U-4 URBAN STREAM RESTORATION

PRACTICE AT A GLANCE

- New techniques have been pioneered in the Chesapeake Bay watershed to restore urban streams using diverse approaches such as natural channel design, regenerative stream channel, and removal of legacy sediments.
- Stream restoration improves the health of aquatic resources, and, when combined with upland restoration practices, is one of the more cost-effective practices to remove sediment and nutrients from urban watersheds.
- Credit is only given when stream restoration projects meet stringent qualifying conditions and can produce functional uplift for local streams so they provide a net environmental benefit in the watershed.
- Thus, not every stream restoration project will qualify for credit. For example, no credit can be granted for any project built to offset, compensate, or otherwise mitigate for an impact elsewhere in the watershed. The same is true for stream bank stabilization projects that are primarily designed to protect public infrastructure by bank armoring or rip rap.
- Stream restoration projects undergo extensive regulatory review and require state and federal permits.

PRACTICE DESCRIPTION

Stream restoration projects work to remove pollutants in several ways. First, the projects retain the sediment and attached nutrients in a stable, restored stream bank or channel that would otherwise be delivered downstream by an actively eroding stream. Some projects can also increase the interaction of the stream baseflow with groundwater, and promote conditions that lead to nitrogen removal. Lastly, projects that reconnect a stream to its floodplain help trap and retain sediment and nutrients carried in smaller floods.

Three different approaches can be used to restore streams:

- *Natural Channel Design* applies the principles of stream geomorphology to maintain a state of dynamic equilibrium among water, sediment, and vegetation that creates a stable channel.

- *Legacy Sediment Removal* seeks to remove legacy sediments from the stream and its floodplain and thereby restore the natural potential of aquatic resources including a combination of streams, floodplains, and wetlands.

- *Regenerative Stream Channel* uses in-stream weirs in perennial streams to increase the interaction with the floodplain during smaller storm events. These projects may also include sand seepage wetlands and other habitats to increase the stream's connection with its floodplain.

Many projects use a combination of these three techniques. Each approach is eligible for pollutant removal credits, as long it meets qualifying conditions, environmental permitting requirements and improves stream health.

WHERE TO FIND THE BEST OPPORTUNITIES IN YOUR COMMUNITY

Stream restoration projects can occur almost anywhere where streams are badly eroding including urbanized areas. They are best implemented when:

- As part of a comprehensive watershed approach
- Geomorphic evidence shows active stream degradation
- The index of biological diversity for the stream scores as fair or worse
- Hydrologic evidence shows the floodplain is disconnected from the stream
- Evidence shows that legacy sediments are prevalent in the project reach
- Evidence that stream functions can be improved
- Adjacent land becomes available through eminent domain due to flooding and offers opportunities for flood-plain reconnection
- Some of the best locations are streams that run through public parks and municipal land

The best opportunities are in areas with severely incised streams that have adjacent flood plain areas to which the stream can be reconnected. Property ownership is a key issue so it is critical to involve adjoining property owners from the get-go.

STREAM RESTORATION APPROACHES

Natural Channel Design

Legacy Sediment Removal

Regenerative Stream Channel

Likewise, the best projects are part of a comprehensive watershed restoration plan to assure better outcomes of the project goals. This plan should identify key upland practices in the watershed as well as priority areas for stream restoration.

GENERAL COST INFORMATION

Despite the fact that they are cost-effective in terms of pollutants removed per dollar expended, stream restoration projects are not cheap. Their cost can range from $150 to $400 per linear foot restored, which means most projects will cost several hundred thousand dollars or more to construct. Therefore, it is critical to assess multiple candidate stream restoration projects to find the most cost-effective ones.

Most communities finance the construction of their stream restoration projects through their long term capital improvement budgets and may require grant funding to implement the project.

TIPS FOR GETTING STARTED IN YOUR COMMUNITY

It can typically take anywhere between one and three years to go from project concept to construction of stream restoration projects, and even longer if there are contentious permit issues. In addition, the design of most stream restoration projects requires a lot of upfront monitoring and survey work, and there may also be additional post-construction monitoring, as well.

Most streams and floodplains are classified as wetlands, and any activity within them is regulated under state and federal wetland permits. Getting a permit to proceed with construction can be a very lengthy process, and is not automatic. Consequently, it is essential to consult with the Corps of Engineers, U.S. EPA and other wetland regulators very early in the process to get feedback on permitting.

Another key tip is to involve the public during the stream restoration design process; particularly if there will be significant construction impacts, such as the removal of large trees.

WHAT DEGREE OF TECHNICAL SUPPORT IS NEEDED

Stream restoration design, permitting and construction can be very complex, and requires a lot of skill in engineering, project management and construction oversight. Most communities will need to hire experienced consultants to do most of the work, but will need good in-house talent to effectively manage the projects.

Stream restoration requires a multidiscipline team including the following:

- Stream restoration should be part of a comprehensive watershed restoration strategy requiring the skills of a watershed planner and those skilled in monitoring and assessment.

- A stream restoration project should be designed by a professional engineer with appropriate training in geomorpholgy. The design team should also consult with a professional biologist to consider what stream functions can be improved or what stream functions might be lost as a result of the project.

- The construction of a stream restoration project also requires an experienced contractor that specializes in stream restoration installation.

- To receive credits, all qualifying projects must have a designated authority responsible for project maintenance that includes both routine maintenance and long-term repairs.

COMPUTING THE POLLUTANT REMOVAL CREDIT

There are three general protocols to define the pollutant load reductions associated with individual stream restoration projects. The protocols are additive, and an individual stream restoration project may qualify for credit under one or more of the protocols, depending on its design and overall restoration approach. A general description is provided below. Jurisdictions may find it beneficial to perform the calculations as part of their design contracting to optimize the project's pollutant load reductions.

Default Rate. Historic projects and new projects that cannot conform to recommended reporting requirements of the Chesapeake Bay Program may be able to receive credit through a default rate (**Table 1**).

Table 1. Interim Approved Removal Rates per Linear Foot of Qualifying Stream Restoration (lb/ft/yr)

Source	TN	TP	TSS*
Revised Default Rate	**0.075**	**0.068**	**44.88 non-coastal plain** **15.13 coastal plain**

Derived from six stream restoration monitoring studies: Spring Branch, Stony Run, Powder Mill Run, Moore's Run, Beaver Run, and Beaver Dam Creek located in Maryland and Pennsylvania

*To convert edge of field values to edge of stream values a sediment delivery ratio (SDR) was applied to TSS. The SDR was revised to distinguish between coastal plain and non-coastal plain streams. The SDR is 0.181 for non-coastal plain streams and 0.061 for coastal plain streams.

Protocol 1. Credit for Prevented Sediment During Storm Flow

This protocol provides a nutrient and sediment reduction credit for qualifying stream restoration practices that prevent channel or bank erosion that would otherwise be delivered downstream from an actively enlarging or incising urban stream.

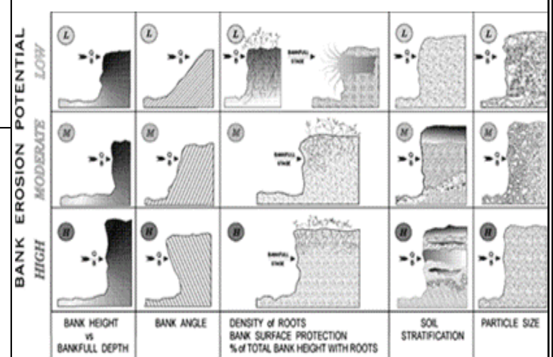
This protocol follows a three step process to compute a mass reduction credit for prevented sediment:

1. Estimate stream sediment erosion rates and annual sediment loadings,
2. Convert erosion rates to nitrogen and phosphorus loadings, and
3. Estimate reduction attributed to restoration (50% default rate) or use monitoring data.

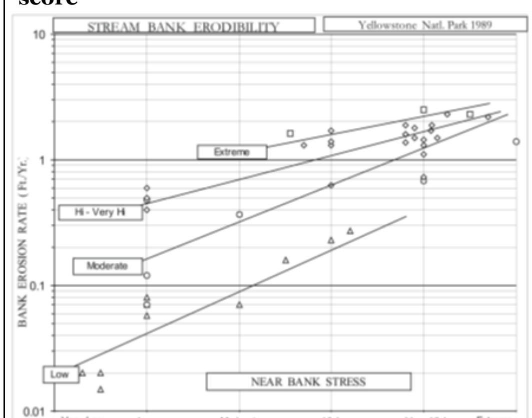
- Monitoring using methods such as cross section surveys and bank pins is the preferred approach.
- When monitoring is not feasible, use the "Bank Assessment for Non-point Source Consequences of Sediment" or BANCS method to estimate sediment and nutrient load reductions.
- The BANCS method utilizes two commonly used bank erodibility estimation tools to predict stream bank erosion: the Bank Erosion Hazard Index (BEHI) and Near Bank Stress (NBS) methods.

BANCS METHOD

1. Assess BEHI score based on criteria below



2. Use field measurements to determine BEHI score



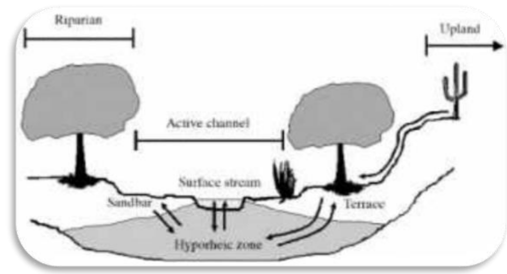
3. Estimate erosion rate using BEHI and near bank stress.

<u>Protocol 2. Credit for In-stream Nitrogen Processing During Base Flow</u>

This protocol provides an annual mass nitrogen reduction credit for qualifying projects that include design features to promote denitrification during base flow within the stream channel through enhanced surface water/groundwater exchange (hyporheic zone) within the riparian corridor. This protocol relies heavily on denitrification research in restored streams within the Baltimore metropolitan area.

- This protocol applies to stream restoration projects where in-stream design features are incorporated to enhance nutrient processing, such as denitrification.
- Qualifying projects receive credit for enhanced nitrogen removal within the stream channel during base flow conditions.
- Protocol 2 only provides a nitrogen removal credit; no credit is given for sediment or phosphorus removal.

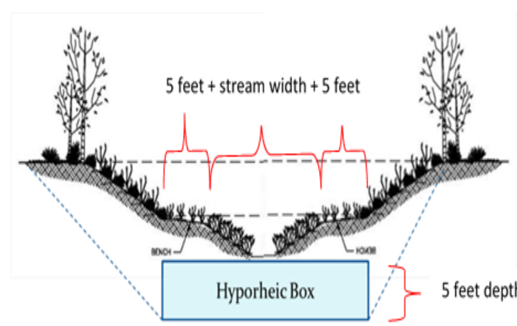
- It is assumed that the denitrification occurs in a "box" that extends the length of the restored reach. The cross sectional area of the box extends to a maximum depth of 5 feet beneath the stream bottom with a width that includes the median base flow channel and 5 feet added on either side of the stream bank (see Figure 3 to the right). The dimensions of the box apply only to sections of the stream where hyporheic exchange can be documented.
- The volume of the "box" is multiplied by a denitrification rate.



Functional ecomorphology: Feedbacks between form and function in fluvial landscape ecosystems. Stuart G. Fisher, , James B. Heffernan, Ryan A. Sponseller, Jill R. Welter

1. Surface and groundwater interaction described as "hyporheic exchange" between the stream channel and the floodplain

2. Restored stream with improved hyporheic connection

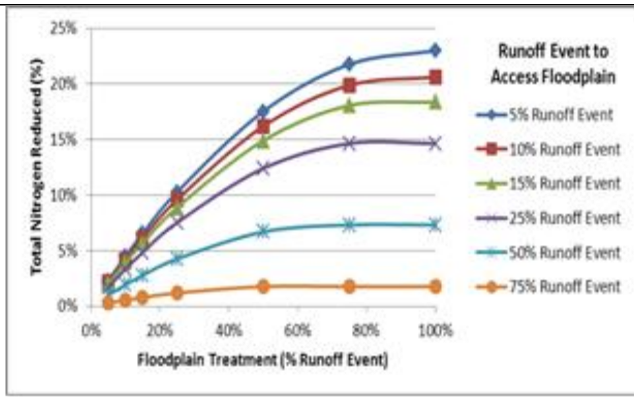


3. Volume used to compute enhance denitrification The credit is determined only for the length of stream reach that has improved connectivity to the floodplain as indicated by a bank height ratio of 1.0 (bank full storm) or less for projects that use the natural channel design approach.

Protocol 3. Credit for Reconnection to the Floodplain

This protocol provides a sediment and nutrient reduction credit for qualifying projects that reconnect stream channels to their floodplain over a wide range of storm events, from the small, high frequency events to the larger, less frequent events.

- Qualifying projects receive credit for sediment and nutrient removal under Protocol 1 and denitrification in Protocol 2 (if applicable) and use this protocol to determine enhanced sediment and nutrient removal through floodplain wetland connection.
- This method assumes that sediment, nitrogen and phosphorus removal occurs only for that volume of annual flow that is effectively in contact with the floodplain.
- A series of curves were developed that relate the floodplain reconnection volume to the effective depth of rainfall treated in the floodplain, which in turn are used to define the nutrient removal rate that is applied to subwatershed loads delivered to the project.



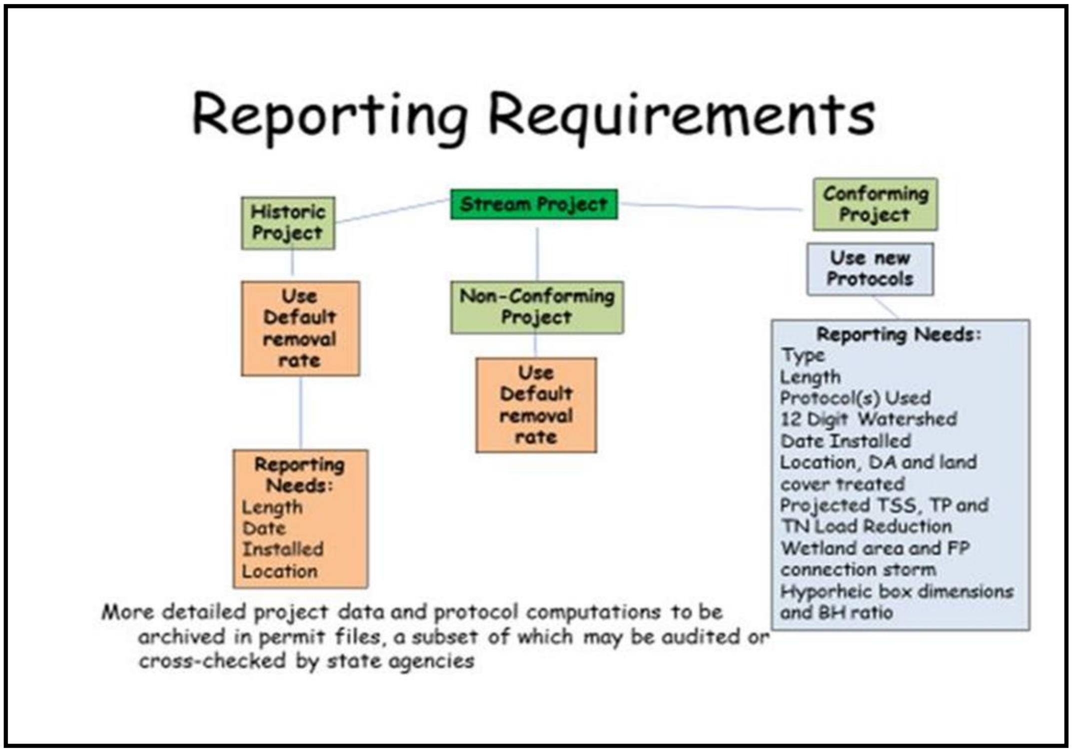
Higher bank in lower picture translates to lower frequency of floodplain access than upper photo and consequently lower reduction efficiencies.

The extent of the credit depends on the elevation of the stream invert relative to the stage elevation at which the floodplain is effectively accessed. Designs that divert more stream runoff onto the floodplain during smaller storm events (e.g., 0.25 or 0.5 inches) receive greater nutrient credit than designs that only interact with the floodplain during infrequent events, for example the 1.5 year storm event.

The floodplain connection volume afforded by a project is equated to a wetland volume so that a wetland removal efficiency for TN, TP and TSS can be applied.

HOW TO REPORT THE PRACTICE TO THE STATE

Basic reporting requirements are presented in the figure below. The maximum duration for the removal credits is 5 years, although the credit can be renewed indefinitely based on a field performance inspection that verifies the project still exists, is adequately maintained and is operating as designed.



WHAT IS REQUIRED TO VERIFY THE PRACTICE OVER TIME

- The installing agency needs to certify that the stream restoration project was installed properly, meets or exceeds its functional restoration objectives and is hydraulically and vegetatively stable, prior to submitting it for credit to the state tracking database. This initial verification is provided either by the designer, local inspector, or state permit authority as a condition of project acceptance or final permit approval.

- The installing agency inspects the project once every 5 years to ensure that it is still capable of removing nutrients and sediments.

- If the field inspection indicates the project is not performing to its original specifications, the locality has one year to take corrective maintenance or rehabilitation actions to bring it back into compliance.

RESOURCES

The following resources are available for help with all aspects of this practice:

Type of Resource	Title of Resource	Web link
Expert Panel Report	Recommendations of the Expert Panel to Define Removal Rates for Individual Stream Restoration Projects (2014) – Short Version	http://chesapeakestormwater.net/wp-content/uploads/dlm_uploads/2013/10/stream-restoration-short-version.pdf
	Recommendations of the Expert Panel to Define Removal Rates for Individual Stream Restoration Projects (2014) – Long Version	http://chesapeakestormwater.net/wp-content/uploads/dlm_uploads/2013/05/stream-restoration-merged.pdf
Archived webcast(s)	Urban Stream Restoration Protocols and Frequently Asked Questions Webcast (2014)	http://chesapeakestormwater.net/events/webcast-urban-stream-restoration/
Expert Panel Appendix A	Appendix A: Annotated Literature Review	http://chesapeakestormwater.net/wp-content/uploads/dlm_uploads/2015/03/Appendix-A.-Annotated-Literature-Review.pdf
Expert Panel Appendix B	Appendix B: Protocol 1 Supplemental Details	http://chesapeakestormwater.net/wp-content/uploads/dlm_uploads/2015/03/Appendix-B.-Protocol-1-Supplemental-Details.pdf
Expert Panel Appendix C	Appendix C: Protocol 2 and 3 Supplemental Details	http://chesapeakestormwater.net/wp-content/uploads/dlm_uploads/2015/03/Appendix-B.-Protocol-1-Supplemental-Details.pdf
Paper	Harman, W., et al. "A Function-Based Framework for Stream Assessment and Restoration Projects." (2012).	http://chesapeakestormwater.net/wp-content/uploads/dlm_uploads/2015/03/A_Function-Based_Framework-2.pdf
Stream Restoration Manual	Urban Subwatershed Restoration Manual Series Manual 10: Unified Stream Assessment: A User's Manual	http://chesapeakestormwater.net/wp-content/uploads/dlm_uploads/2014/09/Manual-10.pdf
More Tools & Resources		http://chesapeakestormwater.net/training-library/urban-restoration-techniques/stream-restoration/