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MANAGEMENT AND RESTORATION

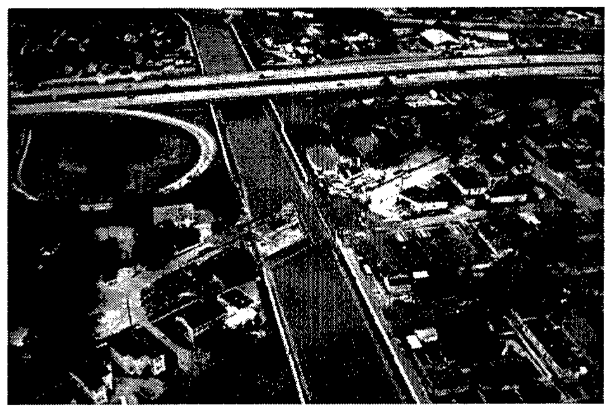
Technology News from the Ecosystem Management and Restoration Research Program May 2001

Technologies for urban stream restoration and watershed management

by J. Craig Fischenich

As recently as 100 years ago, the United States was a nation of farmers. Today, 80 percent of us live in urban and suburban areas. The 1997 National Resource Inventory (Natural Resource Conservation Service (NRCS) 1997) showed a 13-percent increase in developed land within the United States in the preceding 5 years. Population growth in Los Angeles or in Atlanta is in excess of 400 people per day (2000 Census), and, on average, 40 acres of land each day is converted from forest or agriculture to urban uses in each of these communities. As our population continues to grow and sprawl into the surrounding environment, our streams and riparian zones suffer enormous impacts. These impacts carry an ecological and economic price tag.

One of the fastest growing segments of the Corps of Engineers' Civil Works budget is the restoration of streams and channels within urban environments. The Corps and others have begun to explicitly recognize that the environmental effects of development during the last century are now ripe for remedial action. While the quality of our lives has improved in many ways, our ability to sustain that quality of life requires that we restore many of the natural structures and functions



Urbanization profoundly influences the function and character of stream and riparian ecosystems

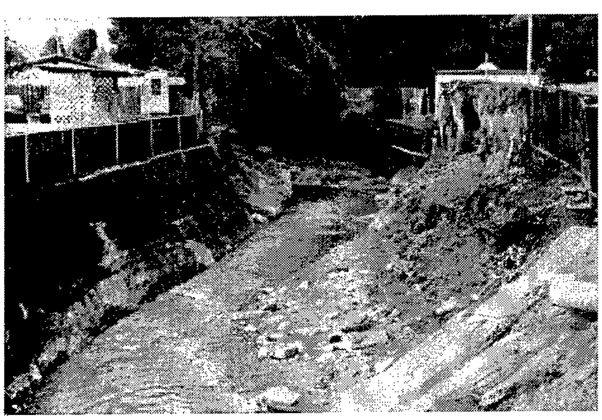
within our environment that have been damaged and disrupted. The impetus for this is not based on narrowly constructed views of environmental quality alone. There is, in fact, increasing recognition of the social, economic, and ecological values of such endeavors. For the Corps of Engineers, the 21st Century may become a century of restoration.

But approaches commonly employed to restore and manage rural streams often do not work for urban streams, and Corps Districts are searching for methods that address the challenges posed in urban environments. Pre-impact conditions can seldom be restored in these systems, and projects designed to replicate historic conditions are likely to fail. Techniques based upon the use of reference systems are impractical because suitable reference data do not exist. Urban streams are continually adjusting to alterations in the watershed's hydrology and sediment yield, which in turn change as watershed development progresses. This adjustment process often lags development by decades – so establishing a reasonable baseline condition for urban streams is problematic. Constraints posed by existing infrastructure, rights-of-way, and diverse local interests present additional challenges. A better understanding of the relative roles of storm water management, riparian buffer establishment, and stream restoration is needed to effectively implement restoration and watershed management projects in urban environments. An objective function-based system to evaluate urban watershed conditions and benefits of and interactions among management alternatives has yet to be developed. Help is especially needed for General Investigations, Challenge 21, and the Continuing Authorities Programs including Sections 204, 206, and 1135, but is also needed to support regulatory reviews and all Corps business practices.

Impacts of Urbanization

The conversion of forests, farmland, wood lots, wetlands, and pasture to residential areas and commercial and industrial developments directly impacts stream and riparian corridors by:

- ➢ Altering stream channels through straightening, lining, or placement in culverts.
- ➢ Reducing riparian corridor width through floodplain encroachments.
- ➢ Increasing sediment yield during development and increasing pollutant loading following development.
- ➢ Displacing native riparian plant communities by invasive non-natives.



Increased runoff from urbanization causes channels to erode and incise – diminishing habitat quality and threatening infrastructure.

In addition to these direct impacts, urbanization changes the runoff and sediment yield characteristics of a watershed. Hydrology and sediment yield are the principal variables that define the shape, character, and quality of a watershed's streams. Streams adjust to these changes - within the constraints imposed by bridges, pipeline crossings, bank stabilization measures, and dams – to establish a new equilibrium condition that is markedly different than their "natural" state. These indirect impacts are often more significant than the direct impacts and include the following:

- ➢ Greater and more frequent peak storm flows, and longer duration of stream flows capable of altering channel beds and banks.
- ➢ Enlargement of the channel through incision and widening processes.
- ➢ Decreased recharge of shallow and medium-depth aquifers that sustain base and low flows.
- ➢ Increased stream temperatures and higher nutrient and contaminant loading.
- ➢ Alteration of the channel substrate.
- ➢ Reduction of stream system function.
- ➢ Reduction of riparian corridor function.
- ➢ Reduction of native wildlife species.

Incision can migrate upstream in the form of headcuts that erode tributaries and damage infrastructure

Changes in sediment load, flow regime, and boundary conditions associated with channelization and urbanization can disrupt stream equilibrium, resulting in rapid channel enlargement through the process of incision. In a typical incising channel, the streambed degrades until critical bank height is exceeded and the bank fails, increasing channel width and sediment load. In many cases, nick points and nick zones migrate upstream and destabilize a large part of the watershed. A new equilibrium may take decades or even centuries to achieve.

A typical incised channel is deep, broad, and lacks a defined or stable low-flow channel. The banks are steep and subject to ongoing erosion. Pool habitat is usually lacking and riparian vegetation is often rare or absent. Much of the original floodplain habitat may have been destroyed by erosion or left permanently dry by the receding streambed. Incising channels have been a major cause of destruction and deterioration of floodplain habitats and associated wetlands.

In urban watersheds, the impervious surface increases runoff and is the primary driving factor in the incision process. In addition to increasing runoff, urbanization decreases the magnitude of baseflows by limiting infiltration, and increases the duration and frequency of runoff events. Both can systemically affect the physical character of the channel and the overall environmental condition of the stream. Conventional thought holds that significant degradation to stream stability, habitat, and water quality occurs at levels of imperviousness on the order of 10 to 15 percent.

Channelization and increased runoff from urbanization adversely affect biological diversity in streams. The abundance and diversity of fish and aquatic insects decreases markedly with level of impact to a stream. In addition, native species are often displaced by non-native species having higher pollution tolerances. Impervious surfaces collect and accumulate pollutants deposited from the atmosphere, leaked from vehicles, or derived from other sources. During storms, accumulated pollutants are quickly washed off, and are rapidly delivered to aquatic systems. Urban streams often contain dangerously high levels of heavy metals, bacteria, fecal coliforms, and other pollutants. These, in turn, affect the biota of the stream and its potential use for recreation.

Water temperature in headwater streams is strongly influenced by local air temperatures. Impervious surfaces both absorb and reflect heat. During the summer months, impervious areas can have local air and ground temperatures that are 10 to 12 deg warmer than the fields and forests that they replace. The trees that could have provided shade to offset the effects of solar radiation are absent, as well. Stream temperatures throughout the summer are increased in urban watersheds, and the degree of warming appears to be directly related to the imperviousness of the contributing watershed.

Economics of Stream Degradation

Some consider restoration a moral imperative serving a need to regain an intimate relationship between nature and the human culture. However, a more pragmatic reason for restoration and good resource stewardship is based upon simple economics. Stream and riparian ecosystems damaged by urbanization cost taxpayers billions of dollars annually, and reduce potential goods and services rendered by healthy ecosystems.

Obvious costs are those associated with remedial activities, including infrastructure repair and replacement, flood control improvements, storm water management, and erosion control. Bridge and culvert replacements and the development of regional facilities for storm water detention add to the costs that must be borne by taxpayers. Costs of stream degradation other than those associated with capitol improvements are more difficult to characterize. It is virtually impossible to place a dollar value on the lost flora and fauna, and other environmental impacts are likewise difficult to monetize.

Non-point-source pollution discharges regulated by the EPA under the Clean Water Act can cost urban taxpayers from $2,000 to $35,000 per impervious acre (Center for Watershed Protection 1997). On a typical construction site, the cost to install and maintain erosion and sediment control can average $800 to $1,500 per cleared acre per year (Paterson et al. 1993). Over a 20- to 25-year period, the full cost to maintain a storm water BMP is roughly equal to its initial construction costs (Wiegand et al. 1986).

The value of retaining riparian corridors as "greenways" is well-documented. The economic impact on the community as a whole by taking land off the tax rolls for greenway conservation is more than offset by other economic returns. For example, the U.S. Environmental Protection Agency (USEPA) (1995) recently analyzed 20 real estate studies across the United States and found that developers could charge a per-lot premium of up to $10,000 for homes situated next to well-designed storm water ponds. Sale prices were nearly one-third higher for homes that had a view of a storm water wetland compared to homes without any "waterfront" influence in a comparison of home prices in Minnesota (Clean Water Partnership 1996).

Many studies have demonstrated that taxable properties adjacent to greenways increase in value and generate greater overall tax revenue for a community. Greenways and other public open spaces also generate economic activity for community businesses and serve as a magnet for tourists and businesses looking to relocate. The following examples reinforce these points:

In Boulder, Colorado, housing prices declined an average of $4.20 for each foot of distance from a greenbelt, up to 3,200 ft away, and in one neighborhood the average decline was $10.20 for each foot of distance. The study showed the average value of property adjacent to the greenbelt to be 32 percent greater than similar properties 3,200 ft away. It also reported the aggregate property value was approximately $5.4 million greater than if there had been no greenbelt, and the tax revenue alone could recover the initial cost of the $1.5-million greenbelt in 3 years (Corrill et al. 1978).

➢ In Durham, North Carolina, market value of homes decreased by $5.51 for each foot away from the Eno River open space corridor (Florida Department of Environmental Protection (DEP) (1999)).

➢ Urban land in Salem, Oregon adjacent to greenbelt (rural farmland) was worth more than $1,200 more per acre than urban land 1,000 ft away (Nelson 1986).

- ➢Property surrounding four greenway parks in Worchester, Massachusetts showed a house located 20 ft from a park sold for $2,675 more than a similar house 2,000 ft away. The study calculated that 219 acres of park land generated $349,195 of economic benefit (More, Stevens, and Allen1982).
- ➢Property values of undeveloped land near the Boise River Greenbelt are $26,000 to $34,000 per acre contrasted with similar land nearby, but not on the greenbelt, valued at $10,000 to 17,000 per acre (Florida DEP 1999).

Greenways also offer potential opportunities to sharing corridors with utilities and other linear facilities including pipelines and fiber-optic cables. The Florida Department of Environmental Protection (1999) reported several examples of income being generated from leases that allow linear facilities to share both aboveground and below-ground development rights:

- ➢The Ventura County, California, Parks Department receives over $36,000 annually from utility leases along and across the Ojai Valley Trail.
- ➢The Paint Creek Trail in Michigan receives $2,000 annually for electric and pipelines along the corridor.
- ➢The Burke-Gilman Trail in Seattle, Washington, has a 25-year lease with U.S. Sprint for a fiber-optics line that will generate $728,000.
- ➢The Cedar Valley Nature Trail in Iowa granted a perpetual easement to Northwestern Bell for a fiber-optics line for $12,000.
- ➢The Northern Virginia Regional Park Authority has generated approximately $1 million from leases along the Washington and Old Dominion Railroad Trail. Included are $250,00 from AT&T, $10,000 annually from natural gas providers, $5,000 annually from television, cable, and telephone companies, and $30,000 for fiber-optic companies (Florida State University 1989).
- ➢AT&T purchased a 36-mile-long right of way for a fiber-optics line and donated the surface to the State of Washington for the Iron Horse Trail.
- ➢The University of Washington allowed U.S. Sprint to use 1.7 miles of a trail in exchange for $113,000 worth of fiber-optic cables in university facilities.
- ➢A perpetual easement on the Glacial Drumlin State Park Trail was granted to U.S. Telecomm in exchange for paving the entire trail, which cost $375,000.

Greenways can provide a multitude of benefits for people, wildlife, and the economy. More expansive and flexible than traditional, more confined parks, greenways can provide a kind of community trail system for the linear forms of outdoor recreation Americans are engaged in today, such as: hiking, jogging, bicycling, rollerblading, horseback riding, cross-country skiing, or just plain strolling.

Spending by residents on greenway-related activities helps support recreation-oriented businesses and employment, as well as other businesses that are patronized by greenway users. Greenways often provide new business opportunities and locations for commercial activities like bed and breakfast establishments, and bike and canoe rental shops. Greenways are often major tourist attractions, which generate expenditures on lodging, food, and recreation-oriented services.

The Urban Restoration Challenge

The National Research Council (1992) provides the following comprehensive definition of restoration:

> … return of an ecosystem to a close approximation of its condition prior to disturbance. In restoration, ecological damage to the resource is repaired. Both the structure and the functions of the ecosystem are recreated. Merely recreating the form without the functions, or the functions in an artificial configuration bearing little resemblance to a natural resource, does not constitute restoration. (p. 18).

Meeting this definition is typically impossible within urban ecosystems because the parameters that drive the basic processes have been forever altered. Nevertheless, several systematic actions can be taken to arrest degradation and enhance ecological functions of urban streams, riparian corridors, and watersheds. These actions have been shown by numerous studies to enhance ecological function, increase local property values and quality of life, and include the following:

- ➢ Secure and develop buffers through conservation easements that will provide long-term protection to high-quality habitats and water resources within the corridor.
- ➢ Enhance surface water management by constructing stormwater detention and water quality facilities to reduce hydrologic and geomorphic impacts, improve water quality, and protect fish and wildlife habitat.
- ➢ Implement specific corridor enhancement and restoration activities that will remediate existing problems or prevent future problems with regard to geomorphology, vegetation, and fish and wildlife habitat.
- ➢ Implement zoning regulations and management practices aimed at reducing identifiable impacts from urbanization activities.

Research Under the EMRRP

A new research work unit was established under the EMRRP to address the challenge of urban stream restoration and watershed management. The objectives of this work unit are to (a) develop detailed technical guidance for the evaluation, restoration, and management of urban streams and watersheds, and (b) formulate the tools needed by District personnel to effectively execute the planning, design, operation, and regulation of urban water resource projects. The guidance and support tools will enable Districts to better develop restoration and management alternatives and designs for urban watersheds.

Many of the specific field needs related to this work unit have been previously identified under the EMRRP work unit "Stream and Riparian Ecosystem Restoration, Enhancement, and Management," and additional needs will be solicited from the EMRRP FRG and other District personnel.

Clear and concise guidelines will be developed to address each of these needs and issued in technical notes (TNs), as part of the Stream Restoration TN Series of the aforementioned work unit. Guidance presented in these technical notes will be provided to Districts for evaluation in terms of applicability, effectiveness, ease of use, and cost. Guidelines and support tools will be modified as appropriate based on the Districts' evaluations. Given the immediacy of the need for this guidance, a compressed schedule that builds upon successes from previous research under the EMRRP is being employed in executing the research. The technical notes and tools will be completed within 2 years, and only part of a third year will be devoted to compilation and dissemination on the Internet.

The products of this work unit will provide District personnel with the means to effectively formulate and evaluate alternatives for stream restoration, flood damage reduction, navigation, and recreation projects in urban watersheds. The ability to quantify the benefits of various storm water management, riparian enhancement, and stream restoration options, and their interactions, will greatly enhance the Corps' ability to develop effective design solutions and will entrench the Corps' position as the leading authority on the subject. Our ability to identify environmental enhancement opportunities achieved through changes in operations practices such as reservoir releases and sediment management in navigable waterways will be improved. The products will provide Corps regulatory authorities with the tools to effectively evaluate impacts and public interest. The return on investment for this work unit should be tremendous as the cost can easily be recaptured in savings from a single urban stream project.

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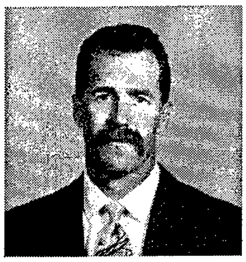

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Upcoming Conference

The ERDC is a cooperating organization for the upcoming ASCE Wetlands Engineering and River Restoration Conference to be held August 27-31, 2001 at the Hilton Hotel in Reno, Nevada. The conference is intended to promote interaction and discussion among engineers, scientists, and other professionals involved with the planning, design, construction, operation, research, policy, regulation, and educational aspects of wetlands and river restoration projects.

The conference will include a number of workshop discussions and focused technical sessions that include short papers with a moderator to facilitate discussion. A number of research efforts under the EMRRP will be highlighted. The technical program will be divided into three tracks: Wetland Creation & Restoration, Watershed Management, and River Restoration. Each track will have two concurrent sessions, and an additional (seventh) track will be devoted to panel discussions, workshops, and technical sessions related to specific interests. Nearly half of the papers are invited to ensure the highest quality for the technical program. Keynote speeches, poster sessions, and exhibits will further promote information exchange. Half-day field trips to local stream restoration and wetland projects will be planned for the middle of the week.

For additional information on the conference, check the conference Website at: *http://www.asce.org/conferences/wetlands2001/home.html*

Upcoming Events

Jun 4-8, 2001 – Northern California, "Advanced Plant Identification (Grasses, sedges, rushes, and aster)," **POC:** Robert Lichvar, 603-646-4657, *Robert.W.Lichvar@crrel.usace.army.mil*

Jun 19-21, 2001 – Coeur d'Alene, 1D, training course for field personnel responsible for delineating wetlands or for those seeking an update on interpreting wetland soils. **POC:** Chris Noble, 601-634-3482, *Chris.V.Noble@erdc.usace.army.mil*

Jul 30-Aug 3, 2001 – Basic Wetland Plant Identification – U.S. Fish and Wildlife Service, National Conservation Training Center, Sheperdstown, WV. **POC:** Robert Lichvar, 603-646-4657, *Robert.W.Lichvar@crrel.usace.army.mil*

EMRRP-EI-01	Quantifying Habitat Benefits of Restored Backwaters, July 2000
EMRRP-EM-01	Linking Biological Models and Spatial Descriptions of Environmental Complexity with Coupled Models, July 2000
EMRRP-SI-09	Width of Riparian Zones for Birds, January 2000
EMRRP-SI-10	Characterization of Sensitive Species and Habitats Affected by the Operation of USACE Water Resource Development Projects, April 2000
EMRRP-SI-11	Riparian Raptors Potentially Impacted by USACE Reservoir Operations, April 2000
EMRRP-SI-12	Riparian Raptors on USACE Projects: Bald Eagle (*Haliaeetus leucocephalus*), April 2000
EMRRP-SI-13	Riparian Raptors on USACE Projects: Osprey (*Pandion haliaetus*), April 2000
EMRRP-SI-14	Riparian Raptors on USACE Projects: Peregrine Falcon (*Falco peregrinus*), April 2000
EMRRP-SI-15	Riparian Raptors on USACE Projects: Red-shouldered Hawk (*Buteo lineatus*), April 2000
EMRRP-SI-16	Bald Eagle Recovery Efforts at Corps of Engineers Projects, May 2000
EMRRP-SI-17	Riparian Shorebirds Potentially Impacted by USACE Reservoir Operations, September 2000
EMRRP-SI-18	Bat Habitat Restoration and Management Opportunities on Corps of Engineers Projects, December 2000
EMRRP-SR-01	Glossary of Stream Restoration Terms, February 2000
EMRRP-SR-03	Preliminary Watershed Assessment, February 2000
EMRRP-SR-04	Coir Geotextile Roll and Wetland Plants for Streambank Erosion Control, February 2000
EMRRP-SR-05	Computing Scour, February 2000
EMRRP-SR-06	Habitat Requirements for Freshwater Fishes, May 2000
EMRRP-SR-07	Resistance Due to Vegetation, May 2000
EMRRP-SR-08	Determining Drag Coefficients and Area for Vegetation, February 2000
EMRRP-SR-09	Reconnection of Floodplains with Incised Channels, May 2000
EMRRP-SR-10	Robert Manning (A Historical Perspective), April 2000
EMRRP-SR-11	Boulder Clusters, February 2000
EMRRP-SR-12	Irrigation Systems for Establishing Riparian Vegetation, February 2000
EMRRP-SR-13	Streambank Habitat Enhancement with Large Woody Debris, May 2000
EMRRP-SR-14	Acid Mine Drainage Treatment, May 2000
EMRRP-SR-21	Rootwad Composites for Streambank Erosion Control and Fish Habitat Enhancement, May 2000
EMRRP-SR-22	Gabions for Streambank Erosion Control, May 2000
EMRRP-SR-24	Design Recommendations for Riparian Corridors and Vegetated Buffer Strips, April 2000
EMRRP-SR-25	Riparian Terminology: Confusion and Clarification, January 2001

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- *Technologies for Urban Stream Restoration and Watershed Management*

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