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REPAIRING SEVERELY DEGRADED stream channels

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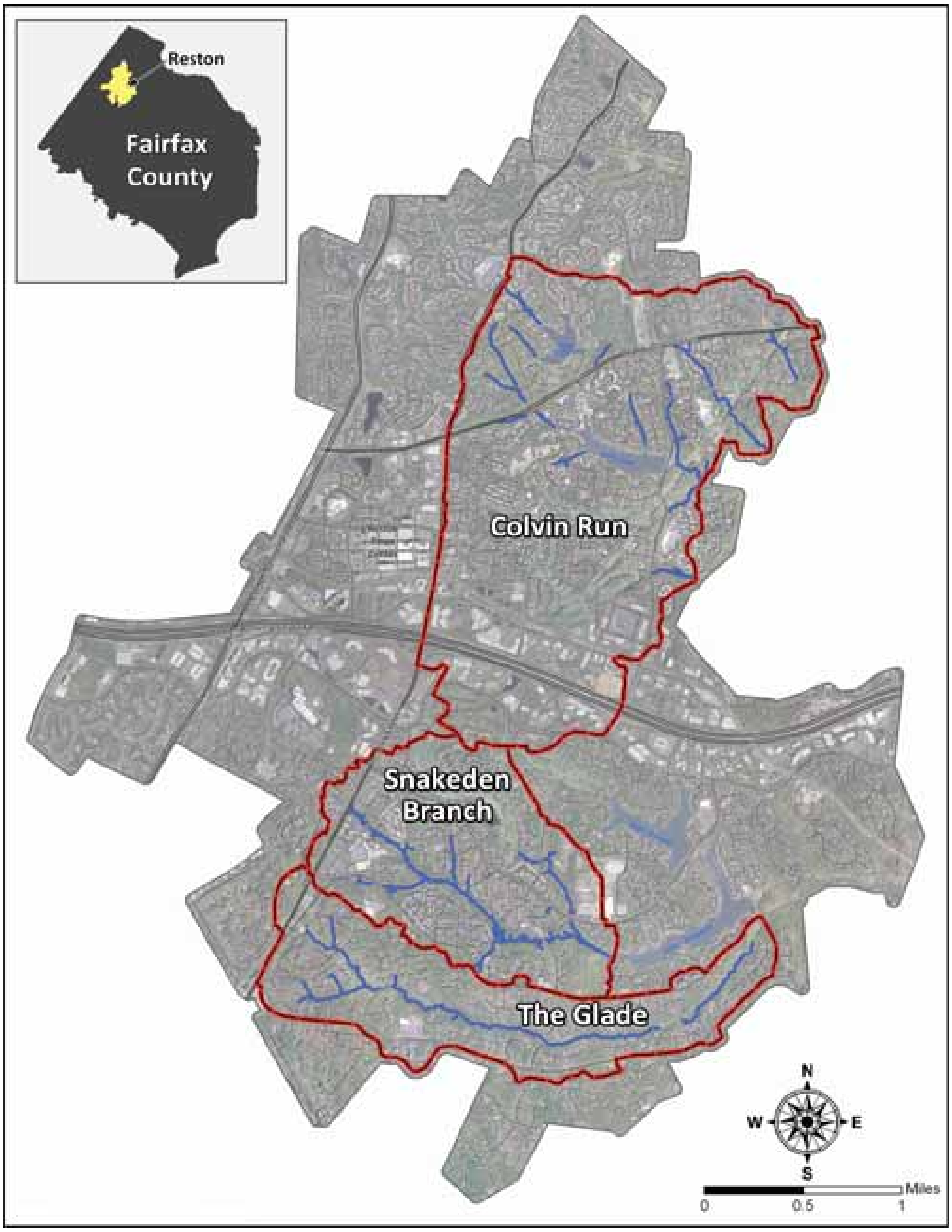
An Urban Stream Restoration Case Study:

The Northern Virginia Stream Restoration Bank

The community of Reston is located in Northern Virginia, approximately 20 miles west of Washington, D.C. Home to approximately 60,000 residents, Reston is one of the largest community associations in the county. Reston Association (RA) manages over 1,350 acres of open space, much of it located in protected stream valleys that are an integral and valued part of the community. Reston was developed primarily in the 1960s and 1970s, before the adoption of widespread stormwater management controls. At that time, the management philosophy was to route stormwater as quickly as possible to the stream valleys. Today, virtually no stormwater management facilities exist within the community.

Predictably, the stream channels have been severely degraded over time, transporting thousands of tons of sediment downstream annually. This sediment either is deposited in large community lakes or is carried downstream to the Potomac River and eventually to the Chesapeake Bay. Besides the environmental impact of the stream bank erosion and subsequent deposition, degradation of the stream channels has resulted in significant impacts to infrastructure (primarily trails, sewers, and bridges), as well to the immediate riparian areas as the streams incise and become disconnected from the floodplain.

Given the severely degraded condition of the channels and the high value placed on them by the Reston community, a citizens' advisory committee published a white paper in 2000 entitled Reston's Watersheds: An Assessment of Conditions and Management Strategies. Two years later, a more formal watershed plan was developed, and it cited the degradation of community



Aerial photograph of Reston, Virginia.

Exposed sanitary manhole within the project area. Inset: Snakedon Branch before: channel is incised and disconnected floodplain.

streams as a top concern. However, with approximately 26 miles of stream channels within Reston and the high cost of restoring streams (especially in an urban setting), the community appeared to have no realistic way to raise the amount of money that would be necessary to correct the problem.

Development Of The Northern Virginia Stream Restoration Bank

Wetland Studies and Solutions, Inc. (WSSI) is a natural and cultural resource consulting firm located in Gainesville, Virginia. WSSI has worked with the Reston community for many years, having obtained the wetland permits for build-out of the community when new regulations arose in the early 1990s. In 2002, the Virginia Department of Environmental Quality (DEQ) and the U.S. Army Corps of Engineers (COE) changed their interpretation of existing regulations regarding compensation for impacts to streams and wetlands (requiring "in-kind" mitigation for stream impacts), thus creating a demand for stream mitigation. This regulatory change, coupled with WSSI's knowledge of Reston and the community's desire to restore the badly degraded stream channels, created the impetus behind the Northern Virginia Stream Restoration Bank (NVSRB).

The concept of a stream mitigation bank is fairly simple. Whenever a public works agency or private landowner needs to impact streams on their property, they are required to mitigate for this impact. One option is for them to restore other streams located either on or off-site. Another option is to pay into a fund that is used by state agencies to restore streams. Since the adoption of related federal regulation in 2008, however, the preferred method is to purchase "credits" from a mitigation "bank" that has been developed by a bank sponsor. This bank provides for the restoration of impaired streams within its service area (as defined by the rivershed and physiographic province). Stream restorers use this pooled money to create much larger, well-designed, and ecologically valuable conservation projects.

Because the NVSRB was to be the first stream mitigation bank in the state, many issues arose in its development. The first and most difficult was the fact that no methodology had yet been created for determining how to "credit" compensation for impacts to streams. At the suggestion of a DEQ representative during a stakeholder meeting, WSSI developed the Virginia Stream Impact Assessment Manual (SIAM) and successfully obtained its approval for use in Phase I of the NVSRB (± 14 miles). With this major hurdle crossed, the Mitigation Banking Instrument (MBI), which governs the operation of the bank, was finally approved by the COE and DEQ over two years after the process had begun.

Data Collection

Collection of data related to the existing conditions of the stream valleys began before final approval of the NVSRB. The most significant effort involved collecting the survey data. Aerial topography of the stream valleys proposed for restoration was obtained at a contour interval of 6 inches, including any areas where access would potentially be necessary. The aerial topography was supplemented with field run surveys of the channel thalweg, along with surveys of the locations of all culverts, utilities, and property boundaries. Collection of tree data also required an extensive survey effort. Fulfilling a community requirement, WSSI located, tagged, and determined the size and species of all trees ≥ 4-inches diameter at breast height (dbh) within the stream valley. To date, nearly 39,000 trees have been field surveyed in this manner.

In addition to collecting the extensive survey data, WSSI also investigated the stream valleys for potential conflicts with wetland and cultural resources. Wildlife evaluations were also conducted to identify high-quality habitat that could then be avoided when possible.

Restoration Design

Phase I of the NVSRB includes approximately 14 miles of urban stream channels in three separate watersheds: Snakeden Branch, The Glade, and Colvin Run. One benefit of such a large-scale project was the ability to begin the restoration at the top of each watershed and work downstream. This approach greatly reduced the potential for problems related to sediment deposition that can arise from excessive bank erosion and construction activities upstream from the project site. The impervious area in these watersheds ranges from approximately 40% in Snakeden Branch and Colvin Run to approximately 15% in The Glade. Much higher percentages are present in certain sub-watersheds. Higher percentages of impervious area result in higher runoff volumes as less precipitation is able to infiltrate into the ground – this is the primary cause of urban stream degradation.

The chosen method for restoring the streams entailed raising the incised channels to re-connect them with the existing floodplain. The alternative approach — and one preferred by some — involved excavating a floodplain at the current incised level of the stream bed. Although this method does provide a firm channel bottom, excavation was not practicable for several reasons. First, utilities run adjacent to and crisscross the stream valley and floodplain and, therefore, would require relocation. Second, excavation of a floodplain would have required removing significantly more trees from within the narrow, wooded stream valleys, an outcome that would not have been acceptable to the community. Lastly, excavation would have necessitated the removal and disposal of massive quantities of soil at significant additional expense. Thus, the decision to raise the channels rather than lower the floodplain was an easy one.

The next design task was to determine a methodology for sizing the restored channels to account for the extreme hydrologic conditions experienced in these urban watersheds. Various methods exist for this purpose, including hydrologic and hydraulic modeling, sizing based on the dimensions of stable streams under similar conditions (known as "reference streams"), and/or the use of "regional curves" that provide channel dimensions based on contributing drainage area and are derived from empirical measurements.

Snakedon Branch post construction: channel is raised to provide floodplain access.

The chosen method for sizing the

Snakedon Branch 3 years after construction: hearty vegetation has returned along the channel.

stream channels entailed a multi-step process. First, WSSI compared published regional curve information from the piedmont region of Maryland to reference reach data collected by WSSI in the Northern Virginia area to assess whether the regional curve data was applicable to the streams in Reston. The results of this assessment confirmed the applicability of the Maryland data. However, the percentage of impervious area in the Reston watersheds was much higher than in the watersheds used to obtain the regional curve data. This fact prohibited direct application of the design parameters – the higher level of imperviousness and resulting higher flow rates for a given watershed size in this urban setting require much larger channels. To solve this problem, WSSI applied a channel "enlargement factor," based on the percent impervious area in the watershed[1], to the piedmont Maryland stream data to provide a design curve tailored to each watershed in Reston.

Although the process of sizing the restored channels began by determining the design flow rate, this was not the sole consideration. Given the confined nature of the stream valleys and the desire to preserve as many existing trees as possible, it was necessary to keep the restored channel in essentially the same footprint as the existing channel.

However, when the geometry of a particular meander bend was too tight to remain stable given the increased flow rates, or if the existing channel was encroaching on a trail or utility (primarily sanitary sewers), the channel alignment was adjusted to alleviate the conflict. Other factors also played a role, including impacts to adjacent

The Glade 1 year post construction. Inset: The Glade pre construction.

trees, a lack of sediment supply (i.e. clear water discharges), and consistency with the reference reach data, among others.

Thus, designing the restored channels was an iterative process, one that was greatly facilitated by WSSI's proprietary stream design automation software, StreamDesigner. This system allows for sizing and layout of the basic channel components (cross-section size and shape, stream profile, and structure placement) using Microsoft Excel spreadsheets. This information is then imported into AutoCAD Civil 3D®, where the channel grading design is automatically performed. This level of automation allows for numerous design iterations with relative ease, resulting in a level of optimization not previously possible given typical project timelines and budget constraints.

Public Outreach

The system of streams and trails in wooded stream valleys is a centerpiece of the Reston community and is often cited by residents as one of the main reasons for wanting to live there. As such, any perceived threat to this wonderful amenity is met with resistance – even when the project is intended to enhance and improve the condition of these resources. Thus, effective public education and outreach became a key component in the success of the NVSRB. This outreach began with announcements on the Reston website; community meetings advertised with general e-mails, postings on the website, and signs placed in the community; articles in the local newspaper; and interviews on a local cable station. Several presentations to the Reston Design Review Board (DRB), which has local review and approval authority for each restoration plan, were also made well in advance of submitting the first restoration plan set.

This outreach campaign seemed to be effective as the project began and continued for much of the first year. However, as the project neared the bottom of the first stream to be restored (Snakeden Branch) and designs for the streams in the neighboring The Glade stream valley were underway, it became apparent that some residents in that watershed were relatively unaware of the project. This unfamiliarity led to rumors and misunderstandings about the project, resulting in significant community opposition. For many residents, the largest concern and misunderstanding centered on the amount of tree clearing that would be necessary to gain access and facilitate the restoration. Some of the issues had to do with the character of each of the two watersheds – Snakeden Branch consists of largely commercial and multi-family residences, whereas The Glade watershed consists primarily of older single-family homes, with many of the residents having lived there since the homes were built in the 1970s. The residents of The Glade watershed are, perhaps, more involved and protective regarding the care and use of their stream valley than any other community in Reston.

In response to the mounting public outcry, WSSI altered the course of action relating to the methods of public outreach and made some changes to certain elements of the design. First, wherever possible, construction access was moved to existing trails and/or the dimensions of access paths were reduced to an absolute minimum dimension that would allow construction equipment to pass. This helped alleviate concerns about unnecessary tree clearing. On the public outreach side, WSSI began regular citizen meetings and included stream walks before commencing the design to solicit their suggestions and concerns. Citizens were also able to review and comment on Preliminary Plans. Meeting announcements were sent by letter to every resident in the watershed, and all project information was made available on WSSI's website. WSSI also set up an e-mail hotline for residents to voice their concerns. All of these efforts to address the particular concerns of the community succeeded in gaining their support and resulted in a better overall project.

In addition to community project approval and approval from the DRB, the final restoration plans also had to be approved by the COE, DEQ, and the Fairfax County Department of Public Works and Environmental Services (DPWES). A permit from the Virginia Department of Transportation (VDOT) was also required to allow entrances to the construction sites from public roads.

Construction

Construction of the NVSRB began in February 2008 at the top of the Snakeden Branch watershed. Within one year, all of Snakeden Branch (20,038 lf) was complete. By the end of 2010, an additional 20,068 lf was completed in The Glade. Work has since begun in the Colvin Run watershed, which is likely to proceed at a slower pace as the slowdown in the economy has reduced demand for stream "credits."

The construction phase of any particular reach begins by placing tree protection fencing around the limits of clearing. This is followed by tree clearing throughout the entire stream reach, as opposed to clearing as the project progresses. Once the construction entrances are installed, the access road is put in place. Timber deck-

Besides the environmental impact of the stream bank erosion and subsequent deposition, degradation of the stream channels has resulted in significant impacts to infrastructure (primarily trails, sewers, and bridges), as well to the immediate riparian areas as the streams incise and become disconnected from the floodplain.

mats were used along the entire length of the haul road to reduce impacts to adjacent tree roots. Once these measures are complete, work in the stream begins.

The restoration work is performed using various sizes of track hoes equipped with a hydraulic "thumb," a necessity for picking up and placing rocks weighing 2 tons each. Materials are transported from the stockpile areas to the active stream work via rubber-tracked carriers with rotating beds, a helpful feature when working in tight quarters. Restoration is performed in the channel itself, with a pump-around system keeping the work area "dry" while work is underway.

Restoration is performed in the channel itself, with a pump-around system keeping the work area "dry" while work is underway.

As previously mentioned, the selected method of restoration is to raise the bed of the incised channel in order to reconnect it with the former floodplain. For deeply incised channels, much of the necessary fill material is comprised of suitable soil (containing minimal organic materials, large rocks, or other debris) that is placed and compacted by the tracked equipment. The top layer of the channel bed (approximately 1-foot) is lined with a reinforced bed material that comprises crushed diabase rock (with an average diameter of about 7 inches), bank run gravel, sand, and topsoil. This reinforced bed material is mixed in specified proportions by the rock supplier for the project. In addition to the reinforced bed, rock structures were also employed, including cross-vanes, step pools, and rock steps. These structures stabilize the channel bed and banks and create a riffle-pool complex that promotes biodiversity within the streambed. Wood has also been incorporated into the design, including the arms in some of the structures as well buried in the bed of the stream to create smaller pool features.

Another important component for creating a stable, ecologically viable restoration project is planting. All disturbed areas are over-seeded with a riparian seed mix that contains dozens of native species, including 6 grass, 21 forb, 5 shrub, and 5 tree species. In addition, native trees and shrubs (8 tree and 10 shrub species) are planted in appropriate hydrologic zones in the form of tubelings (streamside) and 1-gallon container grown materials. The successful establishment of a healthy and diverse riparian corridor is attributed not only to the diversity of the planting palette, but also to the heavy seeding and planting densities at which it is applied.

Flooding during Tropical Storm Hannah (6.2" of rain in 9 hours).

Monitoring And Maintenance

Following the completion of construction and approval of the as-built drawing, the MBI requires that the project be monitored and maintained for 10 years to ensure that the success criteria contained in the MBI are met. This monitoring includes assessment of the success of the vegetation (percent coverage as well as adequate numbers of woody stems per acre and per linear foot of stream edge) as well as survey monitoring of the channel shape and alignment and the stability of the installed structures. Although the MBI includes no success

Stream conditions two days after Tropical Storm Hannah.

criteria related to biological performance within the restored streams, biological monitoring is also being performed to develop information regarding the response of benthic organisms in restored urban streams. Improvements are not expected because of the poor water quality and temperature spikes in these urban watersheds, problems that this project is not designed to address. It is hoped that future public investments will target these watersheds for stormwater management retrofits to improve the water quality entering these restored streams. In addition to the annual monitoring discussed above, WSSI is also required to inspect the project after larger storms that meet certain criteria specified in the MBI.

Thus far, the NVSRB has been extremely successful. All as-built and monitoring criteria have been met and exceeded since the first reaches were completed in March 2008. The completed streams have successfully handled several significant storm events, including tropical storm Hannah (which was a 100-year event) in 2008, and more recent back-to-back storms - hurricane Irene and tropical storm Lee (tropical storm Lee was classified between a 200 and 500-year storm event) in 2011. Overall, the restored stream channels performed very well. The reaches with more mature vegetation handled the flooding with no issues, while some of the recently constructed reaches required minor repairs. This result was expected, because the tree and shrub roots had not yet had time to reinforce the soil. WSSI and RA staff performed post-storm inspections, and crews were mobilized immediately to conduct the minor repairs.

In 2010, WSSI was awarded the Best of Reston Award for work on the NVSRB. This civic award is given to outstanding members of the community who have shown tremendous commitment to improving the lives of others and is a testament to the level of project success that has been achieved, in both the restoration work and the significant community outreach. Project success is also evident through less tangible means – the new-found use and enjoyment of the restored streams by the community. **L&W**

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[1]Caraco, D.S. "Dynamics of Urban Stream Channel Enlargement". Watershed Protection Technologies. 2000: 3(3); 729 – 734.