staff commitments. Some past efforts have failed because inadequate resources were available to complete the effort. Watershed restoration can also involve substantial change within the community. A strong educational program that involves local residents early in the restoration process can help explain the purpose of projects and provide support for the most intrusive changes.

Urban Watershed Restoration Process

The following process identifies a three-pronged approach to watershed restoration through **stormwater retrofitting, pollution prevention**, and **stream en-**

hancement. This process is recommended to achieve realistic improvements in aquatic communities for urban streams within the subwatershed context. Table 2 highlights the major components of the watershed restoration process.

The restoration process begins with an analysis of existing stream channel and subwatershed conditions. Several alternative stream assessment techniques are available to evaluate existing conditions. Stream characterization studies that identify biological communities such as macroinvertebrates or fish may be conducted. Land use assessments that measure impervious cover or percent industrial/commercial land may also be appropriate. Chemical water quality monitoring data may be collected or physical stream geometry parameters may be studied. The more detailed the assessment, the more useful it will be in developing a restoration plan. However, since most programs have limited money, an assessment that quickly provides information and identifies problem areas is most practical. A review of any past monitoring data (physical, chemical and biological) coupled with a rapid watershed wide monitoring protocol, such as the Rapid Stream Assessment Technique (RSAT) (Galli, 1993) is an ideal tool for documenting existing conditions and identifying problem areas.

Urban Watershed Retrofit Process

Once an analysis of existing conditions has been completed, a structural retrofit inventory is conducted. This process involves identifying subwatersheds, locating candidate retrofit sites and determining how much area within the subwatersheds can be controlled.

1. Desktop Survey of Potential Candidate Stormwater Practice Sites

The first step of the process consists of identifying candidate retrofit sites through a desktop survey. To begin, the watershed is subdivided into subwatersheds that range from 1,000 to 1,500 acres in size. This unit forms the fundamental basis for further restoration analysis. Subwatersheds, in turn, are subdivided into individual catchments ranging from 50 to 500 acres in size. Once these drainage units are mapped, low altitude color areal photographs are used to locate potential retrofit sites. Several additional mapping sources are also needed to select candidate sites, including the following:

- Topography (usually at a scale of 1"=200' or finer)
- Impervious cover based on land use/zoning maps
- Property ownership (usually available through tax maps)
- Open space parcels (using a recent aerial photograph and land use maps)
- Existing drainage network (including storm drainage pipes and open channels)

The best potential retrofit sites are usually located adjacent to existing engineered or natural channels, at the outfall of a storm drainage pipe or within an existing older stormwater management facility. Undeveloped parkland and open space areas, golf courses, wide floodplains, highway rights-of-way, and parking lot edges are also good places to look (see article 143 for more information on the details of stormwater retrofitting).

Good potential retrofit sites generally have the following characteristics:

- Within an existing open area (not forested and not occupied by existing structures)
- Has sufficient runoff storage capacity for the tributary catchment
- Feasible to divert stormwater to potential facility
- The site should have a drainage area large enough to make a meaningful contribution to the water quality of the catchment

2. Comprehensive Field Survey of Candidate Stormwater Practice Sites

Candidate retrofit sites meeting the desktop criteria are then field verified using a retrofit inventory sheet (RIS). The RIS includes site-specific information on location, ownership, approximate drainage area, utility locations, etc. An appropriate stormwater retrofit to meet the site specific constraints is identified in the field.

Table 2: Watershed Restoration Process

- Create intergovernmental/partnership agreements where necessary
- Conduct watershed assessment
  - Monitoring
  - Mapping
  - Stream reconnaissance
- Perform subwatershed delineations
- Characterize subwatershed conditions
- Evaluate candidate retrofit opportunities
- Conduct informational workshops and review retrofit opportunities with resident groups
- Assess stream restoration opportunities
- Assemble restoration opportunities into inventory
- Perform pollution prevention opportunity surveys
- Select priority subwatershed for demonstration projects
- Rank individual projects
- Develop comprehensive watershed/subwatershed plan
- Incorporate public involvement and active participation
- Initiate project implementation
- Evaluate restoration efforts

Table 3: Sample Retrofit Scoring System

Description	Score
Pollutant Load Reduction (1 - 10 points)	
Storage	
0.00 -0.25 ac-ft	1 pt
0.26 - 1.00 ac-ft	2 pt
1.01 - 2.00 ac-ft	3 pt
2.01 - 4.00 ac-ft	4 pt
4.01 or more	5 pt
Pollutant Load Reduction (1 - 10 points)	
0% - 10%	1 pt
11% - 30%	2 pt
31% - 40%	3 pt
41% - 50%	4 pt
51% or more	5 pt
Stream Restoration Score (1 - 5 points)	
Directly reduces downstream velocities	1 pt
Provides extended detention control for subbankfull floods	2 pt
Provides habitat or supports fishery reintroduction	3 to 5 pt
Cost Score (1 - 5 points)	
Construction cost estimated at less than $10,000	5 pt
Between $10,001 and $25,000	4 pt
Between $25,001 and $50,000	3 pt
Between $50,001 and $100,000	2 pt
More than $100,000	1 pt
Ease of Implementation Score (1 - 5 points)	
Publicly owned site	2 pt
Access and staging are good or excellent	1 pt
Existing maintenance authority is in place	1 pt
No major wetland permits or other approvals needed	1 pt
Public Benefit (1 - 5 points)	
Site located in priority watershed	1 pt
Benefits small scale citizen habitat project	1 pt
Provides community visibility or amenity	1 pt
Provides environmental education/monitoring opportunity	1 pt
Supports a partnership effort	1 pt

Note: Sample scoring system based on Mid-Atlantic region. Scouring parameters and point ranges may vary from region to region.

In addition, the investigator verifies approximate wetland limits, notes stream conditions, and potential conflicts with or limitations from utility crossings, construction and maintenance access. Potential conflicts with sensitive resources and adjacent land uses are cataloged, available storage estimated, and a preliminary concept sketch is prepared. Photographs are also be taken of the site and vicinity. It is helpful to prepare a field package before visiting each site. The field package contains background information each candidate site, such as topographic maps, storm drainage network wetland maps, and any utility information.

3. Subwatershed Inventory

Once the field investigation is complete, each feasible retrofit site is cataloged in a retrofit inventory. The concept sketches are refined and site specific information added. A preliminary cost estimate is prepared and the RIS is finalized. Often, more than one type of stormwater practice may be designated as suitable for a particular location.

The completed inventory is then used to compute the amount of area controlled within the subwatershed. The total area of the subwatershed draining to proposed retrofit sites is used to select priority subwatersheds for restoration implementation. A sample scoring system (Table 3) provides watershed managers with a tool for allocating resources and developing an implementation approach for construction of specific projects. Scoring parameters can be modified for regional differences or to place extra emphasis on a particular issue of concern.

In some watersheds, prioritizing restoration efforts can be targeted by estimating urban pollutant loads to receiving waters, to identify which land uses within subwatersheds are contributing the greatest load to the receiving waters. In other watersheds, efforts are targeted on the basis of a stream quality ranking system that incorporates parameters such as habitat value and stream geometry.

Watershed Source Control through Pollution Prevention

The second major component of watershed restoration involves identifying and implementing source control measures within selected subwatersheds. Controlling pollution at its source must be a major objective. The best structural stormwater practice retrofits have pollutant removal efficiencies ranging from 40% to 80%, but still discharge some pollutants downstream (Schueler, 1994). Even the best stormwater retrofit program usually cannot control 100% of the subwatershed area. The goal of source control is to prevent pollutants from entering the storm drain network in the first place. The biggest challenge for watershed managers is that an effective source control requires changing people's

behavior. Therefore, efforts geared towards watershed education and behavior modification are likely to have big payoffs.

A good method to identify source control opportunities targets the major land uses within a subwatershed (industrial land uses, which are permitted under the NPDES program, may be handled separately). Where possible, commercial property owners should be identified. Once this is done, business coalitions throughout the subwatershed can be formed for distinct commercial clusters, or by grouping similar businesses together (e.g., vehicle maintenance, food service, warehouse, general retail, etc.)

A random non-regulatory field survey of commercial properties should be conducted to identify evidence of pollutants entering storm drains. Field investigators should look for the presence or absence of pollution prevention practices. The type of practices identified will depend to some extent on the type of business. The type of source control practices to look for are listed in Table 4. The survey should document the location and name of the business, owner information, approximate site area, and approximate impervious area.

Once the survey is complete, business coalition representatives should be selected to help administer the source control program. Informational flyers, targeted at specific businesses (such as automotive-related services), can be distributed to the coalition representatives. The local coalitions will be responsible for implementation of good housekeeping practices, monitoring compliance, and reporting results. Local governments may consider incentives to promote participation in this type of a program, such as special tax incentives, advertising subsidies for environmentally friendly businesses, or special subsidies for stormwater practice implementation.

A residential source control program involves a general review of the residential housekeeping of the watershed. A survey of subwatershed general conditions is conducted, and restoration opportunities targeting specific areas for reducing pollutants are identified (Table 5).

Once the residential survey is complete, homeowner associations and other community involvement groups are contacted to inform their members about the things they can do to reduce pollutants in the streams. Public attitude surveys are one way to assess citizen knowledge of watershed problems and to raise public awareness about watershed restoration issues (Smith *et al.*, 1994). Informational flyers on proper lawn care, auto care, disposal of yard wastes, and recycling of used oil and antifreeze are often included in public education programs. Stream stewardship can also be fostered by storm drain stenciling programs, neighborhood stream clean-up efforts, tree planting days and resident monitoring programs.

Urban Stream Enhancement Procedures

For those subwatersheds where biological diversity is to be enhanced, it is critical to assess the condition of the instream aquatic habitat. In many urban streams, the physical changes to channel geometry and habitat are so severe that few places remain to accommodate aquatic life. In order to restore diverse aquatic community, it is often necessary to physically reconstruct instream habitat structure.

A number of habitat-enhancement tools may be used to re-construct in-stream habitat, depending on the conditions of the stream in question. Pool/riffle sequences may be re-established, fish cover may be provided, channel morphology stabilized, fish barriers removed, and streamside areas revegetated. Several habitat enhancement techniques are presented in Table 6 and discussed in greater detail in article 144 to 150.

Before specific habitat enhancement techniques are proposed, it is necessary to know where and when they are appropriate for the stream. Much of this work can be accomplished during the existing stream condition assessments. Using the RSAT method, for example, field investigators can identify enhancement opportunities while documenting existing conditions.

Using RSAT, the stream network is divided into reach lengths and two to three assessments are conducted over each reach. The segments are evaluated for the following parameters: riparian cover condition, presence and severity of streambank erosion, pool/riffle quality, substrate condition, channel debris, condition of adjacent floodplain, presence of fish barriers, evi-

Table 4: Pollution Prevention, Commercial Properties

Check for the Following Good Housekeeping Measures

- Covered material storage or material stored inside
- Covered dumpster & no dumpster spillage
- Maintenance of vehicles inside
- Floor drains connected to sanitary sewer system
- Aboveground storage tanks with secondary containment
- Vehicle washing and steam cleaning using specified wash systems and connected to sanitary sewer
- Covered loading docks
- Covered vehicle refueling areas
- Absence of trash and debris
- Absence of eroded areas and lack of bare surfaces
- Adequate maintenance of BMPs
- Disconnected impervious surfaces

Table 5: Pollution Prevention Survey, Residential Areas

- Condition of storm drainage system (outfall, catchbasins)
- Condition of roadway surfaces
- Are storm drain inlets and catchbasins stenciled?
- Condition of pervious areas (needless turf, erosion areas, etc.)?
- Condition of residential lawn quality (is there evidence of excessive use of fertilizer?)
- Are there many vacant lots with local dumping of lawn refuge and other trash and debris?
- Is there evidence of substantial residential auto care and car washing?
- Are there opportunities for reforestation/revegetation?
- Identify candidates for stream stewardship

dence of exposed or leaking sanitary sewers, visible water quality impairment. In addition, adjacent land uses and property ownership, access points for heavy equipment, and presence of adjacent wetlands are documented.

The Cost of Urban Watershed Restoration

To date, there have been relatively few urban watershed restoration plans completed and even fewer that have been implemented. There is almost no data on the costs to implement a complete urban watershed restoration plan. One estimate, dating to the early 1990s, put restoration efforts within the Anacostia River Watershed at between approximately one-half to one million dollars per square mile of area (ART, 1992). Clearly, more information is necessary to approximate urban watershed restoration costs.

We can gain some information by looking at the costs of individual practices. For example, structural retrofits can range in cost from as little as $10,000 for minor modifications to an existing stormwater pond to as much as $750,000, or more for complete design and construction of a major wet, extended detention facility (Karouna, 1989). The implementation of a public outreach program for a moderately sized subwatershed in Prince George's County, Maryland costs approximately $30,000 annually (Paul, 1995). The cost to area businesses to implement and maintain pollution prevention practices might vary from a few hundred dollars to several thousand dollars per business per year, depending on the type of business. Stream enhancement projects can range in cost from a few thousand dollars for projects relying on donated plant materials and volunteer labor to $500,000 per mile for complete reconstruction of the stream channel geometry, bank stabilization and riparian revegetation (Black and Veatch, 1994).

Conclusion

Human activity has impacted the biological integrity and physical characteristics of many urban stream systems. Watershed restoration provides an opportunity to undo many past mistakes; however, many activities have created situations where complete restoration to pre-human conditions is impossible. A realistic program which recognizes limitations of a restoration program and targets a specific approach is essential. Watershed managers must recognize when to attempt comprehensive watershed restoration and when to pursue strictly stream corridor management strategies. An effective watershed restoration program is most likely to reach successful results when conducted at the subwatershed scale.

A comprehensive watershed restoration plan incorporates several complementary aspects. Stormwater retrofits can mitigate altered stormwater runoff and reduce pollutant loads, but cannot revive an aquatic system by themselves. Pollution prevention helps reduce pollutants at the source but does not affect the peak flows and erosive conditions in the stream. Stream habitat restoration may provide increased stream channel stability and create conditions where aquatic species might prosper, but without reductions in pollutant load, biological diversity is not likely to improve. Urban watershed restoration must be looked at in a comprehensive manner where each element plays a role in producing conditions where the aquatic community and humans can live side by side.

Table 6: Urban Stream Restoration Goals

Urban Stream Restoration Goals	Techniques/Methods
Control Urban Hydrologic Regime	■ Upstream structural retrofits ■ Parallel pipe systems
Remove Urban Pollutants	■ Source control pollution prevention efforts ■ Upstream structural retrofits ■ Increased/enhanced stream buffers ■ Elimination of illicit connections ■ Erosion & sediment controls
Restore Instream Habitat Structure	■ Create pools/riffles ■ Confine and deepen low flow channels ■ Provide structural complexity ■ Provide in-stream fish cover
Stabilize Channel Morphology	■ Enhance channel geometry (length to width ratio, meander patterns, etc. ■ Stabilize severe bank erosion ■ Stabilize channel and bed to accommodate bank full discharge
Replace/Augment Riparian Cover	■ Provide enhanced tree canopy over headwater streams ■ Stabilize stream banks ■ Provide instream overhead cover ■ Revegetate stream banks and buffers
Protect Critical Stream Substrates	■ Erosion and sediment controls ■ Riffle creation ■ Mechanical stream substrate cleanout ("Mudsucker") ■ Enhance steam buffers
Recolonize Stream Community	■ Remove fish migration barriers ■ Selectively reintroduce pre-disturbance native fish community (where appropriate)

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