Maintaining Forests in Stream Corridor Restoration:

A Best Practices Guide for Projects in Pennsylvania, Maryland, and Virginia

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Source: Ecotone, Inc.

1 Introduction and Purpose

This guidance document includes best practices for consideration by agencies[1] overseeing the implementation of stream restoration projects, as well as seasoned professionals, to minimize unintended impacts to riparian forests and ecosystems in the Chesapeake Bay watershed. It was developed collaboratively between the Center for Watershed Protection, Inc. (CWP), Chesapeake Bay Program (CBP), and stakeholders based on findings from a recent study, Maintaining Forests in Stream Corridor Restoration and Sharing Lessons Learned, that consisted of a survey of regulators, practitioners, and local governments in the Chesapeake Bay watershed; a literature review of guidance documents and policies relevant for stream restoration projects in Pennsylvania, Maryland, and Virginia; interviews with individuals considered experts in stream restoration and/or forest buffers; case study evaluations of stream restoration projects; and state-specific webcasts to discuss study findings.

Stream restoration for the purposes of this guidance document is defined according to the Chesapeake Bay Program (CBP) stream restoration expert panel recommendations[2,3] as "any natural channel design, regenerative stormwater conveyance, legacy sediment removal or other restoration project that meets the qualifying conditions for credits, including environmental limitations and stream functional improvements."[4]

This document is designed to be a reference guide that provides an overview of the best practices and available resources and tools. It consists of the following sections:

- Background: Context for the need for riparian buffer considerations as part of stream restoration projects.
- Regulation Summary and Jurisdiction-Specific Considerations: Summary of state-specific stream restoration considerations and federal, state, and local regulations.
- General Best Practices: Overview of best practices for considering forests as part of stream restoration and a compilation of associated resources and tools.
- Design-Specific Considerations: Unique considerations for specific approaches to stream restoration design.

While some sections of this guide are specific to regulations in Pennsylvania, Maryland, and Virginia, the best practices can be applied to stream restoration projects in other Chesapeake Bay states and beyond.

2 Background


Source: Ecotone, Inc.

Forest buffers are critical for stream health. They improve the stability of stream banks, provide shade, filter nutrients and sediments, and contribute organic material for aquatic food webs. It is generally acknowledged that stream restoration project construction often exerts short-term adverse impacts on forest buffers, and may have long-term effects from construction and delayed tree loss from altered water levels. Depending on the pre-restoration condition and level of construction disturbance, years of ecosystem maturation may be needed before a project fully meets its long-term restoration objectives and realizes its full environmental benefits.

In 2007, CBP partners set a goal to restore 900 miles of riparian forests in the watershed each year in response to the Chesapeake Executive Council Directive 06-1, Protecting the Forests of the Chesapeake Watershed.[5] This goal was renewed in the 2014 Chesapeake Bay Watershed Agreement,[6] which was signed by all six Bay states and the District of Columbia. The agreement also calls for the conservation of existing buffers and for at least 70 percent of riparian areas throughout the watershed to be forested. At the same time, there is growing interest in the implementation of stream restoration in the Chesapeake Bay Watershed, increasing the need for the use of best practices to protect riparian buffers and to minimize their loss during construction of stream restoration projects.

The CBP Stream Restoration Expert Panel Report[7] and recent work group updates[8] intended for the stream restoration crediting protocols to be part of a holistic watershed approach and included qualifying conditions that offer some protection for riparian vegetation. However, stream restoration projects are commonly implemented with the main goal of obtaining total maximum daily load (TMDL) credits, as well as meeting Municipal Separate Storm Sewer System (MS4) requirements, and the qualifying conditions for riparian vegetation have not been consistently met. Because stream restoration and expanding forest buffers are a large component of state Watershed Implementation Plans (WIPs) and the 2014 Chesapeake Bay Agreement, it is imperative to better synergize efforts and investments to minimize negative trade-offs impacts/outcomes of stream restoration to the riparian area and overall stream health.

3 Regulation Summary and Jurisdiction-Specific Considerations


Source: LandStudies, Inc.

Regulations and state-specific guidance to protect riparian vegetation during stream restoration vary across Pennsylvania, Maryland, Virginia, and other states. This section summarizes the federal permit and programmatic requirements that are applicable to all three states, as well as each accompanying state's definition of stream restoration, types of restoration implemented, and acceptable riparian vegetation outcomes. This includes federal requirements like the Army Corp of Engineers nationwide permits, regional permits, and joint permits. This regulatory power is authorized by the Clean Water Act, which mandates the protection of water quality. Key federal regulations applicable to stream restoration are summarized in Table 1. State-specific regulations and examples of local government regulations are summarized in the subsequent sections below.

These regulations may have direct or indirect impacts on riparian forest resources and not all of the regulations related to stream restoration projects are triggered automatically when a project is proposed. Whether or not they ultimately apply depend on factors such as geographic location, the scale of the project, and potential impacts to habitat or water quality. As an example, a small stream restoration project may not trigger regulations regarding forest retention if the project will remove less than a certain prescribed area of forest resources.

Table 1. Federal regulations that may apply to stream restoration projects and associated riparian forest buffers

Regulation	Where it Applies	Description	Implications for Riparian Forests
Nationwide Permit 27 – Aquatic Habitat Restoration, Enhancement, and Establishment Activities	Waters of the United States (WOTUS)	Authorizes activities in waters of the United States associated with (i) the restoration, enhancement, and establishment of tidal and non-tidal wetlands and riparian areas, (ii) the restoration and enhancement of non-tidal streams and other non-tidal open waters, and (iii) the rehabilitation or enhancement of tidal streams, tidal wetlands, and tidal open waters, provided those activities result in net increases in aquatic resource functions and services.	• Restoration or enhancement, maintenance, and legal protection of riparian areas next to open waters (typically 25-50ft on either side of a stream). • Post-construction monitoring (typically 5 years) that may include vegetation. • Riparian areas must be restored with native species
Regional General Permit for Chesapeake Bay TMDL Activities	Nontidal WOTUS in the watershed within the State of Maryland (with some exceptions), the District of Columbia, Fort Belvoir, Fort Myer, and the Pentagon in Virginia	This permit is for projects undertaken to meet TMDL goals for a five-year period on September 1, 2020. The TMDL RGP is applicable to non-tidal wetlands and streams within the State of Maryland, the District of Columbia, and Fort Belvoir, Fort Myer, and the Pentagon in Virginia under regulatory control of the Baltimore District.	• 3-year monitoring requirement following construction completion which may be extended based on monitoring that includes mitigation plantings • Permanent impacts may not exceed 3 acres of nontidal wetlands and/or nontidal streams, or 5,000 linear feet of nontidal streams which will include forested areas
Maryland State Programmatic General Permit-6 Joint Permit	Maryland	Federal joint permit from USACE with the appropriate state agency for environmental policy. The permit covers activities on US waters associated with the restoration, enhancement, and establishment of tidal and non-tidal wetlands and riparian areas, the restoration and enhancement of non-tidal streams and other non-tidal open waters, and the rehabilitation or enhancement of tidal streams, tidal wetlands, and tidal open waters. The permit provides information on reporting procedures, water quality certification details, nationwide conditions regional, and general conditions which are required to qualify for NWP authorization.	• Impacts limited to 10,000 square feet and/or 200 linear feet of streams • Compensatory mitigation at a minimum one-for-one ratio required for permanent losses of streams or other open waters
Pennsylvania State Programmatic General Permit-6	Pennsylvania		• Reporting requirement for activities with permanent impact on more than 500 linear feet of stream
Virginia State Programmatic General Permit Standard Joint Permit Application	Virginia		• Requires use of Natural Channel Design Review Checklist and Selected Morphological Characteristics form that includes planting plans
FEMA National Flood Insurance Program Requirements	100-year floodway as shown on the Flood Insurance Rate Map (FIRM) or Flood Boundary and Floodway Map (FBFM).	44 CFR 60.3 - Floodplain management criteria for flood-prone areas requires that any project in a floodway must be reviewed to determine if the project will increase flood heights. (Also known as "no-rise" certification).	• May affect forest resources since expansion of floodplain may require greater tree removal to meet no-rise requirements

3.1 Pennsylvania Regulations

In Pennsylvania, emphasis is primarily placed on identifying and correcting the underlying cause of degradation. The Pennsylvania Department of Environmental Protection (PA DEP) describes two approaches to stream restoration: evidence-based and triage. The evidence-based approach evaluates the causes of degradation and proposes appropriate designs to correct them. The triage approach involves identifying an urgent stream problem with a willing landowner and being able to secure funding. State representatives, local government representatives, and Pennsylvania-based practitioners are also specific about how to define stream restoration and how to apply that definition in the context of measuring project success. A 2018 PA DEP document defined stream restoration in the context of eligibility for MS4 crediting as "any natural channel design, wet channel regenerative stormwater conveyance, legacy sediment removal or other stream modifications intended to restore natural forms and processes that reduce streambank or streambed erosion and capture pollutants."[9] For PA DEP, stream projects that target symptoms of degradation rather than the underlying cause(s) would not be considered stream restoration. Pennsylvania does not define the term degradation in a formal context with regard to stream restoration. Degradation is assessed using hydrological, ecological, and geomorphic factors to evaluate how a stream has changed over time. This evidence-based approach is used to demonstrate causes of degradation and inform project design.

Legacy sediment removal projects are commonly implemented in Pennsylvania and can involve the removal of relatively substantial amounts of riparian vegetation. However, PA DEP explains that, while the appropriate post-restoration vegetation targets for legacy sediment removal projects may include a forest plant community, they are not exclusionary of other plant community types like those in floodplain wetlands. PA DEP further explains that ecological restoration principles being applied to legacy sediment removal projects consider both the historical condition/natural structure of the site as well as the watershed's modern environment and associated stressors—the application of a historical reference condition is necessary to evaluate the structures and functions of the ecosystem before it was degraded. Historic condition refers to the condition at the time of pre-alteration. Geomorphic controls play a bigger role than vegetative condition in the stream restoration approach selected. In comparison, the Pennsylvania Department of Conservation and Natural Resources (PA DCNR) perspective is that existing upland conditions impacting streamflow and stormwater runoff—as opposed to the site's historic conditions—should be the primary informant of the degree to which a legacy sediment removal project site is reforested. Key Pennsylvania regulations related to stream restoration can be found in Table 2.

Table 2. Pennsylvania regulations that may apply to stream restoration projects and associated riparian forest buffers

Regulation	Where it Applies	Description	Implications for Riparian Forest
PA Code Chapter 105 Dam Safety and Waterway Management	Statewide	Chapter 105 provides for the comprehensive regulation and supervision of dams, reservoirs, water obstructions and encroachments in the Commonwealth and is the primary regulation for stream restoration projects in Pennsylvania.	• Requires an impacts analysis for a proposed water quality project on the following: stream flow, fish and wildlife, aquatic habitat, Federal and State forests, parks, recreation • 3- to 5-year monitoring period for most restoration projects

Table 2. Pennsylvania regulations that may apply to stream restoration projects and associated riparian forest buffers			
Regulation	**Where it Applies**	**Description**	**Implications for Riparian Forest**
PA Code Chapter 102 Erosion and Sediment Control	Statewide	Requires persons proposing or conducting earth disturbance activities to develop, implement and maintain BMPs to minimize the potential for accelerated erosion and sedimentation and to manage post construction stormwater	• Affords protection to riparian buffers being used for post-construction management
Act 394 PA Clean Streams Law	Statewide	The Clean Streams Law is the main law designed to protect freshwater resources. The Clean Streams Law creates the legal framework to "preserve and improve the purity of the waters of the Commonwealth."	• The objective of the Clean Streams Law is to prevent further pollution of the waters of the Commonwealth, but also to reclaim and restore to a clean, unpolluted condition every stream in Pennsylvania that is presently polluted. This will include stream restoration work and the planting plans associated with the work.
Act 247 PA Municipalities Planning Code	Statewide	The state law enabling local municipalities to enact comprehensive plan and zoning, subdivision & land development, and official map regulations.	• The language allows zoning ordinances to permit, prohibit, regulate, restrict, and determine the uses of land, watercourses and other bodies of water and protect and preserve natural and historic resources and prime agricultural land and activities and provides the authority to create stream buffer ordinances. The buffer ordinances may influence stream restoration projects and determine the width of buffer required during replanting.

• 3.2 Maryland Regulations

Maryland stream restoration policies are designed to encourage the creation of stream-wetland complexes and healthy floodplains. There is more emphasis on evaluating projects based on the value of their current conditions as opposed to achieving historic or predevelopment conditions. The type of restoration design is selected based on site-specific factors, but the most commonly implemented types of stream restoration projects are Natural Channel Design (NCD), followed by Regenerative Stormwater Conveyance (RSC) projects. The Maryland Department of the Environment (MDE) recently developed stream restoration guidance (refer to Section 4) that includes best practices for minimizing forest loss during stream restoration. MDE is also conducting new research on ecological restoration and permitting, which aims to produce an operational definition of ecological restoration, revise applicable permits/processes as appropriate, and integrate these findings into MDE's existing work. Key Maryland regulations related to stream restoration can be found in Table 3.

The most commonly implemented types of stream restoration projects in Maryland are Natural Channel Design, followed by Regenerative Stromwater Conveyance.

Table 3. Maryland regulations that may apply to stream restoration and associated riparian forest buffers			
Regulation	**Where it Applies**	**Description**	**Implications for Riparian Forest**
Forest Conservation Act	Statewide	Requires units of local government with planning and zoning authority to establish and implement local forest conservation programs. It also provides for the administration of forest conservation requirements, in the absence of a local forest conservation program. The guidance establishes standards required in forest stand delineations and forest conservation plans	• Any activity requiring an application for a subdivision, grading permit or sediment control permit on areas 40,000 square feet (approximately 1 acre) or greater is subject to the Forest Conservation Act and will require a Forest Conservation Plan. • The Act defines stream restoration and includes a requirement to replant on site an equivalent number of trees as the number removed • Establishes requirements for forest buffers and corridors along intermittent and perennial streams and coastal bays • Details forest conservation thresholds for all land use categories covered by the Act • Details the afforestation and reforestation requirements for compliance with the state Forest Conservation Act • Excludes stream restoration projects from the Forest Conservation Act if they have a binding 5-year maintenance agreement
Critical Areas Law	All land within 1,000 feet of MD's tidal waters and tidal wetlands	The Critical Areas law is a comprehensive program to protect the natural resources of the Chesapeake Bay and its tidal shorelines. The Law calls for local jurisdictions to protect forest and other resources through preservation plans and prohibits changes in land use without obtaining the necessary permit approvals.	• Provides for stream buffers in critical areas of a minimum of 100 ft which can be expanded. • The cutting or removal of natural vegetation in the Buffer is not allowed without an approved Buffer Management Plan • Replanting is typically required for the removal of vegetation and use of native plant species is called for to enhance wildlife habitat.
Nontidal Wetlands	Statewide	Provides the permits required for activities which alter nontidal wetlands. Also contains the activities which are exempt from permit requirements as well as the delegation of authority within the nontidal wetlands protection program. Contains the regulations for nontidal wetland buffer expansions.	• Calls for a minimum 25-foot buffer area for nontidal wetlands. • Nontidal wetland permit application does require applicants to indicate if there will be temporary or permanent tree clearing (upland or wetland) occurring on the overall project site and the total estimated acres of tree clearing.

Table 3. Maryland regulations that may apply to stream restoration and associated riparian forest buffers

Regulation	Where it Applies	Description	Implications for Riparian Forest
Construction on Nontidal Waters and Floodplains	Statewide	Provides the regulations for governing construction, reconstruction, repair, or alteration of a dam, reservoir, or waterway obstruction or any change of the course, current, or cross section of a stream or body of water within Maryland. Contains permit requirements, permit application requirements as well as the regulations and criteria for a variety of construction of various water and floodplain structures.	• Requires a person who proposes to construct, reconstruct, repair, or alter a dam, reservoir, or waterway obstruction, or change in any manner the course, current, or cross section of a stream or body of water within the State except tidal waters, including any changes to the 100-year frequency floodplain of free-flowing streams shall obtain a permit from the Administration before commencing any work
Maryland Water Quality Standards	Statewide	This chapter of the code includes the framework for water quality criteria to protect given designated uses for water resources.	• States that it is the policy of the State that riparian forest buffer adjacent to natural trout waters or recreational trout waters shall be retained whenever possible to maintain the temperatures essential to meeting this criterion.
Forest Preservation Act of 2013	Statewide	The Act seeks to stop forest loss in the state and encourage tree conservation through various incentives to conserve and preserve forestland.	• Provides modified financial incentives to encourage more landowners to convert residential property to forestland and to retain/manage existing tree cover • Requires the state to maintain at least 40 percent tree canopy cover by instituting a "No Net Forest Loss" policy

• 3.3 Virginia Regulations

In Virginia, stream restoration is defined as, "modifications to a stream that make its morphologic structure and fluvial function more consistent with that of a dynamically stable, natural stream."[10] Efforts to improve stream structure and function that are consistent with this definition are referred to as natural channel design. Design approaches are generally categorized by the four NCD priority types.[11] Most implemented projects fall under Priority I, which involves raising the channel to connect to the floodplain and is commonly considered the most preferable restoration design type. However, many Priority II projects, which involve creating a new channel and lowering the floodplain, are also implemented. Key Virginia regulations related to stream restoration can be found in Table 4.

Most implemented projects in Virginia fall under Natural Channel Design Priority I, which involves raising the channel to connect to the floodplain.

Table 4. Virginia regulations that may apply to stream restoration and associated riparian forest buffers

Regulation	Where it Applies	Description	Implications for Riparian Forest
Chesapeake Bay Preservation Act	Counties of Tidewater Virginia as defined in the legislation	The goal of the Act is to protect and improve water quality in the Chesapeake Bay by requiring the implementation of land use management practices including an ordinance to reduce pollution during development and redevelopment and by identifying Chesapeake Bay Preservation Areas (CBPAs).	• Establishes Resource Protection Areas (RPAs) criteria that requires a vegetated buffer on tidal shores and streams no less than 100 feet wide • Documents the criteria for RPA buffers including allowed uses • Calls for comprehensive plans to include elements on shoreline and streambank erosion problems
Virginia Water Protection Permit	Statewide	This regulation requires a Virginia Water Protection permit unless otherwise excluded for wetland activities (excavating, new activities to cause draining that significantly alters or degrades existing wetland acreage or functions; filling or dumping; permanent flooding or impounding; or new activities that cause significant alteration or degradation of existing wetland acreage or functions) or activities that alter the physical, chemical, or biological properties of state waters and make them detrimental to the public health, animal, or aquatic life.	• Protects wetlands from excavation or new activities that may cause draining that significantly alters or degrades existing wetland acreage or functions including associated forested areas. • Permits must contain requirements for compensating impacts on wetlands sufficient to achieve no net loss of existing wetland acreage and functions
Virginia Water Protection General Permit for Impacts Less Than One-Half Acre	Statewide	The purpose is to establish a VWP General Permit to govern permanent and temporary impacts to less than one-half acre of nontidal wetlands or open water and up to 300 linear feet of nontidal stream bed.	• All temporarily impacted streams and streambanks shall be restored to their preconstruction elevations and contours with topsoil from the impact area where practicable within 30 days following the construction at that stream segment. • Streambanks shall be seeded or planted with the same vegetation cover type originally present, including any necessary, supplemental erosion control grasses. • Invasive species identified on the Department of Conservation and Recreation's Virginia Invasive Plant Species List shall not be used to the maximum extent practicable or without prior approval from the Department of Environmental Quality
Fisheries and Habitat of the Tidal Waters	State-owned submerged lands, tidal wetlands, and dunes/ beaches	Details the Virginia Marine Resources Commission and the jurisdiction and powers of the Commission over tidal waters of the state of Virginia.	• Creates standards for use and development of tidal wetlands

3.4 Examples of Local Government Regulations

Examples of local government regulations corresponding to counties included in the case studies analysis are provided in Table 5. There are no local level regulations for the Pennsylvania case study.

Table 5. Example local government regulations that may apply to stream restoration and associated riparian forest buffers

State	Regulation	Where it Applies	Description	Implications for Riparian Forest
VA	Fairfax County Chesapeake Bay Preservation Ordinance	All lands designated as part of the RPA or RMA in Fairfax County	County ordinance that codifies requirements for RPAs and Resource Management Areas ("RMAs") that are subject to the criteria and requirements as described by the state Code.	• Water Quality Impact Assessment for any proposed land disturbance, development, or redevelopment within an RPA that is not exempt. • Tree Canopy target goals should be met by preservation of existing trees preferentially • 100-foot buffers in RPA
VA	Fairfax County Public Facilities Manual	Countywide	The purpose and intent of Chapter 12 is to provide plan submission requirements, technical specifications and on-site practices that support the administration, implementation, and enforcement of the tree conservation requirements of the Code.	• 10 Year Tree Canopy requirement to provide for the conservation of trees so that the minimum tree canopy for the site reaches a projected canopy percentage. • Tree Conservation Plan Requirements
VA	Fairfax Tree Conservation Ordinance	Countywide	This ordinance was designed to control the destruction of trees and established the Office of Urban Forest Management to administer the ordinance. The code establishes tree preservation and planting requirements for private property.	• Allows the Director of Land Development Services to require periodic inspections of tree conservation activities • Addresses 10-year tree canopy requirements for different land uses • Tree preservation and planting requirements • The code provides for periodic monitoring and inspections
MD	Anne Arundel Subdivision and Development	Countywide	Subtitle 3 on Forest Conservation provides the general development provisions. on forest stand delineations, forest conservation plans, afforestation and reforestation methods, forest conservation funds, and violations of the subtitle. Subtitle 4 on Natural Features lists the development provisions for nontidal wetlands, streams, steep slopes, nontidal floodplains, and for environmental site design.	• Establishes priority retention areas including trees, shrubs, and plants located in sensitive areas, including the 100-year floodplain, intermittent and perennial streams and their buffers, steep slopes, non-tidal wetlands, and all associated buffers • Sets afforestation and reforestation policies including the preferential sequencing and the use of native species • Requires 100-foot buffers on streams

4 General Best Practices

The nutrient and sediment load reduction credits provided by stream restoration projects have become a driver of project implementation for meeting the Chesapeake Bay TMDL, as well as local TMDL and MS4 requirements. While many stream restoration projects have been successful in minimizing riparian impacts, there have also been many projects that have resulted in the loss of riparian forests and vegetation. The CBP Stream Restoration Expert Panel report[12] and recent work group updates[13] recommended that all stream restoration projects adopt a holistic watershed approach and improve the functional uplift of the riparian ecosystem. This section describes six general best practices—Site Selection, Establishing Goals and Objectives, Design and Permitting, Stakeholder Engagement, Construction, and Maintenance and Monitoring—for minimizing riparian forest and vegetation impacts and helping to ensure functional uplift is obtained.

Functional Uplift[14]
Ecosystem functions are defined as the physical, chemical, and biological processes that occur within an ecosystem. Some specific examples from the "Function-Based Framework for Stream Assessment & Restoration Projects" are hydraulic, physiochemical, and biology functions. An aquatic resource can perform these functions at varying degrees. Performance is measured using function-based parameters. Improvements to the capacity of a specific ecosystem function are considered functional uplift.

Table 6 is organized by the six best practices and includes helpful guidance documents that contain information related to the best practices. Weblinks are provided to each document, as well as the jurisdictional application for each resource. Section 7 includes an annotated bibliography that provides a short description of each resource and the best practices they address.

Table 6. Guidance documents and resources to minimize riparian forest impacts

Citation	Title	Jurisdiction	General Best Practices Addressed					
			Site Selection	Establishing Goals & Objectives	Design & Permitting	Stakeholder Engagement	Construction	Maintenance & Monitoring
Baird & Wetmore (2003)	Riparian Buffers Modification & Mitigation Guidance Manual	VA			✔	✔		✔
Berger et al. (2021)	Recommended Stream Restoration Best Practices: Voluntary Guidance for Stormwater Program Managers in the COG Region on Best Practices for Implementing Stream Restoration Projects	DC MD VA	✔	✔	✔	✔	✔	✔
Harman et al. (2012)	A Function-Based Framework for Stream Assessment & Restoration Projects	US	✔	✔				

Table 6. Guidance documents and resources to minimize riparian forest impacts

Citation	Title	Jurisdiction	General Best Practices Addressed					
			Site Selection	Establishing Goals & Objectives	Design & Permitting	Stakeholder Engagement	Construction	Maintenance & Monitoring
Keystone Stream Team (2007)	Guidelines For Natural Stream Channel Design for Pennsylvania Waterways	PA				✔	✔	✔
Schueler & Stack (2014)	Stream Restoration Expert Panel Report	Bay[1]	✔	✔	✔			✔
Wood et al. (2021)	A Unified Guide to Crediting Stream and Floodplain Restoration Practices in the Chesapeake Bay Watershed	Bay[1]	✔	✔	✔		✔	✔
Burch et al. (2019)	CBP Stream Restoration Verification Guidance	Bay[1]						✔
Law et al. (2015)	Designing Sustainable Stream Restoration Projects within the Chesapeake Bay Watershed	Bay[1]		✔	✔			✔
MD DNR (2018)	Regenerative Stream Conveyance Construction Guidance	MD			✔		✔	✔
MDE (2022)	Guidance for Stream Restoration Based on Key Wildlife Habitats: Upper Coastal Plain Stream-associated Wetlands	MD	✔	✔	✔	✔	✔	✔
MDE (n.d.)	MS4/Chesapeake Bay TMDL/Trust Fund Restoration Project Wetlands & Waterways Permit Package Checklist	MD	✔		✔	✔	✔	
PA DEP (2022)	Pennsylvania Function-Based Aquatic Resource Compensation Protocol	PA	✔	✔	✔	✔		
Palone & Todd (1998)	Chesapeake Bay Riparian Handbook: A Guide for Maintaining Riparian Forest Buffers	DC MD VA				✔	✔	
RRC (2011)	Practical river restoration appraisal guidance for monitoring options (PRAGMO)	UK[2]		✔		✔		

Table 6. Guidance documents and resources to minimize riparian forest impacts

Citation	Title	Jurisdiction	General Best Practices Addressed					
			Site Selection	Establishing Goals & Objectives	Design & Permitting	Stakeholder Engagement	Construction	Maintenance & Monitoring
USBR & ERDC (2016)	National Large Wood Manual—Assessment, Planning, Design, and Maintenance of Large Wood in Fluvial Ecosystems: Restoring Process, Function, and Structure	US		✔	✔		✔	
USDA NRCS (2007)	Stream Restoration Design (National Engineering Handbook 654)	US		✔	✔	✔	✔	
USNVC (2022)	U.S. National Vegetation Classification	US	✔					
VA DCR (2004)	The Virginia Stream Restoration & Stabilization Best Management Practices Guide	VA	✔		✔			
VA DEQ (1992)	Virginia Erosion and Sediment Control Handbook	VA			✔		✔	
Yochum (2018)	Guidance for Stream Restoration	US		✔			✔	

[1] Chesapeake Bay
[2] Also applicable in the U.S.

4.1 Site Selection

Proper site selection is the most important best practice to target restoration to areas in need for restoration and to prevent impacts to existing high-quality streams and riparian areas. Proper siting is critical to assure a good, positive return on investment in terms of ecological and water quality benefits, as well as minimizing impacts to riparian vegetation. The stream restoration expert panel[15] recommended a watershed-based approach for screening and prioritizing stream restoration projects to focus restoration efforts at locations that will provide the most benefit in terms of sediment and nutrient reduction, as well as improvement to stream function. Funding availability and landowner willingness are commonly identified key parameters for site selection, but without a holistic watershed-based approach, can result in project implementation at locations that are not necessarily the most optimal. Stream restoration should be **directed to areas of severe stream impairment and avoid high-quality areas** such as stable stream reaches, wetlands, seeps, good quality vegetative communities, rare or sensitive species, important cultural features, specimen trees, etc. Table 7 lists state mapping tools and datasets that may help with the site selection process.

Table 7. State mapping tools and datasets that may help with the site selection process

State	Resource	Description
Bay	Resource Lands Assessment (RLA) (Chesapeake Bay Program)	The RLA tool uses GIS models and professional expertise to provide a multi-state view of the most important resource land in the Chesapeake Bay region. The tool is intended to guide land protection strategies, be a resource for the land trust community, suggest conservation focus areas, and identify important areas for the forestry industry.
PA, MD, VA, WV	Watershed Resources Registry	Watershed Resource Registries are online mapping tools that showcase state-specific preservation and restoration models. They can be used to identify sites for restoration projects, assess and compare potential sites, avoid or minimize impacts to existing high-quality areas, and print site maps for field assessments.
PA	Pennsylvania Priority Landscapes (PA Department of Conservation and Natural Resources)	This online map showcases priority landscape areas in Pennsylvania. It is a composite map that equally weighs forest pest, wildfire, ecology, water, and working forest parameters—the resultant intersections are identified as priority landscape areas.
PA	Watershed Conservation Prioritization (PA Natural Heritage Program)	This resource includes both an online interactive map, a static map, and downloadable data. The Watershed Conservation Prioritization resource uses data from the Aquatic Community Classification to qualitatively examine watersheds in the State based on their biological assemblages and stream habitat types.
MD	Forests of Recognized Importance (MD Forest Service)	This resource identifies areas with Forests of Recognized Importance (FORI), which were previously termed High Conservation Value Forests (HCVF). The MD Forest Service defines FORI as: 100-ft buffers of Stronghold Watersheds, trout-bearing streams, streams feeding municipal drinking water reservoirs, and MDE Tier II High-Quality Waters.
MD	BioNet (MD Biodiversity Conservation Network)	This BioNet data identifies and prioritizes ecologically important lands for the conservation of Maryland's diverse plants, animals, habitats, and landscapes using a hierarchical criteria matrix. The goal of this data is to encourage effective land management practices and to facilitate and improve the effectiveness of public-private partnerships.
MD	The GreenPrint Map (MD Department of Natural Resources)	The GreenPrint map illustrates Targeted Ecological Areas (TEAs), which are lands and watersheds of high ecological value that MD DNR has identified as a conservation priority. It contains other datasets pertaining to State-operated land conservation programs and other protected land data for reference.
VA	Forest Conservation Values Model (VA Department of Forestry; Figure 1)	The Forest Conservation Value (FCV) model is intended to strategically identify forest areas with the highest priority for conservation in Virginia. The FCV model prioritizes forestlands that are of the highest quality, most productive, and/or most vulnerable by evaluating six components: forested blocks, forest management potential, connectivity, watershed integrity, threat of conversion, and significant forest communities/diminished tree species.

Table 7. State mapping tools and datasets that may help with the site selection process

State	Resource	Description
VA	Virginia Natural Landscape Assessment (VA Department of Conservation and Recreation)	The Virginia Natural Landscape Assessment (VaNLA) is a mapping tool that includes a landscape-scale analysis for identifying, prioritizing, and linking natural lands in Virginia. It Includes mapping of ecological cores with attributes like rare species, patch characteristics, and water quality benefits. It is intended to identify target areas for land protection activities, including but not limited to guiding conservation easement purchases, informing comprehensive planning efforts, reviewing the ecosystem impacts of proposed projects, and targeting land for habitat restoration.
VA	Development Vulnerability Model (VA Department of Conservation and Recreation)	The Virginia Development Vulnerability Model aims to quantify the risk facing greenspace (natural, rural, or other open space lands) of conversion to urbanized uses by presenting relative ranks of development potential. This model is based on a Random Forest machine-learning model that uses various local site characteristics, neighborhood characteristics, and distance measurements as predictors.
VA	Watershed Impact Model (VA Department of Conservation and Recreation)	The Virginia Watershed Impact Model aims to inform efforts to improve/maintain water quality and/or ecological integrity by establishing priority areas for conservation, restoration or the implementation of best management practices. In addition to the model's primary "potential impact" dataset, it also includes other intermediate datasets for reference, such as stormwater runoff potential, prevalence of karst features, and overland flow distance to surface waters.

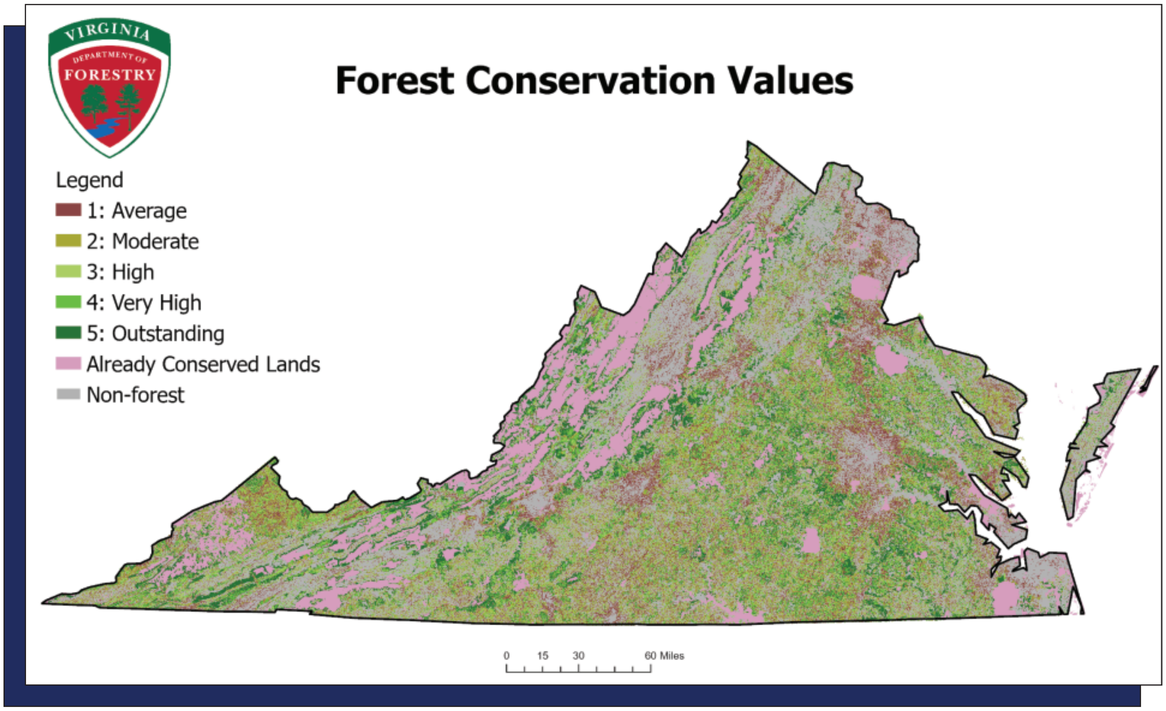


Figure 1. Map of Forest Conservation Value model results in Virginia (Source: VA DOF[16]).

Stream restoration, no matter how well executed, cannot successfully restore the stream and riparian forest systems without complementary upland work. Options for combining stream and floodplain restoration with stormwater, forestry, wetland, and agricultural BMPs in the contributing watershed area should be evaluated when screening and prioritizing projects. It is generally accepted that individual stream restoration projects are more effective when pollutant loads and flow from the contributing watershed also are reduced.

Best Practices for Site Selection
Follow a watershed-based approach for screening and prioritizing stream restoration projects that target restoration to areas in need (generally streams with poor biological quality) and avoid high-quality areas with healthy stream and riparian conditions. Guidance should be followed from the appropriate federal, state, or local regulatory authorities regarding assessment and incorporation of existing high-quality habitat and ecosystem functions into project design. In addition, stream restoration projects should be avoided in watersheds where significant land use change is planned that may cause adverse effects to the project.
Evaluate options for combining stream restoration with stormwater infiltration, other upland stormwater management practices, forestry, wetland, and agricultural BMPs in the contributing watershed.
Combine stream restoration with sanitary sewer rehabilitation. Sanitary sewer main lines that are gravity flow often physically lie in streams and floodplains. Older lines cause problems with exfiltration of sewage into the stream and infiltration of stream/groundwater flows into the sewer. Repair of sanitary sewer lines in the stream or floodplain could be aligned with stream restoration to target restoration to locations where disturbance will already be occurring. The longest/largest opportunities presumably would be in association with USEPA consent decree repairs, such as in Baltimore City, Baltimore County, WSSC, etc.

• 4.2 Establishing Goals and Objectives

Many stream restoration projects are implemented solely to meet nutrient and sediment load reduction goals for TMDL purposes and MS4 requirements.. However, the CBP Stream Restoration Expert Panel Report, recent work groups, and CBP partners and stakeholders suggest that the full spectrum of water quality goals (e.g., temperature, dissolved oxygen, etc.) and riparian buffer goals be taken into consideration. Establishing achievable goals and objectives is one of the most important steps in a stream restoration project that determines not only the design, but the data collection effort and methodologies

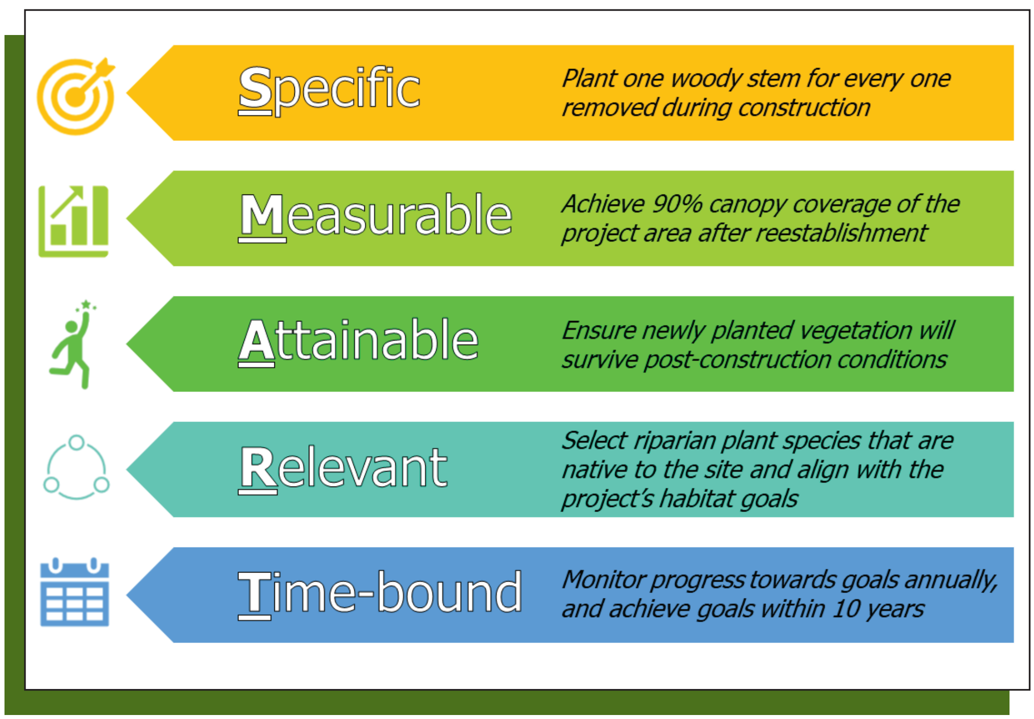


Figure 2. Example of a SMART goal for maintaining riparian vegetation in stream restoration projects. SMART goals are Specific, Measurable, Attainable, Relevant, and Time-bound[17].

for assessments. Goals are general, while objectives are measurable and in support of the stated goals.[18,19] Figure 2 provides an example of how to develop specific goals and objectives using the SMART approach (Specific, Measurable, Attainable, Relevant, and Time-bound) described by the River Restoration Centre,[19] which is a tool for designing useful and achievable restoration goals. When restoration-related goals are too broad (e.g., "restore the habitat"), they are more difficult to map out and less likely to be achieved. Developing SMART goals can help to ensure that restoration outcomes meet the goals set by practitioners and stakeholders.

The CBP stream restoration expert panel and subsequent work groups recommended that proposed stream restoration projects be developed through a functional assessment process, such as the Stream Functions Pyramid[20] (Figure 3) or functional equivalent. It is important to note that stream evolution theory is still evolving with widely divergent opinions and views, which should be considered in any functional assessment. The Stream Functions Pyramid Framework can be used to determine the restoration potential at a proposed project site, which is the highest level of restoration or functional lift that can be achieved given the site constraints and health of the watershed. Once the restoration potential is known, specific design goals and objectives can be established, or original goals and objectives may need to be refined.

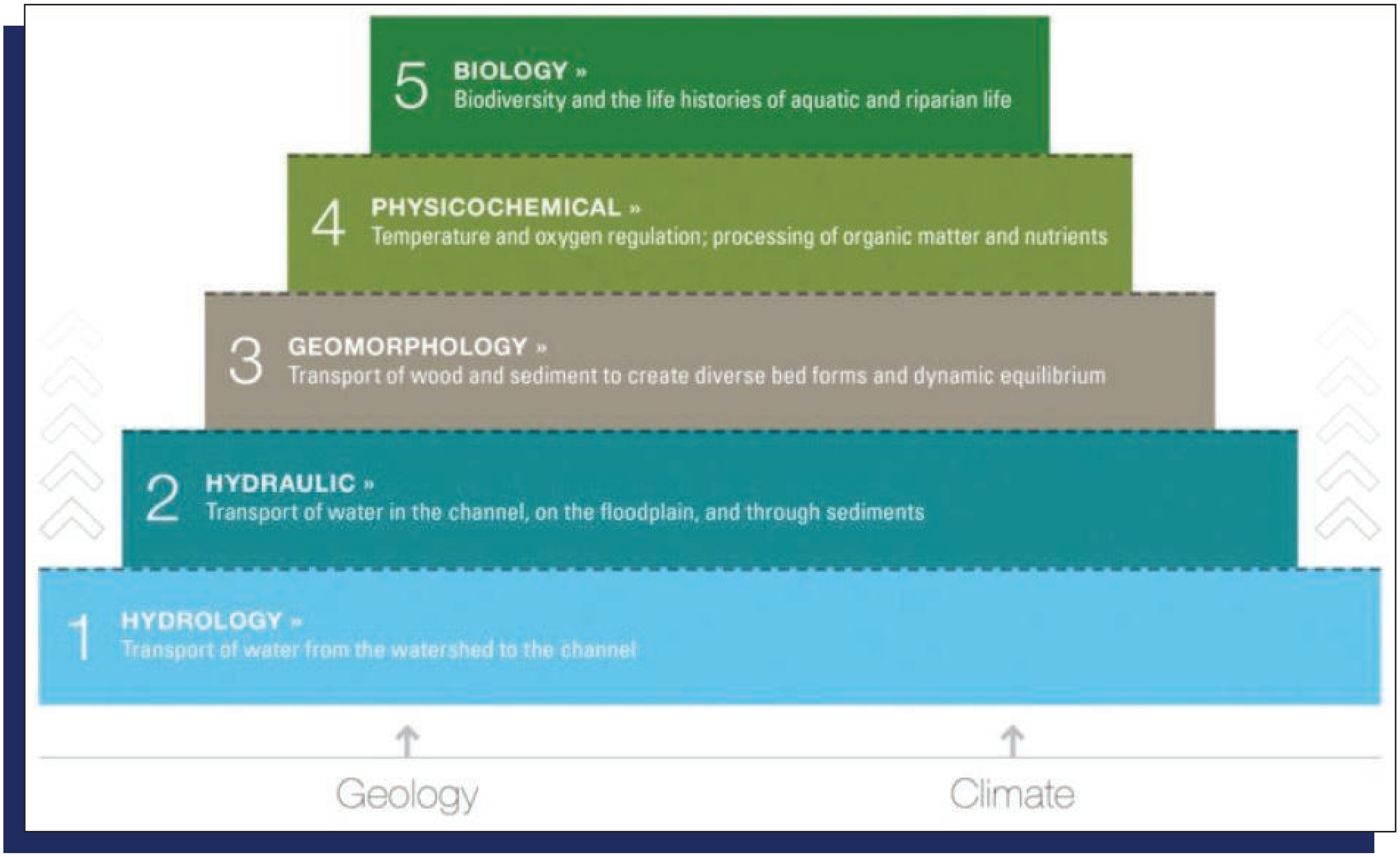


Figure 3. Stream Functional Pyramid[21], which is a widely used functional assessment process.

Establishing or maintaining a mature riparian forest may or may not be an appropriate and/or achievable goal for all sites or projects. Depending on current, historic, and projected future watershed and reach conditions, some stream restoration designs affecting the riparian area will follow natural succession that doesn't lead to a forested condition. In addition, some currently forested sites will transition to other communities, often due to prolonged increased groundwater elevations, and/or extended inundation and saturation of the floodplain. The project goals should be carefully considered with all stakeholders (refer to Section 4.4 Stakeholder Engagement) to determine if forested riparian conditions are appropriate and achievable.

Best Practices for Establishing Goals and Objectives
Develop stream restoration projects through a functional assessment process, such as the Stream Functions Pyramid (Harman et al., 2012) or functional equivalent.
Review the project goals with all stakeholders to determine if forested riparian conditions are appropriate and achievable within the context of the stream and floodplain condition that would naturally form given existing and likely future watershed and reach conditions and be self-sustaining over time. Additional stakeholder considerations should include aesthetics, recreation, and cultural concerns.
Coordinate with forest agencies to incorporate riparian forest goals and objectives. Coordination between foresters and stream restoration practitioners at this stage of project development will help avoid conflicting riparian forest and stream restoration goals and objectives.
Consider the thermal impact of the project on the affected stream and incorporate thermal refugia. Climate has a large influence on rising stream temperatures across the Chesapeake Bay watershed. Evaluating and limiting the thermal impact of stream restoration projects can help mitigate the effects of climate-related stream temperature increases, which aligns with Chesapeake Executive Council Directive No. 21-1 Collective Action for Climate Change[22] calling for the threats of climate change to be addressed in all aspects of the partnership's work to restore the Chesapeake Bay and its watershed.

4.3 Design and Permitting

The design of a stream restoration project should take into account the site conditions, regulatory requirements, guidance, and restoration goals and objectives. Designs should also consider whether a forested riparian area is appropriate, and practitioners should be familiar with differing goals and priorities in the various jurisdictions over riparian forest management. This section provides general best practices for design and permitting, and Section 5 covers best practices applicable to specific stream restoration designs.

It is critical to determine the restoration potential of the riparian forest and get community input that involves walking the existing sites, marking trees that will be removed, and developing artistic renderings of the revegetation plan not just during full revegetation but at different periods after construction. Trees should be ranked during the planning process based on factors such as tree health, location, size, value, bank proximity, root mass erosion status, and amount of shade cast. Planting plans for the project design should consider:

- plant species selection, quality, and age class
- species selection based on seed dispersal potential to encourage regeneration
- incorporation of assisted migration riparian tree candidates to ensure planted species are adapted to changing climate conditions[23]
- local source material, and local phenotypes
- a planting strategy/plan with input from a plant ecologist or natural resource specialist that is suitable for the entire limit of disturbance (LOD) and include a selection of approved trees, shrubs, and herbaceous materials, in addition

Ecosystem Services' Restoration Constructability Checklist

Ecosystem Services has developed a Restoration Constructability Checklist. This checklist is intended for use when evaluating a project prior to implementation, but it is not a design checklist, nor is it a project screening tool. This checklist is designed to evaluate items specific to construction that may or may not have been adequately addressed during the design and permitting process, including several items related to tree and forest impacts. The Checklist can be found in Appendix A.

to planting densities and planting zones in the construction plan set
- review and approval of the planting plan and proposed species by the appropriate authority prior to installation, and approval of any plant substitutions before the substitute species are installed
- site modifications to accommodate and foster existing and new plants
- predator- and pest-resistant planting and/or landform design
- techniques that provide higher degrees of canopy coverage in shorter amounts of time
- consideration of invasive species impacts
- post-construction monitoring and remediation (refer to Section 4.6)

Early feedback from regulators is also important before a design is undertaken.

Ground-truthing site conditions is crucial for most projects at various stages of implementation, including initial assessment, and at any significant change points in the process. Sometimes survey data is inaccurate, incomplete, or otherwise corrupt. Also, the time that many stream and riparian area projects take place is sufficient that it becomes important for designers to refresh their memory of the site.

Early feedback from regulators is also important before a design is undertaken. Pre-application meetings with federal and state permitting agencies help the applicant design a project that will minimize environmental impacts, including existing riparian resources, before a final design is committed to and a great deal of money is spent. This early feedback also helps to identify aspects of the proposed project that may affect permit approval and possible alternatives to streamline the approval process.

Figure 4. Nursery plantings

Figure 5. Design meeting with MD DNR during the concept development phase for a stream restoration project.

Best Practices for Design and Permitting

Conduct pre-application meetings with state and federal permitting agencies to ensure that the conversation regarding avoidance of tree impacts happens early in the process.

Configure the restoration design to unique site conditions instead of the site to a specific type of practice.

Conduct a comparative analysis of different restoration approaches to evaluate the impacts of both temporary construction and completed restoration landscaping, as well as maintaining existing forest, relative to the creation of a long-term, sustainable system. This comparative analysis of restoration approaches should also consider the level of risk a client or landowner is willing to accept for both routine and restorative maintenance.

Coordinate with forest agencies to ensure that the stream restoration design does not impact established riparian forest goals and objectives and to identify site-specific best practices for minimizing impacts to the riparian area. Forest agency input is critical because each site/project is unique and decisions on tree removal vary depending on factors such as the quality of the tree, what needs to be done for the stream restoration, input from stakeholders, etc.

Prioritize the protection of high-quality mature trees to the extent possible and rank on-site trees during the planning process based on factors such as tree health, location, size, value, bank proximity, root mass erosion status, and amount of shade cast.

Develop (and implement) planting plans that prioritize native species and consider impacts of invasive species. Use planting plans that track survivability and post-construction vegetative management (including supplemental plantings and invasives control) as tools to handle discrepancies, which allows for fine-tuning as the forest and vegetation re-establishes.

Consider planting techniques to provide higher degrees of canopy coverage in shorter amounts of time while still being amenable to maintenance of plantings. Plantings need maintenance for years to succeed and planting configurations should be management friendly.

Consider assisted migration in planting plans to incorporate species adapted to changing climate conditions. Check for riparian tree candidates that may be suitable for migration, depending on location in Chesapeake Bay Watershed and projected movement due to changing climate conditions and hydrology.

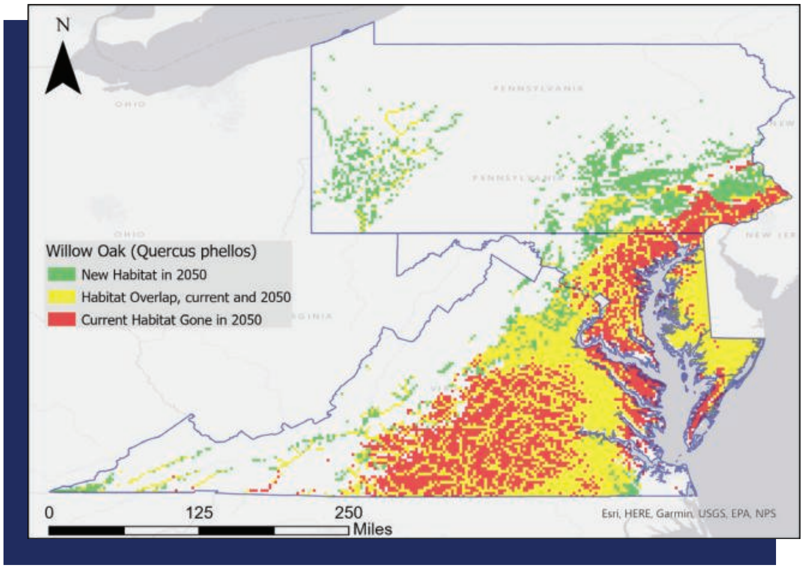


Figure 6. Willow Oak current expected range compared to the range in 2050 for PA, MD, and VA developed based on data available from Forecasts of Climate-Associated Shifts in Tree Species (ForeCASTS)

4.4 Stakeholder Engagement

Stakeholders include a range of individuals from internal and external groups that should be engaged early in the project process prior to the submission of permit applications to the state. Internal stakeholders may include outreach managers, reviewers and permitting agencies, staff from various government departments and agencies, and elected officials. External stakeholders may include local residents and landowners near the site, community groups, non-profit organizations, others in the planning and design process, and schools. Stakeholder goals and objectives should be clearly defined and prioritized. Risks also need to be mutually understood by the community, planners, and designers for implementing any successful project.[24]

The social context of the restoration should be accounted for as part of stream restoration.[25] An often overlooked and misunderstood risk associated with stream restoration projects is the acceptance of the project by those who live near the stream and its floodplain. While a stream restoration project may be technically sound from a biophysical perspective, if it is not in harmony with community objectives, it may also be considered a failure.[26]

Many community complaints are related to tree loss and Impacts to the terrestrial system in public areas where larger floodplain reconnection projects are proposed. Some stream restoration projects are initially very high impact, potentially removing a large number of trees, and changing the general shape of the stream channel and corridor. Plantings done for revegetation can take many years, before the vegetative community is reestablished, and decades for reforestation. During and immediately following construction, the project sites look so different from the familiar state of the site and "natural" areas, that many people in the community complain to local officials.

To avoid these complaints, it's important to understand what the community wants and then include those desires into overall considerations for what is appropriate for the site within the regulatory requirements. It's also important that the community be involved in reviewing project documents and assisting with decision making. Impacts need to be understood, including what the project site will look like during and after construction. Giving the community a thorough understanding about the projects and incorporating their input into the design can help to manage expectations and ensure the project is in harmony with community objectives.

Best Practices for Stakeholder Engagement

Conduct pre-restoration community engagement, including getting local stakeholders involved, communication about the project, setting expectations, and gathering consensus on the project's goals and objectives. It is critical that community members understand the project during the early stages of concept development so they are aware of how and why the forest may be impacted in their neighborhood and what can be done to prevent or mitigate the impacts. Community outreach should consider strategies for inclusive engagement, such as developing outreach materials in languages other than English.

Coordinate with federal, state, and local governments, as well as practitioners, forest agencies, contractors, landowners, and local community stakeholders to come to consensus on the preferred design approach and project goals/objectives.

An often overlooked and misunderstood risk associated with stream restoration projects is the acceptance of the project by those who live near the stream and its floodplain.

4.5 Construction

Impact to the riparian forest from the construction process is an important consideration for stream restoration projects. Geomorphic restoration work inherently involves site impacts, some of which are unavoidable, but should be minimized to the extent possible. Site conditions may also vary between the time the design is finalized and the permit is issued and therefore it is critical for the designer and contractor to walk the site prior to construction to identify challenges that may need revision and further coordination with regulatory agencies. Likewise, unforeseen conditions arise during the construction process (e.g., discovery of large rock deposits) that require modifications to the design approach. It is critical to have the designers on-site periodically during the construction process so they can make "change orders" if necessary and notify regulatory agencies regarding the need for formal approval or permit modification. "As-Built Designs" are typically required post-construction to account for any changes that occur because of unforeseen site conditions, which should also include the riparian vegetation. An independent environmental monitor or inspector may be needed in sensitive areas to oversee construction and coordinate any changes with regulatory agencies.

Construction of stream restoration projects can lead to local destruction of riparian cover within the project reach. Machine access, construction material transport, laydown and staging, and other components of the work introduce clearing, soil and root compaction, possible accidental direct damage to trees, often significant grading, and possibly even rerouting of the stream channel itself through established vegetation. The proper selection of construction practices and equipment appropriate for the site can help to minimize these adverse impacts. A list of best practices for construction is provided below.

Figure 7. Tree planking around existing trees prevents damage during stream restoration construction (Source: Ecotone, Inc.)

Best Practices for Construction
Site managers responsible for riparian forest impacts should be present on site.
Carefully draw and manage LODs so they are as small as possible, and the construction sequence is organized to prevent equipment from repeating trips over the same area many times.
Flag and mark individual trees and swaths of trees to be protected and those to be removed.
Plan access routes to retain marked desired trees and verify plans with regulatory agencies. Utilize the existing channel as the primary access road to the extent practicable.

Best Practices for Construction

Apply additional protection measures to trees that are at risk of being impacted by construction activities. Some practitioners use bracing/wood posts around the trunks to prevent equipment damage, and others use a combination of foam and wood for protection. Sturdy metal cages may be installed around trees and shrubs on sites with large deer populations. All trees within 5 feet of the LOD should be armored.

Use rubber-tire construction vehicles to minimize compaction. Ideally, those vehicles should be as small as possible. Mulch beds of sufficient depth and/or mats may be needed to prevent compaction.

Carefully trim roots if impact from construction equipment is unavoidable and minimize pruning to 30% of the critical root zone or less.

Install water gators (bags of water attached to the tree that slowly drip down) and apply mulch around the trees to keep underlying soil moist.

Implement ground protection practices to minimize rutting and compaction from construction and reinforce the organic content of the forest floodplain soils, which benefits native species.

Reuse downed or removed trees on-site. Leaving cut trees in the floodplain to serve as coarse woody debris can help restore habitat features and serve as a source of carbon.

Retain an independent environmental inspector or monitor answerable to regulatory agencies when required, or in sensitive areas with special resource needs and construction practices.

4.6 Monitoring and Maintenance

After construction, monitoring should be performed to assess if the project is fulfilling the goals and objectives. If not, project remediation may be needed through adaptive management. Documentation of project performance should be maintained for communication with stakeholders and adding to the knowledge base of the restoration community.

Most restoration projects undergo monitoring for 2 – 5 years after construction, based on required state and federal permit conditions. Once the original permit expires, responsibility shifts to the installing agency to meet CBP stream restoration verification requirements[27] for visual inspections once every 5 years. These inspections are designed to eliminate projects that fail or no longer meet their restoration objectives and to reduce or eliminate their sediment and nutrient reduction credit. Verification inspection also generates useful data on real world projects that can refine future restoration methods and practices.

While permit and CBP verification related monitoring is valuable, it typically does not include monitoring of the riparian ecosystem, which is needed to guarantee success of the project. Long-term

Invasive Species Resources

Bay

USFS Invasive Plants Field and Reference Guide: An Ecological Perspective of Plant Invaders of Forests and Woodlands (n.d.)

NPS and USFWS Plant Invaders of Mid-Atlantic Natural Areas (2010)

Mid-Atlantic Invaders Tool (n.d.)

Maryland

Maryland Invasive Species Council Website (n.d.)

MD DNR Common Invasive Plants Easy ID Cards (2020)

Virginia

Fairfax County Non-Native Invasive ID and Control Booklet (n.d.)

Virginia Invasive Species Plant List (2014)

Pennsylvania

PA DCNR Invasive Plants in Pennsylvania Webpage (n.d.)

Figure 8. Staff from Ecotone, Inc. conducting riparian forest assessments (Source: Ecotone, Inc.)

monitoring of riparian benefits and total ecosystem benefits done by professionals/scientists is recommended (Figure 8). When appropriate, a pooled monitoring approach may be beneficial. Monitoring can also include local watershed organizations or citizens that have gone through training, such as Master Naturalists.[28] Project sponsors may need to have long-term resources available to better ensure that the stream and riparian area are restored as projected.

An additional component of successful monitoring is the management of invasive species. The clearing and disturbance associated with stream restoration projects can create open space for invasive encroachment, and invasive species growth is common in the first two years post-construction. These effects are compounded by climate change, which encourages invasive vine growth. There are several online resources for the identification, prevention, and removal of invasive species. A list of some useful websites and online resources about invasive species in the Chesapeake Bay watershed is provided above.

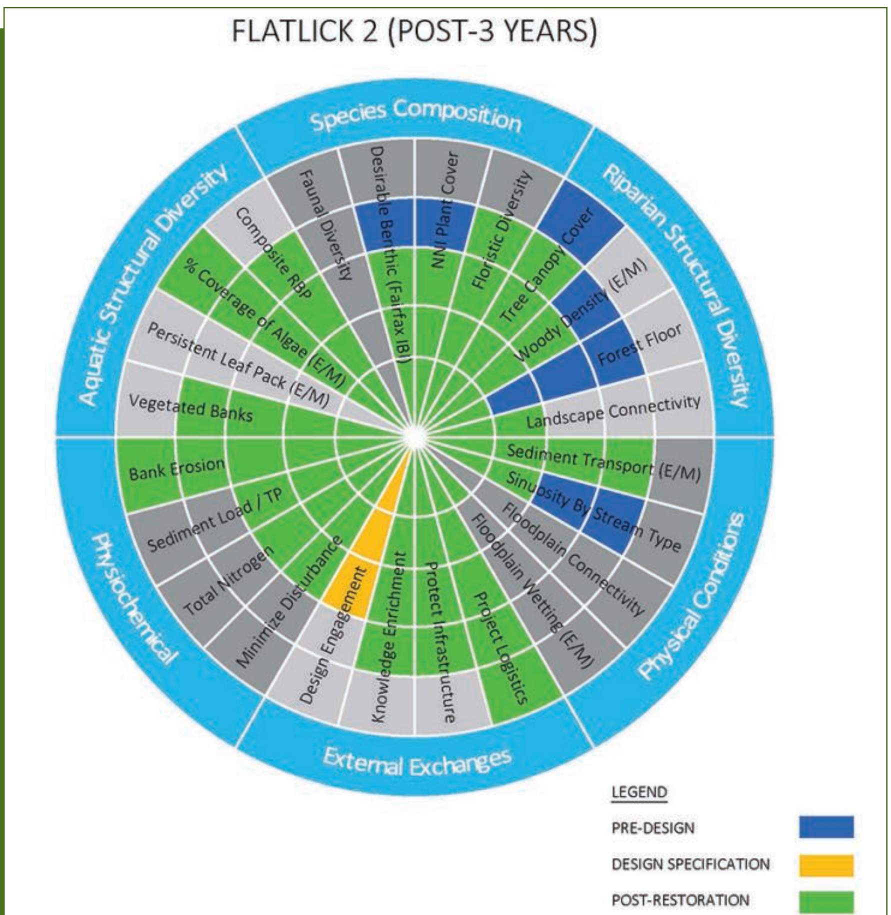


Figure 9. Fairfax County's Restoration Recovery Wheel for the Flatlick Branch NCD project (constructed 2018)

Fairfax County, VA has developed a "Restoration Recovery Wheel," which is a framework that helps define success across multiple metrics of pre-design, design specification, and post-construction success. The higher a project scores on a variety of different metrics and measurements determines whether the project is considered successful. Figure 9 shows an example of the Fairfax County Restoration Recovery Wheel for measuring the 3-year post-construction success of the Flatlick Branch project, which was a natural channel design project constructed in 2018. This Recovery Wheel framework demonstrates the degree to which the project has achieved success metrics related to physiochemistry, external exchanges, physical conditions, riparian structural diversity, species composition, and aquatic structural diversity. By collecting monitoring data informed by success metrics, the post-construction management of the site can be optimized to improve riparian conditions over time.

Best Practices for Monitoring and Maintenance
Set aside a minimum of 10% of total project costs for post-construction monitoring and maintenance. Costs should be sufficient to replace or repair failed structures, adjust water levels, or undertake other remedial measures and undertake specialized monitoring in sensitive areas. This may include water chemistry measures and habitat surveys.
Utilize performance-based contracting and warranty monitoring for plant survival and contractual requirements.
Monitor beyond the LOD, and include a site's undisturbed areas, and adjacent upstream and downstream areas.
Develop clear monitoring metrics as a way of evaluating goals and the degree of project success.
Implement both a short and long-term vegetation management plan to maintain the post-restoration vegetation target for the banks and floodplain that includes invasive species management, climate change impact management, deer predation protection, and other predation and pest control measures.
Maintain a designated maintenance trail when appropriate and agreed upon by regulatory agencies on projects to allow practitioners to monitor and maintain constructed projects without contributing additional disturbance.

5 Design-Specific Considerations

This section describes the main approaches to stream restoration design and their associated unique considerations. There are varying and sometimes conflicting opinions about the practices described below. Care must be taken to select a design approach that is best suited for each site's unique landscape characteristics to minimize any impacts to the riparian forest and vegetation. Note that all design approaches should follow the general best practices in Section 4 to minimize impacts and assure sustainability of the riparian vegetation.

5.1 Floodplain Restoration

Floodplain restoration is the practice of increasing the hydrologic connection of rivers and streams to their floodplains. It can be included as a component of all the stream restoration design types described in the remainder of this section, including natural channel design, legacy sediment removal, regenerative stormwater conveyance, and beaver dam analogs. Note that not every project can reconnect to the historical floodplain because of encroachment from adjacent urbanization and farm fields. In some cases, only part of the floodplain can be reconnected, or reconnection may not be possible, such as in ultra-urban areas.

Floodplain restoration is the practice of increasing the hydrologic connection of rivers and streams to their floodplains.

Figure 10 shows pre- and post-construction photos of the Furnace Creek floodplain reconnection project that was constructed in Anne Arundel County, MD in 2020.

Preconstruction: Lower Project Subbreach

Preconstruction: Concrete Channel in Upper Project Subbreach

Post-construction

Figure 10. Pre- and post-construction photos of the Furnace Creek floodplain reconnection project in Anne Arundel County, MD.

Unintended consequences of floodplain restoration identified by the Protocols 2 and 3 work group[29] include:

- Riparian/floodplain forest losses are common due to clearing for design and construction access and increased inundation.
- Field and lab studies show that too much long-term soil inundation results in mortality and morphological changes in tree species.
- Construction disturbance and frequent inundation of the floodplain can serve as vectors for invasive species along restored and unrestored streams.
- Changes in vascular plant communities as a result of floodplain inundation are expected and may be desirable or undesirable depending on the goals for the habitat outcome.

Several recent assessment tools developed by Starr & Harman[30,31] may be useful for measuring functional uplift at floodplain restoration projects, possibly in combination with traditional wetland functional assessment methods such as the Federal Highway Administration (FHWA), hydrogeomorphic (HGM), Wetland Evaluation Technique (WET) and others. The group agreed that basic research to define and test new metrics to effectively measure functional uplift in floodplains was an urgent management priority.

Additionally, stream restoration projects that involve encroachment of federally regulated floodways must consider regulations set forth by the National Flood Insurance Program (NFIP) managed by the Federal Emergency Management Agency (FEMA).[32] A floodplain is comprised of the floodway and the floodway fringe. The floodway includes the channel and the adjacent land areas that must be reserved in order to discharge the base flood without cumulatively increasing the water surface elevation more than a designated height that is prescribed by FEMA and state regulations. The area within the floodplain but outside the floodway is called the floodway fringe. NFIP regulations require the completion of an engineering analysis to confirm that the proposed encroachment would not result in any increase in flood levels during occurrence of the base flood discharge, in which case a No-Rise Certification is issued. If an impact will occur due to the stream restoration project, a Conditional Letter of Map Revision (CLOMR) must be submitted to FEMA before restoration, as well as a Letter of Map Revision (LOMR) for as-built conditions after construction. Stream restoration design types developed solely to avoid undergoing the CLOMR process or requesting a variance should be avoided if possible. For example, Natural Channel Design (NCD) Priority 2 that lowers the floodplain and creates a new channel and floodplain bench often requires a much greater clearing footprint with associated tree loss, hardened or armored restoration to provide stability for bankfull storm flows, and subsequently a lack of improved habitat. Often the floodplain bench is in a subsoil layer not conducive to sustainable vegetative plantings.

• 5.2 Natural Channel Design / Channel Reconfiguration

Channel reconfiguration may entail reconnection of a historically abandoned channel, partial channel realignment, or complete construction of a new channel.[33] Historically, channel reconfiguration has been the subject of a great deal of controversy among researchers and practitioners, primarily regarding the use of template-based restoration approaches over more process-based approaches.[34,35] The primary argument centers on one of the industry standards for stream restoration design, the Natural Channel Design (NCD) method,[36] which many argue is a "template-based" approach. The NCD method uses a Channel Evolution Model similar to Schumm et al.[37] to predict channel trajectory for determining appropriate stable reference reaches to provide channel dimension, pattern and profile for design. Stream designers today are using more sophisticated approaches combining the NCD approach with sediment transport models and two-dimensional hydraulic modeling.

NCD guidance includes forest preservation and restoration, and a checklist has been developed for this purpose[38] that references the preservation of mature trees as part of permitting. Many state- and municipal-level agencies will have their own forest conservation plan requirements (refer to Table 1, Table 2, Table 3, and Table 4) that prevent unnecessary removal of trees, especially large/mature trees, but NCD itself does not focus as much on trees and forest areas as some believe it should.

Preconstruction **Post-construction**

Figure 11. Pre- and post-construction photos of the Pohick Creek NCD project in Fairfax County, VA.

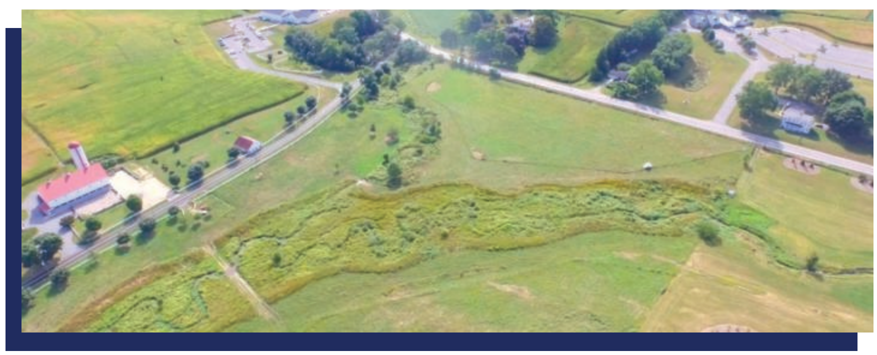
• 5.3 Legacy Sediment Removal

Legacy sediment removal (LSR) involves careful modifications to valley bottoms that contain legacy sediments to increase the interaction of the stream with its floodplain and the hyporheic aquifer. Legacy sediments include any deposits that have occurred since European settlement, including very recent sediment deposits, often created by features such as mill dams, road embankments, floodplain fill, and other kinds of stream corridor impairment.[42] This usually involves restoring smaller baseflow channel(s) and removing legacy sediments to effectively lower the floodplain to promote interaction of surface flows with the underlying hyporheic aquifer, which produces riparian wetland conditions over much of the floodplain. In some cases, not all the legacy sediment area can be removed because of restrictions in the floodplain. LSR projects restore a vegetative community that includes a diverse mosaic of herbaceous plants, shrubs and water-loving trees and less continuous and drier floodplain forest cover. The restored vegetative community seeks to mimic the natural reference condition for the valley bottom that is supported by historical accounts from centuries ago. However, the historic condition is not necessarily favored in all jurisdictions.

The CBP legacy sediment removal workgroup[39] noted the following considerations related to riparian forests/trees and LSR projects:

- Depending on the site location, upland trees growing on legacy sediments may not be endemic to the riparian wetland community. The tree community may need to shift from upland/dry to wet/floodplain-adapted species in the valley bottom.
- Existing tree mortality can occur due to more frequent inundation/higher water table in the restored floodplain, but these are intended to shift from upland to a wetland community of herbs, shrubs, and trees.
- Project monitoring indicates that construction disturbance is a vector for invasive plant species in any stream restoration project. Risk may be lower for connected vs. disconnected floodplains. Post-construction invasive management is critical to establish a sustainable wetland plant community.
- Some degradation of excavated "toe of slope" or perched wetlands has been observed, but these are replaced by more extensive wetland complexes in the stream corridor that generally increase wetland functions.

Preconstruction



Post-construction

Post-construction

Figure 12. Pre-restoration (top) and post-restoration (bottom) photos of the Big Spring Run legacy sediment removal project in Lancaster, PA (Source: LandStudies, Inc. and http://www.bsr-project.org/photos.html)

5.4 Regenerative Stormwater Conveyance

Regenerative stormwater conveyance (RSC), also known as step pool stormwater conveyance systems, refers to two specific classes of stream restoration as defined in the technical guidance developed by Anne Arundel County DPW[40] and Flores.[41] The RSC approach has also been referred to as coastal plain outfalls, regenerative step pool storm conveyance, base flow channel design, and other biofiltration conveyance.

Dry channel RSC involves restoration of ephemeral streams or eroding gullies using a combination of step pools, sand seepage wetlands, and native plants. These applications are often located at the end of storm drain outfalls or channels. The receiving channels are dry in that they are located above the water table and carry water only during and immediately after a storm event. The CBP stream restoration expert panel[42] concluded that dry channel RSC should be classified as a stormwater retrofit practice rather than a stream restoration practice.

Wet channel RSCs can be located in intermittent streams but are more typically located farther down the perennial stream network and use instream weirs to spread storm flows across the floodplain at increases in the stream stage for events much smaller than the 1.5-year storm event, which has traditionally been assumed to govern stream geomorphology and channel capacity. Wet channel RSC may also include sand seepage wetlands or other wetland types in the floodplain that increase floodplain connection, reconnection, or interactions with the stream.

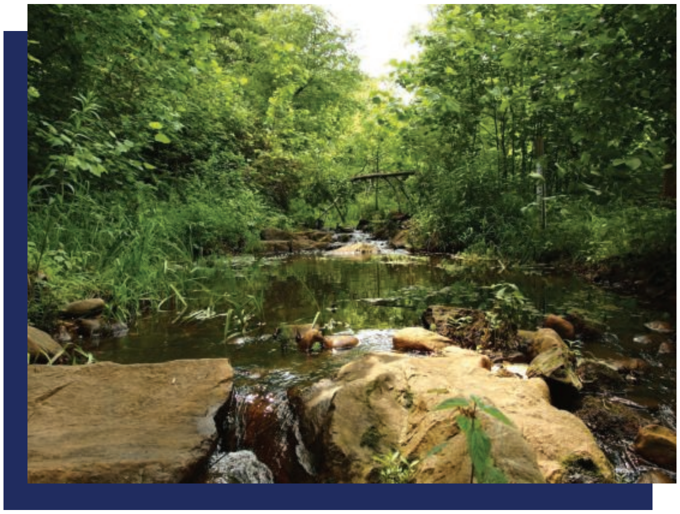


Figure 13. Wet channel RSC projects (left: Wilelinor, right: Cowhide Branch; Source: Anne Arundel County, MD)

Since RSCs are often constructed by raising the streambed to reconnect the stream to its floodplain, MD DNR RSC construction guidance[43] recommends heavy equipment traffic be contained to the sand and woodchip in-stream haul road to minimize compaction of soils and tree removal in the riparian area. The haul road is then be used as the streambed upon project completion. The continuous layering of sand and woodchips rather than a one-time application of pre-mixed materials is strongly recommended as it allows for areas of higher microbial activity to develop. Repeated seeding with temporary seed during construction and permanent seed towards the end of construction to establish a sufficient seed bank at the top 12 inches of the haul road—seeding after each fresh layer of wood chip applied. This practice increases the probability of continued stabilization and establishment of native vegetation after project completion.

Figure 14. RSC sand and woodchip haul road constructed in-stream to raise the stream bottom and to minimize impacts to the riparian area (Source: [MD DNR RSC Construction Guidance]; Photo Credit: Underwood & Associates, Inc., and Actaeon Group)

5.5 Beaver Dam Analogs

Beaver dam analogs (BDAs) are channel-spanning structures that mimic or reinforce natural beaver dams and can be used to raise the bed of the stream channel to connect to the floodplain. The Beaver Restoration Guidebook: Working with Beaver to Restore Streams, Wetlands, and Floodplains[44] provides an excellent overview to the types of beaver dam analogs, design considerations, and the risks involved in their use. Research has shown that beaver colonization after BDA installation can help combat stream channel erosion and entrenchment by promoting sediment deposition. Beaver dams have also been shown to improve floodplain connectivity, attenuate flows, and increase habitat complexity.[45,46]

Figure 15. Two examples of beaver dams and their influence on the surrounding environment (Source: Ecotone, Inc.)

Although wood from the riparian buffer can be used as construction materials for BDAs, Bennett et al.[47] strongly recommends acquiring waste products from timber harvesting to minimize riparian tree loss and integrate forestry management with stream restoration. Woody material for BDAs may be obtained by yard waste facilities and local landowners, but it is important to avoid material that has been contaminated by pesticides, herbicides, and/or fertilizers. This is aligned with insights from practitioners who were interviewed as a part of this project, who explained that utilizing trees that were already identified for removal, either on-site or off-site, is an effective way to reduce both material/transport costs and on-site riparian impacts. In terms of best practices for transporting woody materials to a project location, Bennett et al. (2019)[47] recommends the use of ATVs, handcarts, and/or boats, as appropriate, to navigate access constraints and minimize construction disturbance.

6 Summary

The role that the riparian ecosystem plays in stream restoration projects varies considerably. Restoration practitioners, forest management professionals and researchers hold varying viewpoints on how forests and riparian areas should be considered as part of stream restoration projects. This is due to conflicting information in the scientific literature, limited information about riparian cover in the CBP stream restoration expert panel report and work group documents, differences across state and local government regulations, and personal biases. Yet the value of minimizing the impact and maximizing the protection of riparian forest (and other vegetation) during stream restoration is unquestionable. This guidance document includes a compilation of the best practices for consideration by agencies overseeing the implementation of stream restoration projects, as well as seasoned professionals in the Chesapeake Bay watershed, when planning for stream restoration projects to minimize unintended impacts to riparian forests and ecosystems. The BMPs selected are based on the best available knowledge at the time of this writing. Our current understanding of best practice is always evolving as new science sheds light on how aquatic ecosystems respond to restoration interventions along the stream and its floodplain. Therefore, the guidance should be updated on a regular basis as new information becomes available.

7 Annotated Bibliography

Baird, A. R. T., & D. G. Wetmore. 2003. Riparian Buffers Modification & Mitigation Guidance Manual. Prepared for Virginia Department of Conservation and Natural Resources (VA DCR).

Riparian Buffers Modification & Mitigation Guidance Manual

The guidelines are intended to aid local governments in helping a property owner with questions regarding riparian buffer activities, Resource Protection Areas, and potential conflicts with the intent of the Bay Act and regulations. This manual provides information on permitted buffer modification guidance, as well as buffer management recommendations and plant species guidance.

Berger, K., Howard, C., Bonnaffon, H., Trieu, P. & A. Maynard (Editors). 2021. Recommended Stream Restoration Best Practices: Voluntary Guidance for Stormwater Program Managers in the COG Region on Best Practices for Implementing Stream Restoration Projects. Metropolitan Washington Council of Governments. (MWCOG)

Recommended Stream Restoration Best Practices: Voluntary Guidance for Stormwater Program Managers in the COG Region on Best Practices for Implementing Stream Restoration Projects

This guidance provides details on specific practices local governments can use to best implement stream restoration projects and builds on the recommendations from the CBP expert panel. Best practices include creating a road map and the contents of that product, setting priorities and metrics for success, and planning for inspection and monitoring. The guidance provides information on development of a road map for the site selection process that documents how a decision to pursue a stream or outfall and gully stabilization project will be reached and what its goals are. This includes enumeration of specific project goals, including primary programmatic goals such as stream stability and pollution reduction, and secondary goals such as habitat improvement and minimization of impact to existing high-quality forest ecosystems. The guidance also includes tips on defining stakeholders, elements of a public outreach process, and communication needs to promote public engagement. There are also construction best practices to reduce impacts from tree loss, quality control practices for restoration planting, and tips on making adjustments during construction.

Burch, J., Cox, S., Davis, S., Fellows, M., Hoverman, K., Law, N., Mumaw, K., Rauhofer, J., Schueler, T., & R. Starr. 2019. Recommended Methods to Verify Stream Restoration Practices Built for Pollutant Crediting in the Chesapeake Bay Watershed. Submitted by Restoration Group 1: Verification and Approved by the Urban Stormwater Work Group of the Chesapeake Bay Program.

Recommended Methods to Verify Stream Restoration Practices

A group of stream restoration experts provided recommended methods for verifying the pollutant reduction performance of individual stream restoration projects built to meet the Chesapeake Bay TMDL goals. The memo highlights general guidance on how to verify stream restoration projects in the Chesapeake Bay watershed. This includes; defining what constitutes an adequate post-construction document for stream restoration projects, determining the quantitative data collected during the project necessary to assist in future verification efforts, identifying visual indicators that can determine whether an individual stream restoration project is still performing its designed water quality functions, and the specific thresholds for project failure that trigger the need loss of pollutant reduction credits and remedies.

Handler, S., Pike, C., & B. St. Clair. 2018. Assisted Migration. USDA Forest Service Climate Change Resource Center.

Assisted Migration

The U.S. Forest Service has a collection of information, guidance, and tools related to assisted migration (Handler et al., 2018; https://www.fs.usda.gov/ccrc/topics/assisted-migration). This webpage includes: 1) background information on the science behind assisted migration, 2) challenges and opportunities related to management, 3) a summary of recent assisted migration applications, and 4) links to tools. These tools include: 1) a web-based mapping application to help match seedlots with planting sites (Seedlot Selection Tool), 2) an atlas of information on current and project suitable habitat for eastern-US tree species (Climate Change Tree Atlas), 3) a generator of maps showing suitable habitat ranges for North American tree species (ForeCASTS), and 4) a collection of maps and tables showing projected changes in variables affecting growing conditions for trees (Research Map).

Harman, W., R. Starr, M. Carter, K. Tweedy, M. Clemmons, K. Suggs, C. Miller. 2012. A Function-Based Framework for Stream Assessment and Restoration Projects. US Environmental Protection Agency, Office of Wetlands, Oceans, and Watersheds, Washington, DC. EPA 843-K-12-006.

A Function-Based Framework for Stream Assessment & Restoration Projects

The document provides a framework for approaching stream assessment and restoration using a function-based perspective. The document highlights the importance of site selection in river restoration and provides site selection criteria for reference ranges based on project goals and objectives and the stream's impaired functions. The document also covers the application of the Stream Functions Pyramid to help establish project goals and objectives.

Keystone Stream Team. 2007. Guidelines for Natural Stream Channel Design for Pennsylvania Waterways.

Guidelines For Natural Stream Channel Design for Pennsylvania Waterways

These guidelines are intended to help watershed organizations with the planning and implementation of stream restoration projects and professionals with stream restoration design, construction, and permitting and build consistency across natural stream channel design projects. The guidelines outline a general procedure for project design from planning to post-construction monitoring and reviews the importance of involving all interested parties and persons who have a stake in the outcome of the proposed restoration, recommending a watershed community meeting and pre-application meetings.

Law, N., B. Stack, R. Starr and E. Yagow. 2015. Designing sustainable stream restoration projects within the Chesapeake Bay watershed. CBP. STAC Publication No. 15-003. Edgewater, MD. 50 pp.

Designing Sustainable Stream Restoration Projects within the Chesapeake Bay Watershed

A Scientific and Technical Advisory Committee (STAC) workshop report that includes a general framework for defining how functional uplift may be assessed for stream projects implemented for the Chesapeake Bay TMDL.

Maryland Department of Natural Resources (MD DNR). 2018. Regenerative Stream Conveyance Construction Guidance: First Edition.

Regenerative Stream Conveyance Construction Guidance

This guidance presents conceptual information on constructing regenerative stream conveyance projects and implementation techniques for common features. This includes a focus on assessment of wetland or upland floodplain conditions, constructing regenerative projects, and implementation techniques for common features.

Maryland Department of the Environment (MDE). 2022. Guidance for Stream Restoration Based on Key Wildlife Habitats: Upper Coastal Plain Stream-associated Wetlands. MDE, Baltimore, MD. 46 pages

Guidance for Stream Restoration Based on Key Wildlife Habitats: Upper Coastal Plain Stream-associated Wetlands

This guidance presents an approach to recommendations for restoration based on the extent of degradation and condition of the Key Wildlife Habitat riparian wetland resources. This includes a Watershed Resources Registry (WRR) to identify sensitive species resources, nontidal wetlands of special State concern, and check for other designations (e.g., forest interior bird habitat) and other features which may be potential constraints on design or need specialized construction practices. The WRR also has identified priority areas for restoration and protection. The guide also includes information on identification of stream degradation sources, assessment of existing stream and wetland/ riparian conditions, and assessment of Key Wildlife Habitat (KWH) conditions.

Maryland Department of the Environment (MDE). n.d. MDE, MS4/Chesapeake Bay TMDL/Trust Fund Restoration Project Wetlands & Waterways Permit Package Checklist.

MS4/Chesapeake Bay TMDL/Trust Fund Restoration Project Wetlands & Waterways Permit Package Checklist

The checklist and other documents outline steps to demonstrate functional impairment of a site, or aquatic resources which include biological function-based parameters and geomorphology/hydraulic function-based parameters for perennial or intermittent streams, description of biological degradation and geomorphology/ hydraulic function degradation. It also advises assessment of wetland or upland floodplain conditions before restoration design choice, as well as preparing a Forest Stand Delineation and identifying all trees to be removed in the LOD.

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Chesapeake Bay Riparian Handbook: A Guide for Maintaining Riparian Forest Buffers

This handbook addresses the design of buffer systems for nonpoint source pollution reduction, determination of buffer width. Site evaluation, planning, and establishment; streamside stabilization components and techniques along with aspects of agricultural/rural, silvicultural/Forest management, and Urban/Suburban considerations. The guide includes a Chapter (13) with information and education strategies from professional training to landowners, volunteers, and the media. This includes tips on holding meetings, working with the media, and working with volunteers.

Pennsylvania Department of Environmental Protection (PA DEP). 2022. Pennsylvania Function-Based Aquatic Resource Compensation Protocol. Document Number: 310-2137-001.

Pennsylvania Function-Based Aquatic Resource Compensation Protocol

The protocol outlines how aquatic resource compensatory mitigation evaluations should be conducted using this methodology and the factors to consider when doing so. Specifically, the protocol; covers how Aquatic Resource Condition Level 2 Rapid Assessment Protocols and Intensive Assessments are used in site selection.

Schueler, T. and Stack, B. 2014. Recommendations of the Expert Panel to Define Removal Rates for Individual Stream Restoration Projects. Approved by the Water Quality Goal Implementation Team of the Chesapeake Bay Program September 8, 2014.

Recommendations of the Expert Panel to Define Removal Rates for Individual Stream Restoration Projects

This report reviews research on the impact of stream restoration projects in reducing the delivery of sediments and nutrients to the Chesapeake Bay. It also provides recommendations from an expert panel on methods to credit projects to account for pollutant reductions due to project implementation. The recommendations include four general protocols defining the pollutant load reductions and examples for calculating total loads for various project implementation scenarios.

The River Restoration Centre (RRC). 2011. Practical River Restoration Appraisal Guidance for Monitoring Options (PRAGMO)

Practical river restoration appraisal guidance for monitoring options (PRAGMO)

This document is intended as a living guidance document on suitable monitoring for river and floodplain restoration projects. There is discussion on the importance of good goal setting for river restoration projects that involves SMART goals: **S**pecific, **M**easurable, **A**ttainable, **R**elevant and **T**ime-bound.

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U.S. National Vegetation Classification

This database provides a comprehensive classification system for all vegetation types in the United States. The system is a central organizing framework for documentation, inventory, monitoring, and study of vegetation on scales ranging from forests to plant communities that can help to avoid restoration site selection in areas with existing good quality communities and rare species.

United States Bureau of Reclamation and United States Army Engineer Research and Development Center (USBR & ERDC). 2016. National Large Wood Manual—Assessment, Planning, Design, and Maintenance of Large Wood in Fluvial Ecosystems: Restoring Process, Function, and Structure. 628 pp.

National Large Wood Manual—Assessment, Planning, Design, and Maintenance of Large Wood in Fluvial Ecosystems: Restoring Process, Function, and Structure

The manual describes the application of using a structured process as well as decision support tools for making informed restoration decisions. It also discusses the interdisciplinary design needs to address biological, physical, and social factors specific to the engineering challenges of large wood restoration projects. Methods of public outreach that can be used during large wood projects are also reviewed. This includes public notices, stakeholder engagement, and continued outreach. It also examines legal issues, project failures, and construction-related risks.

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Part 654 Stream Restoration Design National Engineering Handbook; Chapter 2 Goals, Objectives, and Risk

The handbook includes a detailed description of the need and approach for selecting stream restoration project goals and objectives. This includes a discussion of the importance of community engagement.

Virginia Department of Conservation and Natural Resources (VA DCR). 2004. The Virginia Stream Restoration & Stabilization Best Management Practice Guide. Prepared with assistance from KCI Technologies, Inc. and the Center for Environmental Studies at Virginia Commonwealth University.

The Virginia Stream Restoration & Stabilization Best Management Practices Guide

The guide presents an overview of stream channel design through guiding principles and methods. It also describes the possible legal aspects involved in permitting work within the stream channel. The guide also outlines three steps for a site selection study that includes the assessment of degraded stream functions and values, stream reach rankings, and prioritization.

Virginia Department of Environmental Quality (VA DEQ). 1992. Virginia Erosion and Sediment Control Handbook.

Virginia Erosion and Sediment Control Handbook

A technical guide to meet requirements dictated by the VA Erosion and Sediment Control Law and the VA Erosion and Sediment Control Regulations. Includes the designated standards as well as guidelines and support materials to assist users in the implementation of the technical standards in accordance with the provisions of the law and regulations.

Wood, D., Schueler, T., and B. Stack. 2021. A Unified Guide for Crediting Stream and Floodplain Restoration Projects in the Chesapeake Bay Watershed.

A Unified Guide to Crediting Stream and Floodplain Restoration Practices in the Chesapeake Bay Watershed

This guide provides a single source for stream practitioners and Bay managers to answer their questions on crediting stream restoration projects. The guide is organized to provide the most essential details that Bay managers and stream practitioners need to know on the current protocols to credit stream restoration projects. This includes types of stream restoration practices and the methodologies for calculating pollutant credits. The guide also includes information on qualifying conditions, construction best practices and post-construction project verification.

Yochum, S. E. 2018. Guidance for Stream Restoration. U.S. Department of Agriculture, Forest Service (USDA FS), National Stream & Aquatic Ecology Center. Technical Note TN-102.4. Fort Collins, CO.

Guidance for Stream Restoration

This guidance looks at fundamental principles of preliminary field assessments along with design approaches and analyses for stream restoration as well as specific planning and design features relevant when developing stream restoration projects. The guide includes an overview of establishing goals and objectives and conducting existing condition assessments (including riparian vegetation) with links to additional resources and information.

Appendix A. Restoration Constructability Checklist

This Restoration Constructability Checklist was developed by Kip Mumaw, PE, who is a Principal Engineer at Ecosystem Services. This checklist is intended for use when evaluating a project prior to implementation, but it is not a design checklist, nor is it a project screening tool. This checklist is designed to evaluate items specific to construction that may or may not have been adequately addressed during the design and permitting process. Ideally, this checklist should be reviewed during project scoping and completed between preliminary and final design.

Instructions

1. At the top of the checklist, enter the name of the of the project and either the date of completion or due date.
2. If your project has a wide array of conditions and restoration approaches, consider creating separate checklists for each condition.
3. Update/add to the checklist items as needed. Be sure to reference any supporting documentation.
4. As checklist items are completed, enter "Done" in the corresponding cell under the "Status" column header. Be sure to include the initials of the person(s) who completed the item and any associated notes in the corresponding cells.
5. Once completed, share the completed checklist with the individual(s) designated for quality control.

ECOSYSTEM SERVICES

Restoration Constructability Checklist

Project Name:

Project Date:

Status	Checklist Item	Completed By	Notes
	Have project constraints been identified? If not, document all physical, environmental, and regulatory constraints.		
	Are there existing trails or roads that can be used for construction access?		
	Are easements required for construction access? If so, develop landowner outreach and easement acquisition plan.		
	Does infrastructure constrain restoration? If so, identify area available for restoration and where infrastructure may need to be protected or relocated.		
	Will large, native trees (>12" dbh) need to be removed for construction? If so, note how many, their size and condition, and for what reason trees are being removed.		
	Will stream canopy be impacted by construction or restoration activities? If so, determine the percent of canopy removed and remaining.		
	Is tree protection identified on the plans and is it adequate to protect forest resources?		
	Are existing trees appropriate to the restored conditions? I.e., are trees adapted to post-restoration flooding and inundation conditions?		
	Does planting plan take into consideration post-restoration canopy conditions or other potential stressors?		
	Will sensitive features be impacted due to construction? If so, develop avoidance and minimization plan.		
	Are streambank trees compromised? If so, inventory size and species.		
	Are invasive species present? If so, inventory communities and treatment plan as necessary.		
	Will construction/restoration likely spread invasive species?		
	Is onsite construction material available? If so, inventory type and quantities.		
	Is there an onsite disposal area available? If so, document location and permit as necessary.		
	Are there Time of Year Restrictions for species of concern?		
	Will construction/restoration impact known or likely habitat for species of concern? If so, conduct survey (if not already completed) and evaluate alternatives.		
	Will construction require pump-around and/or diversions? If so, note the required pump size.		
	Are soil amendments necessary to support planting plan?		

Endnotes

1 State and federal permitting agencies reserve the discretion to apply this guidance to support better permit decisions and always retain the authority to make permit decisions and/or establish permit conditions for TMDL-driven stream restoration projects. Likewise, decisions about how to weigh the potential for temporary adverse impacts on existing site environmental qualities against the long-term environmental benefits is left to the appropriate regulatory agencies.

2 Schueler, T. & B. Stack. 2014. Recommendations of the Expert Panel to Define Removal Rates for Individual Stream Restoration Projects. Approved by the Water Quality Goal Implementation Team of the Chesapeake Bay Program September 8, 2014.

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4 It's important to note that the term "restoration" can be misleading because it has the connotation that the stream will be returned to a historical condition, which is often not possible due to changes in hydrology, soils, flow and general pattern and profile. In these cases, the result would be rehabilitation instead of restoration. However, for simplicity and to remain consistent with existing CBP stream restoration guidance, the term restoration will be used throughout this document.

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22 https://www.chesapeakebay.net/documents/43419/climatedirective_final.pdf

23 The U.S. Forest Service has a collection of information, guidance, and tools related to assisted migration (Handler et al., 2018; https://www.fs.usda.gov/ccrc/topics/assisted-migration).

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28 Master Naturalists Program certifications typically include the completion of a training curriculum and volunteer work. More information on Master Naturalist Programs in the Chesapeake Bay watershed can be found at these sites: Maryland Master Naturalist Program; Pennsylvania Master Naturalist Program; Virginia Master Naturalist Program.

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