Pollutant Removal Credits for Buffer Restoration in MS4 Permits

Final Panel Report

June 2019

Approved by

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Executive Summary

Sound management of buffer areas is an effective approach to protecting water quality in New Hampshire. However, regulators and communities lack synthesized, scientifically justified guidance on how to quantify the water quality benefits of buffers and compare them to those derived from other structural Best Management Practices (BMPs). The *Credit for Going Green* project helped address this need by using an expert panel process to develop consensus-based recommendations for pollutant load reduction performance curves for restored or constructed buffers. These curves are intended to meet in-stream pollution reduction targets in development, redevelopment, restoration, or other land use change projects. This report describes the work and findings of the project's expert panel from January 2018 to March 2019.

Going Green was inspired by an integrated policy analysis of buffer management conducted in the Great Bay Watershed from 2015 to 2018. This analysis included an assessment of community perspectives on buffers, an analysis of the regulatory context, and reviews of relevant biophysical and social science literature. It was also motivated by regional trends related to stormwater runoff and its potential impact on water quality in the Great Bay Estuary watershed, including increased population and impervious surfaces.

The project built on other initiatives as well, including the Pollution Tracking and Accounting Pilot Program (PTAPP) and the New Hampshire Association of Natural Resource Scientists Wetland Buffer Scientific Workgroup. It was modeled after a similar project that developed green infrastructure pollutant removal efficiency and runoff volume reduction curves for Chesapeake Bay. (These are now accepted by the United States Environmental Protection Agency (USEPA) and used by the bay's communities.) Both projects used a weight-of-evidence approach, based on independent peer reviews at the National Academy of Sciences, to synthesize expert opinions on a subject around which there was uncertainty due to insufficient data and data that was unattainable because of physical constraints or lack of resources.

Going Green's advisory committee included representatives of local communities, New Hampshire Department of Environmental Services (NHDES), and USEPA Region 1. The committee provided input on the panel process, literature review, and identification of panel members. The panel included experts in local and regional watershed hydrology, stormwater management, soil science, fish and stream ecology, and spatial understanding of nutrient attenuation. The panel was managed using best practices for collaboration, decision making, and transparency. Over the course of six meetings, panelists reviewed existing data and literature, identified conditions under which buffers are most effective at pollutant removal, characterized the factors that influence that effectiveness, developed pollutant load reduction

performance curves, and made recommendations for how to use these curves in models available for the Great Bay Watershed.

They summarized their findings in a technical memorandum (see Appendix 7.1). This memorandum is designed to help municipalities, engineers, and regulatory officials use the curves to quantify pollutant removal rates for buffers ranging from 20 to 100 feet in width in redevelopment, development, restoration, and other land use change projects. It includes four sets of curves that characterize the removal of total nitrogen, total suspended solids, and total phosphorus in hydrologic soil groups A, B, C, and D. These curves can also be used to allocate credit for installing buffer areas in USEPA permits and other stormwater management efforts. The memorandum summarizes the panel's key decisions to develop these curves, describes situations that curves cannot address and other caveats, and provides examples to demonstrate how the curves could be applied.

An advisory committee provided input on the utility of these curves and how best to share them with relevant audiences. Project organizers used this input to develop additional communication materialsto share these products with municipal leaders and technical assistance providers in New Hampshire, Rhode Island, Massachusetts, and at a regional conference. They also developed a roadmap that captures best practices and lessons learned about the expert panel process for others who wish to apply this approach to other management questions.

Project partners include the University of New Hampshire Stormwater Center, Great Bay National Estuarine Research Reserve, Narragansett Bay National Estuarine Research Reserve, Waquoit Bay National Estuarine Research Reserve, and Roca Communications+. *Going Green* was sponsored by the National Estuarine Research Reserve System Science Collaborative, which supports collaborative research that addresses coastal management problems important to Reserves and their communities. The Science Collaborative is funded by the National Oceanic and Atmospheric Administration and managed by the University of Michigan Water Center.

Section 1: The Panel and Its Work

1.1 Panel Charge and Membership

The panel's charge was to develop consensus-based recommendations for pollutant load reduction performance curves that could be used to meet pollution reduction targets. It was anticipated that the recommendations would take the form of a removal percentage per unit area of buffer. For the panel to meet its charge, scientific, practitioner, and management communities had to agree on defensible pollutant load reductions. As a result, the panel included experts in local and regional watershed hydrology, stormwater management, soil science, fish and stream ecology, and spatial understanding of nutrient attenuation. To ensure the curves would be easy to apply and verifiable, it also included representatives of the USEPA, New Hampshire state regulatory programs, and a former private sector practitioner with extensive experience working with local communities. (See Table 1).

Table 1: Going Green Expert Panel Members	
Panelist	**Position & Affiliation**
Dr. James Houle (Chair)	Program Director, University of New Hampshire Stormwater Center
Dr. Thomas Ballestero	Director, University of New Hampshire Stormwater Center Associate Professor, Civil Engineering
Dr. Michael Dietz	Director, Connecticut Nonpoint Education for Municipal Officials (NEMO) Associate Extension Educator, University of Connecticut
Mr. Mark Voorhees	Environmental Engineer, U.S. Environmental Protection Agency Region 1
Mr. Ted Diers	Administrator, NHDES, Watershed Management Bureau
Ms. Karen Dudley	Resource Soil Scientist, USDA Natural Resources Conservation Service
Dr. Nigel Pickering	Research Associate Professor, Washington Stormwater Center (Formerly of Horsley Witten Group)
Mr. Pete Steckler	GIS & Conservation Project Manager, NH Certified Wetland Scientist, The Nature Conservancy, NH
Mr. John Magee	Certified Fisheries Professional & Fish Habitat Biologist, New Hampshire Fish and Game Department
The panel retained a consultant who had run an expert panel process to develop credits for non-structural BMPs in the Chesapeake Bay Region: Thomas Scheuler, Executive Director of the Chesapeake Stormwater Network.	

1.2 Advisory Committee Membership

The panel was supported by an advisory committee consisting of stakeholders from regulatory agencies, communities subject to municipal separate storm sewer systems (MS4) regulations, design consultants, and technical assistance providers. As the panel progressed, it became clear that more perspectives from municipalities, the private sector, and technical assistance providers were needed. Committee members who joined the group later in the process are indicated with an * in Table 2.

Table 2: Going Green Advisory Committee Members	
Committee Member	**Position & Affiliation**
Suzanne Warner	Environmental Engineer, U.S. Environmental Protection Agency
Eric Perkins	Environmental Scientist, U.S. Environmental Protection Agency, Region 1
Gretchen Young	Assistant City Engineer, City of Dover
Sally Soule	Coastal Watershed Supervisor, N.H. Department of Environmental Services
Jackie LeClair	Wetlands Protection Unit Manager, U.S. Environmental Protection Agency
*William Arcieri	Senior Water Resource Scientist, Vanasse Hangen Brustlin, Inc.
*Owen Friend-Grey	Assistant City Engineer, City of Rochester
*Abigail Lyon	Community Technical Assistance, Piscataqua Region Estuaries Partnership
Steve Miller	Coastal Training Program, Great Bay National Estuarine Research Reserve
Tonna Marie Surgeon Rogers	Coastal Training Program, Waquoit Bay National Estuarine Research Reserve
Jennifer West	Coastal Training Program, Narragansett Bay National Estuarine Research Reserve

The committee's primary role was to provide input and feedback on key decision points in the *Credit for Going Green* project, including expert panel selection, compilation of the literature review, final reporting, and the dissemination of products and outcomes. Advisory committee members assisted the expert panel as needed, but were not participants in the process to allow for the greatest autonomy of the panel.

1.3 How the Panel Collaborated

The panel used a weight-of-evidence approach based on independent peer reviews at the National Academy of Sciences, which was designed to synthesize expert opinions on a subject around which there is uncertainty due to insufficient data and data that is unattainable because of physical constraints or lack of resources. In support of an efficient and respectful process, they employed the following best practices:

A. Start with a Working Charter

The support team developed a draft charter to help clarify the panel's goal, approach, and decision making process. The panel refined this charter at the start of the process.

B. Hold Periodic Meetings

There were six meetings held between January and September 2018. The first was a four-hour face-to-face meeting. Subsequent meetings were held via web conference with some panelists meeting in person. Meetings were recorded, transcribed, and made available to the panel throughout the process.

- March 6th, 2018
- April 4th, 2018
- May 16th, 2018
- August 16, 2018
- September 18, 2018

C. Use Collaboration Best Practices

The panel agreed to the following principles of collaboration:

- Commit the time, energy, and resources needed to meet project objectives
- Recognize the validity of differing points of view
- Recognize the complexity involved in buffer-related issues
- Be prepared to listen intently to understand others' views
- Regard disagreements as problems to be solved, not battles to be won

D. Agree On a Process for Decision Making

While the panel worked toward consensus, they did not interpret it as unanimous agreement. The chair and process support person worked to ensure that opposing points of view were respectfully discussed and to identify areas of agreement. They used the continuum of consensus (Figure 1) for key decisions, which allowed panelists to endorse a recommendation, agree with reservations, disagree but stand aside, hold and demand more work, or not agree and therefore stop the decision.

Figure 1: Continuum of Consensus *Courtesy, Center for Leadership and Organizational Change*

E. Maintain Momentum Between Meetings

To encourage decision making and build cohesion among panelists, the process support team used the following techniques:

- Pre-meeting surveys: At least three weeks before each meeting, panelists received a survey that guided their preparation. The survey asked panelists to review and confirm notes from the previous meeting and provided reminders and/or guidance about "homework." The survey also asked panelists to apply the continuum of consensus to key decision points identified at the previous meeting. Survey responses helped the process support team highlight topics that required additional discussion at the next meeting; they used those to inform the next meeting's agenda.

- Meeting Prep: One week before the meeting, panelists received an agenda, support materials, survey responses, and the PowerPoint file that the chair would use to guide the meeting. The presentation included comments from the survey and identified the relevant panelist so they could speak to their rationale.

- Google Drive: The panel used a protected Google Drive folder that contained resources such as the literature review, meeting notes, agenda, and working charter. This platform supported file development, sharing, revision, and storage, and allowed for panelists to access shared literature, models, and materials.

Section 2: Glossary

2.1. Commonly Used Acronyms

- AOT - Alteration of Terrain
- BMP - Best Management Practice
- DCIA - Directly Connected Impervious Area
- EPA - United States Environmental Protection Agency
- HSG - Hydrologic Soil Group
- MS4 - Municipal Separate Storm Sewer System
- PLER - Pollutant Load Export Rate
- TN - Total Nitrogen
- TP - Total Phosphorus
- TSS - Total Suspended Solids

2.2 Commonly Used Terms

- **Buffer**: An upland area adjacent to wetlands and surface waters (the panel used New Hampshire state definitions for *wetlands* and *surface waters*).

- **Contributing Area:** The amount of land that could generate runoff to the buffer.

- **Credit***:* The estimated pollutant load reduction given for the use of buffers in regulatory permits issued for development, redevelopment, restoration, and other land use change projects under the NPDES Stormwater Permit Program and other efforts to manage stormwater.

- **Directly Connected Impervious Area (DCIA)**: The portion of impervious area with a direct hydraulic connection to the MS4 or a waterbody via continuous paved surfaces, gutters, drain pipes, or other conventional conveyance and detention structures that do not reduce runoff volume (EPA Region 1 MS4 Guidance).

- **Denitrificatio**n: Process by which bacteria remove nitrogen from the soil that results in nitrogen release to the atmosphere as a gas.

- **Expert Panel Process:** An approach to synthesizing the opinions of authorities on a particular subject around which there is uncertainty due to insufficient data or data that is unattainable because of physical constraints or lack of resources.

- **Hydrologic Flow Path:** The pathways surface and subsurface water follow in a given groundwater velocity field.

- **Hydrologic Soil Group (HSG):** Based on the premise that soils found within a climatic region that are similar in depth to a restrictive layer or water table, the transmission rate of water, texture, structure, and degree of swelling when saturated will have similar runoff responses. Determined by the water transmitting soil layer with the lowest saturated hydraulic conductivity and depth to any layer that is more or less water impermeable (such as hardpan or bedrock) or depth to a water table (if present).

- **Infiltration:** The downward entry of water into the soil or rock.

- **Optimal buffer condition**: As defined by this panel, a forested buffer with a width of 100 feet capable of achieving the maximum removal efficiency values described in Table 1 in the technical memo (see Appendix 7.1). This defines the upper boundary of pollutant removal performance for these curves. Deviations from this condition result in penalties that reflect lower performance expectations.

- **Performance:** A buffer's ability to function and remove Total Nitrogen (TN), Total Suspended Solids (TSS), and/or Total Phosphorus (TP).

- **Penalty:** Reduction in credit from the total possible; reflects the impact of different, less optimal conditions on the buffer's ability to remove TN, TSS, and/or TP.

- **Pervious Land:** Areas of land that allow infiltration and groundwater recharge, excluding impervious surfaces such as pavement, concrete, and rooftops, among others.

- **Pollutant Load Export Rate (PLER):** Rate of total pollutant load exported from a unit area watershed, typically based on land use category on an annual basis (e.g. pounds of nitrogen per acre per year (lb-TN/acre/year).

- **Removal Credit or Removal Efficiency**: A buffer's capacity to remove TN, TSS, and TP.

- **Runoff Loading:** Total volume of water divided by the area of the buffer.

- **Surface waters:** Perennial and seasonal streams, lakes, ponds, and tidal waters within the jurisdiction of the state, including all streams, lakes, or ponds bordering on the state, marshes, water courses, and other bodies of water, natural or artificial (485-A:2 Definitions. – XIV).

- **Turf** (aka lawns, turf grass, turf cover): Pervious areas managed for dense grass cover, which may involve one or more of the following practices: fertilization, irrigation, and weed control.

- **Wetlands:** Areas that are inundated or saturated by surface water or groundwater at a frequency and duration sufficient to support (and that under normal conditions do support) a prevalence of vegetation typically adapted for life in saturated soil conditions (482-A:2 Definitions).

- **Wetland Functions:** Practical, measurable values of wetlands. The 12 primary wetland functions recognized in New Hampshire are ecological integrity, wetland-dependent wildlife habitat, fish and aquatic life habitat, scenic quality, educational potential, wetland-based recreation, flood storage, groundwater recharge, sediment trapping, nutrient trapping, retention, or transformation, shoreline anchoring, and noteworthiness (482-A:2 Definitions).

Section 3: Background on Buffer Conditions in the Great Bay Watershed

3.1 Environmental Conditions Requiring Increased Buffer Management

In 2008, the Great Bay was placed on the New Hampshire Department of Environmental Services (NHDES) Section 303(d) list for Threatened and Impaired Waters. Great Bay is impaired for aquatic life due to declining eelgrass coverage caused by reduced water clarity, which is caused in part by phytoplankton abundance due to excessive nitrogen levels. Many of these impairments remain today and the methodology for their determination is described in the NHDES Consolidated Assessment and Listing Methodology (CALM). The eelgrass loss trend that was documented in 2008 has continued to worsen and remains a serious concern. In 2014, NHDES released the final report of the Great Bay Nitrogen Nonpoint Source Study (GBNNPSS). This estimated stormwater as the source of 34% of the nitrogen loads to Great Bay.

Several trends related to stormwater runoff and its potential impact on the Bay's water quality have been tracked in recent decades and are summarized in the 2018 State of Our Estuaries Report (2018 SOOE). Between 1990 and 2015, the population of the 52 Maine and New Hampshire towns in the Piscataqua Region watershed grew by 38%. There were 19,483 new multi- and single-family housing permits issued in the New Hampshire towns from 2000 to 2015. Between 1990 and 2010, impervious surfaces in the Great Bay Estuary watershed increased by 120% and have continued to increase over the last five years.

Combined with changes in precipitation, population, and development, these impervious surfaces are sending more contaminants, including nutrients, into the bay and its tributaries. At the same time, total nitrogen loading to the Great Bay Estuary from 2012 to 2016 was 26% percent lower than 2009 to 2011 levels. Low rainfall and corresponding streamflow during this period, as well as significant reductions in nitrogen loading at municipal wastewater treatment facilities, are the primary reasons for this decrease. Most of the variability relates to nitrogen from nonpoint sources from stormwater runoff and groundwater contributions. These sources accounted for 606.6 tons per year or 67% of the nitrogen load for 2012 to 2016.

Buffers are a well-established, scientifically justified method to maintain and mitigate water quality threats and promote habitat, biodiversity, and concomitant ecosystem service functionality that benefits ecosystems and societies alike. Changes in estimated pollutant loads to water bodies from overland flow can occur in three fundamental ways: 1) A change in the land use condition (e.g. residential home development replacing forest land) 2) Inadequate assessment of natural landscape capacity (e.g. buffers) to attenuate or remove increased pollutant loads 3) a reduction or adjustment of pollutant loads based on estimated effectiveness and scale of application of best management practices, including buffers.

3.2 Buffer Options for the Bay: An Integrated Policy Analysis

Buffer Options for the Bay (BOB) was an integrated policy analysis conducted from 2015 to 2018 to support policy and land use decisions involving buffers in New Hampshire's Great Bay region. BOB generated ten biophysical and social science publications and reports focused on buffers in Great Bay and beyond, including a Community Assessment, Synthesis of Policy Options, and a Coastal Science Literature Review. These studies helped identify the need for this expert panel process and have been a resource for its design and implementation.

BOB was created through a collaboration of public, academic, private, and nonprofit organizations dedicated to leveraging the capacity of buffers to protect water quality, guard against storm surge and sea level rise, and sustain fish and wildlife in the region. BOB was sponsored by the National Estuarine Research Reserve System Science Collaborative, which supports collaborative research that addresses coastal management problems important to Reserves and their communities. The Science Collaborative is funded by the National Oceanic and Atmospheric Administration and managed by the University of Michigan Water Center.

3.3 Current Buffer Policy

New Hampshire was one of the first states to regulate the protection of wetlands. Jurisdiction for tidal wetlands began in 1967 and for nontidal wetlands in 1969. Today, management of buffer areas is governed by a combination of federal, state, and local policy. State and federal buffer regulations are administered by the New Hampshire Department of Environmental Services (NHDES). These regulations restrict certain land use activities within shoreland and wetland areas. Their extension to buffer areas is limited to water bodies defined under the New Hampshire Shoreland Water Quality Protection Act (SWQPA) and the Prime Wetlands list.

Such decentralized shoreland and wetland policies allow for flexibility at the community level, giving municipalities the opportunity to apply local knowledge and control to their regulations. Many municipalities can and do enact more restrictive buffer regulations to protect valued water bodies. Yet, this flexibility comes at the price of consistent enforcement and protection across the state. Buffer width size regulations vary widely, with some towns having no regulations at all. This inconsistency leaves many smaller shorelands and undesignated wetlands beyond state jurisdiction, without protection, and at risk for degradation as New Hampshire communities continue to grow and develop. This risk is compounded by insufficient understanding of policy options, inadequate access to related resources, and confusion over terminology among stakeholders.

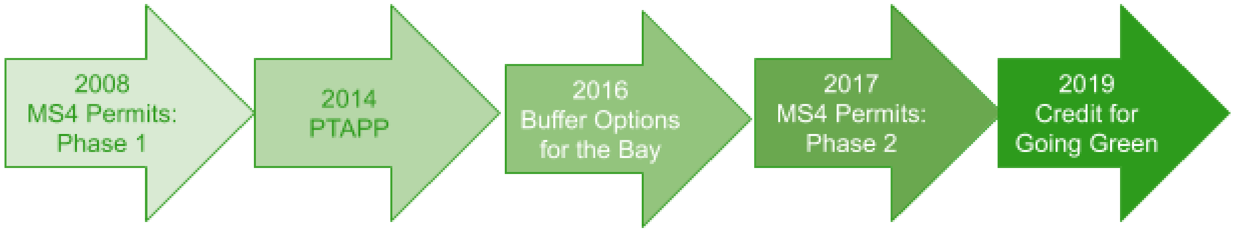
The existing framework of laws and programs is complex and at times confusing, presenting many challenges for municipalities and landowners. As a result, organizations like the New Hampshire Department of Environmental Services, the University of New Hampshire Stormwater Center, the Great Bay National Estuarine Research Reserve, and the Piscataqua Region Estuaries Partnership are focused on providing assistance—like the *Going Green* project—to support communities as they seek to manage these resources more effectively.

3.4 Community Perspectives on Buffers

The opportunity to strengthen buffer regulations for the smaller streams and undesignated wetlands lies with the state's municipalities. **BOB's assessment of community perspectives in the Exeter-Squamscott subwatershed** identified several common values and perspectives among decision-makers and other stakeholders related to buffers. Through 38 interviews with stakeholders in four watershed communities, the analysis identified a fundamental need to quantify the direct benefits of buffers and buffer restoration in terms of pollutant load reduction estimates. While perspectives on buffer value among individuals varied, there were commonly held values that relate to efforts to conserve, restore, or manage buffers.

3.5 Past Efforts Related to Buffer Pollutant Load Reduction Rates

In the last ten years, the research, government agency, technical assistance, and consultant communities have strived to help municipalities address pollution in their waterways and meet emerging federal permits related to stormwater and wastewater. The *Credit for Going Green* project builds on the work of the Pollution Tracking and Accounting Pilot Program (PTAPP) and the Buffer Options for the Bay (BOB) projects, both of which seek to meet scientific and socio-political needs related to buffer management in New Hampshire. The following diagram tracks the initiation of these projects in the context of regulatory requirements.



EPA Region 1 Municipal Separate Storm Sewer System (MS4) Permit: The National Pollutant Discharge Elimination System (NPDES) General Permit for Stormwater Discharges from Small Municipal Separate Storm Sewer Systems (MS4s) in New Hampshire was released in January 2017 with an effective date of July 1, 2018. The final New Hampshire Small MS4 general permit establishes Notice of Intent (NOI) requirements, prohibitions, and management practices for stormwater discharges from small MS4s in New Hampshire. The permit applies to 30 out of the 42 Great Bay Estuary communities. The permit focuses on sixMinimum Control Measures (MCMs) that include:

1. Public Education and Outreach
2. Public Involvement and Participation
3. Illicit Discharge Detection and Elimination (IDDE)
4. Construction Site Stormwater Runoff Control
5. Post Construction Stormwater Management in New Development and Redevelopment
6. Pollution Prevention and Municipal Good Housekeeping

Pollution Tracking and Accounting Pilot Program (PTAPP): Tracking and accounting for pollutant load reductions achieved through various stormwater and nonpoint source control projects is challenging. Some communities have initiated steps to develop tracking systems; however, regional consensus has not been reached on accounting or tracking methods. Communities agree that regional coordination on tracking and accounting is needed and would be beneficial, however, implementation resources are limited.

To help municipalities meet the more rigorous MS4 permit requirements, the University of New Hampshire Stormwater Center and NHDES worked with municipal officials, public works departments, and engineering consultants to create the PTAPP tracking and accounting database. They also developed guidelines and recommendations for tracking and accounting systems and identified potential tools to enable municipalities to perform a quantitative assessment of pollutant load reductions associated with stormwater and nonpoint source management activities in the Great Bay region. The project has also launched a pilot PTAPP database for communities to test.

NH Association Of Natural Resource Scientists Wetland Buffer Scientific Workgroup: In March 2015, the Board of Directors of the NH Association of Natural Resource Scientists (NHANRS) authorized its Legislative Committee to form a Wetland Buffer Scientific Work Group to investigate the scientific basis for establishing protective buffers to jurisdictional wetlands in New Hampshire. The purpose was to provide science for use in future discussions regarding the need to advance wetland protection and to what extent. The workgroup published their findings in a report in June 2017.

The group agreed it would be beneficial to develop a simplified approach to siting and implementing protective wetland buffers. They developed criteria for High Value Wetlands (HVWs) to be used in this approach. One critical concept behind this approach is to allow an applicant, landowner, or natural resource professional to determine whether a wetland would be subject to a buffer based on a relatively short list of science-based criteria. Through various meetings, the group arrived at a consensus-based list of potential criteria for the HVW designation.

Section 4: Review of Available Science

At the start of the *Going Green* project, the panel chair worked with the advisory committee to identify the following literature reviews of science relevant to buffer management in New Hampshire:

- Recommendations of the Expert Panel to Reassess Removal Rates for Riparian Forest and Grass Buffers Best Management Practices, submitted to the Chesapeake Bay Program, October 2014

- Draft annotated bibliography of sources that the Environmental Law Institute (ELI) consulted for the draft report, submitted to the RI DEM, undated, received December 2017

- Key Findings from Available Literature from the Buffers Options for the Bay, project managed by the Great Bay National Estuarine Research Reserve completed by the Nature Conservancy, Roca Communications+, and GBNERR. Undated, received December 2017

- Riparian Buffers: A summary of nutrient reduction values reported in the literature May 22, 2017 Draft Prepared for the Vermont Agricultural BMP Expert Panel.

The chair conducted a meta-analysis that led to a composite outline of relevant literature that the panel reviewed prior to the first meeting. This informed their preliminary discussion of key issues including buffer width, soil type, land use, slope, type (grassed, vegetated, or forested), pollutants (TSS, TP, TN), habitat, water temperature, biodiversity, carbon sequestration, flood resilience, flow path, surface and subsurface flow, longevity, operation and maintenance, performance, and lag time. The panel agreed the outline provided an adequate foundation, but that they would add resources as needed.

Midway through the process, panelist Karen Dudley (USDA Natural Resource Conservation Service) compiled 82 additional references to help the panel reach a consensual definition of buffers and agree on the conditions that would influence the performance curves. Through this review, Dudley identified the following conditions as key to a buffer's capacity to remove pollutants from runoff:

- ***Soil type*** strongly influences infiltration and denitrification. Infiltration is determined by soil structure and consistency. HSG A (sandy or gravelly soils) have desirable high infiltration rates, but do not remove all pollutants effectively especially those in dissolved form.

- ***Denitrification*** is facilitated by wetter soils with higher water tables and organic material. HSG D was considered optimal for denitrification.

- ***Historically forested soils*** with limited compaction and those with ample organic matter and an undulating topography were the closest thing to being wet without actually being hydric soil.

- ***Hydrologic flow path*** is driven by landscape and soil. Optimal treatment of runoff occurs in wetlands or areas with a high water table that increase hydraulic residence time.

- ***Slope*** was noted in a 2010 study which indicated that buffer slopes less than 10% are good for sediment removal, but slopes greater than 10% have negative impact. NRCS staff with significant experience with erosion work concurred that < 10% was optimal and that 15–20% slopes had negative impacts.

- ***Land use intensity*** of the area draining into buffer and buffer itself influenced performance.

- ***Buffer health and longevity*** is optimal in highly vegetated, diverse buffers, which are more effective at removing pollutants but may require maintenance. Buffers that become forested or diverse over time are expected to become more effective.

Section 5: About the Panel's Decisions

To meet its charge, the panel identified a set of optimal conditions for a buffer that served as the foundation for four sets of performance curves. They set a 100% credit for an "optimal buffer" and then calculated reductions (penalties) for suboptimal buffer conditions on each performance curve. The curves, optimal conditions, and the decisions that underpin them are captured in the technical memo in Appendix 7.1. In the making of these decisions, the panelists considered the following key questions and relevant, available science:

- How do you define buffers for the purpose of developing performance curves?
- Which types of land use should be allowed for accounting, e.g. urban or non-urban?
- How do you define optimal buffer conditions for pollutant reduction given available science and data?
- How do you aggregate and incorporate different types of buffers into curve development?

- How can findings and results from the Chesapeake Bay model be used to develop curves for New Hampshire?
- What is the relationship between buffer performance over time and credit allowed by the curves?
- Which scenario for curve development is the most practical and accurate given available information and intended use of the curves?

Section 7: Appendices

7.1 Final Technical Memo

Pollutant Removal Credits for Restored or Constructed Buffers in MS4 Permits

Technical Memorandum

June 2019

Contents

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1. Introduction

This technical memorandum is intended to help municipalities, engineers, and regulatory officials to quantify pollutant removal rates for restored or constructed buffers, whether in development, redevelopment, or restoration projects, or any time there is a change in land use. These rates can be used to allocate credits for regulatory permits issued under the NPDES Stormwater Permit Program and other efforts to manage stormwater.

Issued in January 2017, New Hampshire's Small Municipal Separate Storm Sewer System (MS4) General Permit describes tracking and accounting metrics to quantify nutrient and sediment pollutant loading for different land uses. It also includes removal efficiency curves for a range of non-proprietary best management practices (BMPs). The performance curves in this memo will allow restored or constructed buffers to be credited like other BMPs by using a method that applies a quantitative value to their capacity for pollutant removal. To date, this capacity has only been valued in a qualitative way. Specifically, these curves may be used to calculate the removal efficiency for total nitrogen (TN), total suspended solids (TSS), and total phosphorus (TP) for restored or constructed buffers ranging from 20 to 100 feet in width. This calculation is based on four performance curves formed around hydrologic soil groups A, B, C, and D.

This memorandum was generated by the Credit for Going Green Project, which used an expert panel process to develop consensus-based recommendations to help New Hampshire stakeholders use buffers to meet in-stream pollution reduction targets. The project was modeled after a similar initiative in the Chesapeake Bay region. Credit for Going Green was sponsored by the National Estuarine Research Reserve System Science Collaborative, which supports collaborative research that addresses coastal management problems important to Reserves and their communities. The Science Collaborative is funded by the National Oceanic and Atmospheric Administration and managed by the University of Michigan Water Center.

2. Definition of Terms

This memorandum uses the following definitions for key terms.

- ***Removal efficiency*** (RE): the restored buffer's capacity to remove total nitrogen (TN), total suspended solids (TSS), and total phosphorus (TP), calculated as the difference between the mass entering the buffer and the mass leaving, divided by the mass entering

- ***Performance***: the restored or constructed buffer's ability to remove TN, TSS, and/or TP

- ***Credit:*** the estimated pollutant load reduction given for the use of restored or constructed buffers under the NPDES Stormwater Permit Program and other efforts to manage stormwater

- ***Penalty:*** the reduction in credit from the total possible—reflects the impact of less optimal conditions on a restored buffer's ability to remove TN, TSS, and/or TP

3. About the Expert Panel and Its Process

Going Green's expert panel process synthesized the opinions of a group of authorities on a subject around which there had been uncertainty due to data that was insufficient and/or unattainable because of physical constraints or lack of resources. The panel included state and regional regulators and experts in watershed hydrology, stormwater management, soil science, fish and stream ecology, and spatial understanding of nutrient attenuation. Their charge was to develop nutrient and sediment removal rate percentages for upland buffers based on the best available science for New Hampshire landscapes.

In support of this, panelists conducted an extensive literature review. They determined that while numerous data sources for New Hampshire exist, these were not sufficient to depart from removal efficiencies used by the Chesapeake Bay initiative on which this process was modeled (Table 1). Likewise, they decided the range of geological areas used in the Chesapeake region would be applicable in New Hampshire if hydrologic soil groups (HSGs) were used to differentiate pollutant load reduction.

Table 1: Chesapeake Bay Program Pollutant Removal Efficiencies for Buffers According to Geology	Forest on one side of the stream (same as 2008)			Grass on one or both sides of the stream (same as 2008)		
	TN	TP	TSS	TN	TP	TSS
Inner Coastal Plain	65	42	56	46	42	56
Outer Coastal Plain (well drained)	31	45	60	21	45	60
Outer Coastal Plain (poorly drained)	56	39	52	39	39	52
Tidally Influenced	19	45	60	13	45	60
Piedmont (schist/gneiss)	46	36	48	32	36	48
Piedmont (sandstone)	56	42	56	39	42	56
Valley and Ridge (karst)	34	30	40	24	30	40
Valley and Ridge (sandstone/shale)	46	39	52	32	39	52
Appalachian Plateau	54	42	56	38	42	56

In addition to the literature review, the panel held six meetings to discuss key issues related to the performance expectations of upland buffers. These discussions, as well as further review of additional scientific and regulatory resources, helped them define an optimal restored or constructed buffer condition that would fulfill the upper boundaries of performance expectations and therefore be eligible for maximum credit under New Hampshire's MS4 permit.

The panel also agreed to use the maximum and minimum removal efficiency values represented in Table 1 to develop the final performance curves. To mimic the hydrological response unit modeling approach used in USEPA Region 1 performance curves, they selected buffer and data ranges that are bounded by the maximum removal efficiency (RE) percentages. The curves were then scaled to buffer width and shifted by the maximum RE for the corresponding HSG (Hydrologic Soil Group) using the minimum and maximum RE values in Table 1.

4. Key Decisions

The performance curves in this memorandum reflect panel decisions related to topics for which there was sufficient existing data, as well as others for which further research or data collection may be warranted. This section provides an overview of these decisions.

1. **Optimal Buffer Condition**: The panel selected a forested buffer with a width of 100 feet as the optimal buffer condition that could achieve the maximum removal efficiency values described in Table 1. This condition defines the upper boundary of pollutant removal credit. Deviations from this condition result in penalties that reflect lower performance expectations. As noted elsewhere, additional width may result in additional treatment, but the science does not exist to quantify that addition.

2. **Minimally Acceptable Buffer Width:** The panel selected 20 feet as the minimally acceptable buffer width and the lower boundary of pollutant removal performance. While the y-intercept (zero removal efficiency) occurs at a buffer width of 0 feet, credit begins for buffers that are 20 feet wide. Narrower buffers, while valuable in their own right, cannot receive credit under this system. Panelists felt that the primary benefit of the first 20 feet of a buffer is to ensure the long-term sustainability of the overall buffer.

3. **Grassed Buffers**: Both grassed and forested buffers have been shown to reduce nitrogen effectively. Yet while grass can provide dense protection of soil surfaces, it usually generates more runoff than forest (Belt et al. 2014). Several studies have found that grassed buffers are less effective than forested ones at removing nutrients (Lowrance 1998, Mayer et al. 2005). Therefore the panel assigned a 20% credit

reduction (penalty) based on Chesapeake values for nitrogen removal for grassed buffers (Lowrance 1998, Mayer et al. 2005).

4. **HSGs and Sediment and Phosphorus Removal:** The properties of soil impact pollutant reduction through infiltration and adsorption. The panel determined that hydrologic soil group (HSG) type 'A' soils would receive the maximum credit for total suspended solids (TSS) and total phosphorus (TP) removal.

5. **HSGs and Nitrogen Removal**: Given that total nitrogen (TN) performance is enhanced by decreased depth to groundwater and increased water residence time in the soil, the panel assumed that removal efficiencies for nitrogen would be *inversely* proportional to those for TSS and TP. In other words, while HSG A soils are optimal for TSS and TP removal, HSG D soils are best for TN removal. This assumption is corroborated by the range of performance values from the Chesapeake Bay studies (Table 1.)

6. **Contributing Area, Land Use, Impervious Cover, and Pollutant Loading:** *Contributing area* is the amount of land upgradient of a buffer that could generate runoff to the buffer. In a retrofit project, contributing area may include the buffer itself. The amount of contributing area, not including the buffer, that can be used to calculate *pollutant loading* is limited by the *land use* and *impervious cover* (IC) values in Table 2.

   This is because loading depends on distributed, rather than concentrated, flow conditions. Concentrated flows create channels across a buffer, which decrease its capacity for pollutant removal. Theoretically, the denser the IC, the more quickly concentrated flow occurs. As a result, the length of contributing area used to calculate pollutant loading decreases with increasing impervious cover. TN and TP load export rates for this project come from values developed for the 2017 NH MS4 permit.

Table 2: Land Use Categories and Associated Pollutant Load Export Rates (PLER)

Loading Ratio by Land Use			**PLER lb/ac/yr**		
Land Use	*% Density of Impervious Cover (IC)*	*Maximum Contributing Upland Distance (ft)*	*TSS*	*TN*	*TP*
Low Residential	<36	400	108	3.8	0.55
Residential	36-60	300	186	6.2	1.07
Commercial/ Transportation	>60	100	234	9.3	1.16

POLLUTANT REMOVAL EQUATION: L = R*A WHERE L (contributing pollutant load in lbs/yr) = **R** (pollutant load rate in lbs/acre/yr) *** A** (area in acres)

5. Situations These Curves Cannot Address

- **Buffers wider than 100 feet:** The panel did not have access to sufficient data or science to support recommendations for calculating removal efficiencies for restored or constructed buffers wider than 100 feet. However, there is extensive scientific support for the conclusion that wider buffers advance a variety of services beyond pollutant removal, including the provision of wildlife habitat, flood and storm surge protection, streambank stability, and nutrient cycling. The Buffer Options for the Bay Project synthesized this science in their Coastal Science Literature Review.

- **Buffers narrower than 20 feet:** While the panel decided the y-intercept (zero removal efficiency) of performance curves would occur at a buffer width of 0 feet, they determined the removal efficiency credit would begin at a minimum width of 20 feet. Narrower restored or constructed buffers, while valuable, will not receive pollutant removal credit in this framework.

- **Slopes steeper than 15%:** The performance curves are applicable to contributing areas with slopes of up to 15%. To calculate buffer removal efficiency for slopes between 5 and 15%, the panel agreed upon pollutant removal reduction multipliers outlined in Table 3. For slopes greater than 15%, there are no recommended removal efficiency curves.

Table 3: Performance Multiplier Based on Buffer Land Slopes up to 15%

Health and Longevity: consensus reached on 10-year lifespan of credit			
Slope	0–5%	5–10%	10-15%
Buffer Multiplier	1	0.75	0.5

- **Level spreader use:** Level spreaders transform concentrated flow into distributed flow. Level spreaders fall under the category of structural best management practices (BMPs). Application of these performance curves for land use change involving the use of level spreaders should be at the professional discretion of the site designer and permitting authorities.

- **Existing buffers:** While the curves are applicable to any buffer, credit is only given for development or redevelopment projects, including restoration, or any time there is a change in land use.

6. Considerations When Using the Curves

- The process used to create these curves is based on a weight-of-evidence approach that surveyed the best and most current available literature.

- The curves were established for use in New Hampshire and employed experts well versed in the state's ecological, hydrological, and regulatory systems. Efforts to adapt these curves and the equation for other regions should engage regional experts and data in the process.

- The performance curves are based on HSGs A, B, C, or D, but sometimes a site will consist of more than one HSG. The panel recommends choosing the most conservative option, i.e. the soil type that is less effective at pollutant reduction. For example, if the site consists of HSG B and HSG C, choose C.

- Longevity and maintenance: The credit calculated through these curves is applicable to restored or constructed buffers for up to ten years. After ten years, the panel recommends that the buffer be re-evaluated. For example, if a buffer was vegetated and is now forested, the credits could increase, whereas if it was forested and is now grassed, the credit should be decreased.

7. Performance Curves

Pollutant reduction performance curves were developed for each HSG. Three points calibrate these curves, which are presented as Figures 1 through 4 on the following pages.

- Point 1: All pollutant removal curves start at the minimum buffer width of 20 feet.

- Point 2: All pollutant removal curves end at the maximum buffer width of 100 feet.

- Point 3: There is an inflexion point at a buffer width of 35 feet. Values at the 35-foot buffer width represent minimum removal efficiency values from Table 1, whereas the 100-foot buffer width represents the maximum removal efficiency values from Table 1.

Figure 1: Performance Curves for nutrients (TN, TP) and sediment (TSS) for upland buffers of various widths (forested and grassed) for hydrologic soil group A.

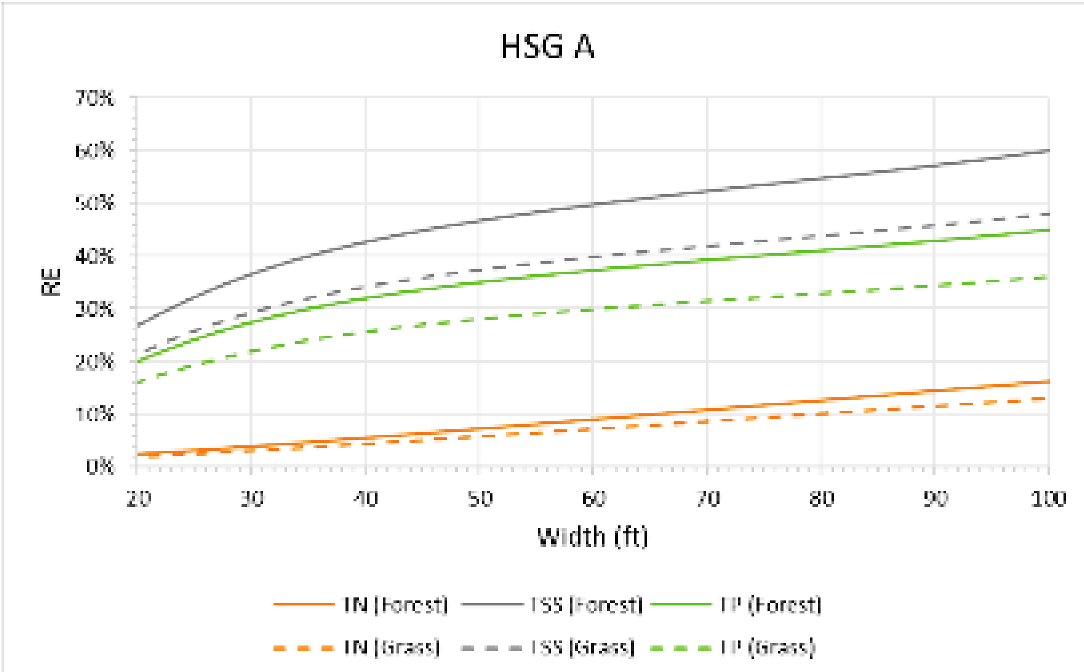


Figure 2: Performance Curves for nutrients (TN, TP) and sediment (TSS) for upland buffers of various widths (forested and grassed) for hydrologic soil group B.

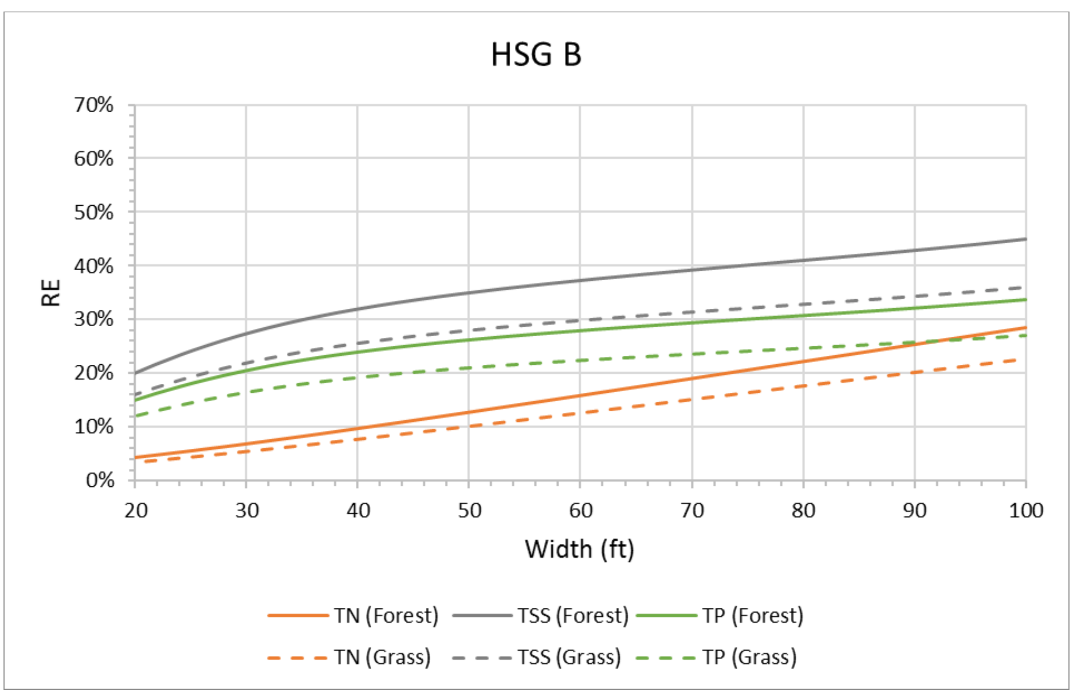


Figure 3: Performance Curves for nutrients (TN, TP) and sediment (TSS) for upland buffers of various widths (forested and grassed) for hydrologic soil group C.

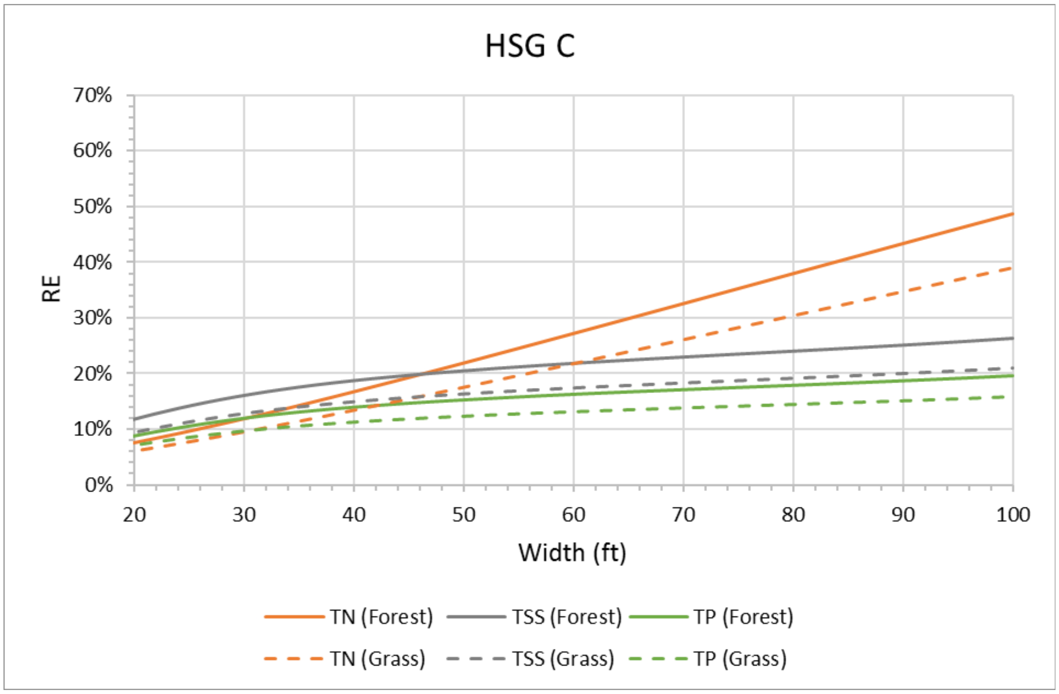
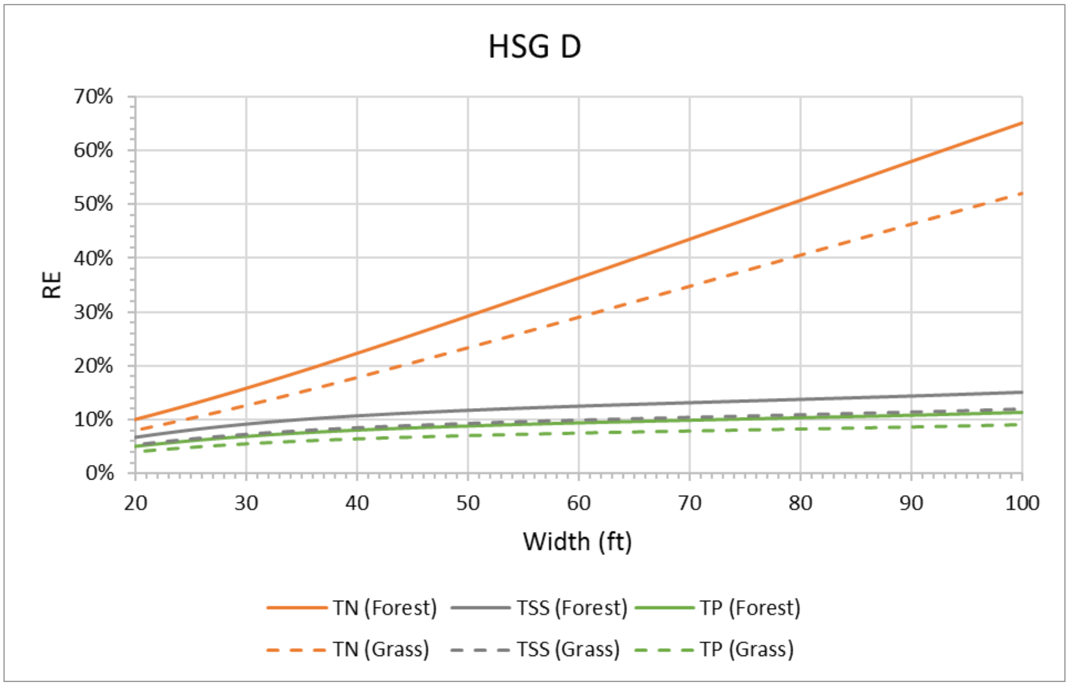


Figure 4: Performance Curves for nutrients (TN, TP) and sediment (TSS) for upland buffers of various widths (forested and grassed) for hydrologic soil group D.



The curves (Figures 1 through 4) are applicable to slopes up to a maximum of 5%. For slopes between 5–15%, use the multipliers outlined in Table 3 to calculate buffer removal efficiency.

Table 3: Performance Multiplier Based on Buffer Land Slopes up to 15%			
Health and Longevity: consensus reached on 10-year lifespan of credit			
Slope	0–5%	5–10%	10–15%
Buffer Multiplier	1	0.75	0.5

8. Calculating Pollutant Load Reduction Credits

The following methods adhere to the annual phosphorus and nitrogen load export rates presented in the 2017 NH MS4 permit. The baseline pollutant load is a measure of the annual phosphorus, nitrogen, and sediment load discharging in stormwater runoff from various land uses. Land uses were adapted from the Pollutant Tracking and Accounting Pilot Project (PTAPP) and further consolidated to the land uses presented in Table 2. The actual restored or constructed buffer is treated as a land use change. In addition to land use, upslope contributing areas treated by the buffer receive a load reduction efficiency credit according to the values presented in Table 2.

There are two approaches to calculating pollutant load reductions for buffers:

1. Developed areas where buffers are being created
2. Developed areas where buffers already exist

It should be noted that only the first approach results in a net pollutant load reduction that could receive credit using these curves. *The second is useful for calculating existing buffer environmental services with respect to pollutant reduction.*

Example 1: Developed Area Enhanced by a Buffer

Situation: A new 100-ft wooded buffer is established for a commercial site with HSG B soils and a maximum slope of 2.5%. IC is anticipated to be < 60%. The site's runoff flows to the buffer and from there into a stream. The site extends 1,000 feet along the length of this stream.

1. *Calculate the contributing pollutant load to the buffer:* Determine the area (in acres) of the buffer and the land area that is contributing flow to the buffer. Then select the Pollutant Load Export Rates (PLERs) for the appropriate land use classification in Table 2.

Use the following equation to determine your existing pollutant load:

L = RxA WHERE L (contributing pollutant load in lbs/year) = **R** (pollutant load rate in lbs/acre/year) **x A** (area in acres)

2. *Select the appropriate performance curve from Figures 1–4:* Choose based on the site's HSGs, buffer width, and vegetation type. If slopes are greater than 5% and less than 15%, take an average of the slopes and select the appropriate multiplier from Table 3.

3. *Determine the load reduction:* Use the appropriate curve to select the removal efficiency and multiply by the contributing load you calculated in step 1. This is the load reduction; it should be expressed as pounds per year and can be used over the service life (longevity) of the buffer, in this case 10 years. For example:

   - Calculate the buffer area: 100 feet x 1,000 feet = 100,000 square feet or 2.30 acres.
   - Based on the land use type, identify the maximum contributing distance upslope of the buffer (Table 2): 100 feet.
   - Calculate the total area: contributing area {(100 feet) + buffer width (100 feet)} x (buffer length) 1,000 feet = 200,000 square feet or 4.6 acres.
   - Calculate the pollutant loads from the commercial area using values from Table 2. The results are summarized in Table 4.

Table 4: Pollutant Loading Values for the Example Problem

Pollutant	PLER (lbs/acre/year)	Acres	Load (lbs/year)
TSS	234	4.6	4930
TN	9.3	4.6	42.7
TP	1.2	4.6	5.3

4. *Identify the removal efficiencies:* In this case, we use the RE from Figure 2 (because the site is HSG B) to apply to the existing pollutant load to calculate the overall project load reduction. The results are summarized in Table 5.

L x RE = LR WHERE L (contributing pollutant load in lbs/year) X RE (Removal Efficiency) **= LR** (project load reduction in lbs/year)

Table 5: Overall Pollutant Load Reductions for Example Problem

Pollutant	RE %	Load (lbs/year)	Load Reduction (lbs/year)
TSS	45	4930	2219
TN	28	42.7	12.0
TP	34	5.32	1.81

These load reductions may now be used to make the case for regulatory compliance or to address other accounting metrics for environmental services associated with buffers.

Example 2: Calculation of Pollutant Load Reduction From an Existing Buffer

Situation: A land manager wishes to calculate the pollutant load reduction services of an existing 200-foot grassed buffer within a low use residential site with HSG A soils and a maximum slope of 5.1%. The site's runoff flows to the existing buffer and from there into a stream. The site extends 500 feet along the length of this stream.

1. *Calculate load to the buffer:* Given that this is an existing buffer, its area is not included as part of the contributing area. Instead, use Table 2 to determine the appropriate travel length and calculate the contributing area (in acres) to the existing buffer. Then select the Pollutant Load Export Rates (PLERs) for the appropriate land use classification in Table 2 and use the following equation to determine your existing pollutant load:

   L = RxA WHERE **L** (contributing pollutant load in lbs/yr) = **R** (pollutant load rate in lbs/acre/yr) ***** **A** (area in acres)

2. *Select the appropriate performance curve from* Figures 1–4: Choose based on the site's HSGs, buffer width, and vegetation type. Given that the site has slopes greater than 5% and less than 15%, identify the appropriate multiplier from Table 3.

3. *Determine the load reduction:* Use the appropriate curve to select the removal efficiency and multiply by the contributing load you calculated in step 1. This is the load removed. The load reduction should be expressed as pounds per year and can be used over the service life (longevity) of the buffer, in this case 10 years.

4. *Calculate the load reduction credit:* Determine using the established curves.
   - Based on the land use type, identify the maximum contributing distance upslope of the buffer (Table 2): 400 feet.
   - Calculate the contributing area to the buffer: contributing area {(400 feet) x (buffer length) 500ft} = 200,000 square feet or 4.6 acres.
   - Calculate the pollutant loads from the low use residential land use using values from Table 2. The results are summarized in Table 6.

Table 6: Pollutant Loading Values for the Example Problem

Pollutant	PLER (lb/acre/year)	Acres	Load (lb/year)
TSS	108	4.6	497
TN	93.8	4.6	431.5
TP	0.55	4.6	2.5

5. *Identify the removal efficiencies:* Use the RE from Figure 1 (because the site is HSG A) to apply to the existing pollutant load to calculate the overall project load reduction. The results are summarized in Table 7.

L x RE = LR WHERE L (contributing pollutant load in lbs/yr) **X RE** (Removal efficiency units?) **= LR** (project load reduction in lbs/year)

Table 7: Overall Pollutant Load Reductions For Example Problem			
Pollutant	RE %	Load (lb/yr)	Load Reduction (lb/yr)
TSS	49	497	244
TN	36	431.5	155.3
TP	12	2.5	0.3

These load reductions may be used to account for load reductions for regulatory compliance or to interface with other accounting metrics for environmental services associated with buffers.

9. References

Belt, K., Groffman, P., Newbold, D., Hession, C., Noe, G., Okay, J., Weller, D. (2014). “Recommendations of the expert panel to reassess removal rates for riparian forest and grass buffers best management practices.” Chesapeake Bay Program.

Environmental Protection Agency (EPA), 2017. *New Hampshire Small MS4 General Permit.* https://www.epa.gov/npdes-permits/new-hampshire-small-ms4-general-permit

Flanagan, Shea E.; Patrick, David A.; Leonard, Dolores J.; and Stacey, Paul, "Buffer Options for the Bay: Exploring the Trends, the Science, and Options of Buffer Management in the Great Bay Watershed Key Findings from Available Literature" (2017). PREP Reports & Publications. 380.

Lowrance, R., L.S. Altier, J.D. Newbold, R.R. Schnabel, P.M. Groffman, J.M. Denver, D.L. Correll, J.W. Gilliam, J.L. Robinson, R.B. Brinsfield, K.W. Staver, W. Lucas, and A.H. Todd. 1997. “Water quality functions of riparian forest buffers in the Chesapeake Bay Watershed.” Environmental Management 21:687-712.

Mayer, Paul M., S. K. Reynolds, Jr., T. J. Canfield and M.D. McCutchen. 2005. “Riparian Buffer Width, Vegetative Cover, and Nitrogen Removal Effectiveness: A Review of Current Science and Regulations.” U.S. Environmental Protection Agency, Washington, DC, EPA/600/R-05/118, 2005.

Soil Survey Staff. 2009. *National Engineering Handbook. Part 630 Hydrology. Chapter 7, Hydrologic Soil Groups.* United States Department of Agriculture, Natural Resources Conservation Service.

United States Environmental Protection Agency (USEPA) (2017). 2017 *Final New Hampshire Small MS4 Permit, appendix F.*