**Design Specifications & Nutrient Accounting for
Riparian Buffer Improvement in Developed Areas**

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| **Practice Description and Utility** |
| ***Purpose:*** This document addresses the practice of improving riparian zones in developed areas through reforestation. It provides design and implementation criteria, and nutrient credit calculations for compliance with nutrient management strategy rules. ***Utility & Applicability:*** This practice complements the existing design standards and accounting method for buffer restoration in agricultural drainages and may be used towards compliance with any nutrient rule that allows the use of offsite practices. This practice is designed for, and its applicability is limited to, riparian zones receiving drainage from developed catchment areas. Non-forested acreage in developed catchments will consist of predominantly impervious or managed pervious cover. For on-site use on new development sites, the practice would require approval by the local government permitting authority as well as the NCDEQ Division of Energy, Mineral and Land Resources (NCDEMLR) Stormwater Permitting Program. Eligible riparian lands are those that meet the definition of either ‘restoration site’ or ‘enhancement site’ found in the state’s Buffer Mitigation rule, 15A NCAC 2B .0295, and that are situated adjacent to perennial or intermittent streams or ephemeral channels or qualifying ditches, all as defined or otherwise set out in that rule. Eligible improvement widths on either side of a stream range from a minimum of 20 feet to a maximum of 200 feet. Restoration of the first 50 feet of width adjacent to perennial and intermittent streams constitutes a land use change that shall also adhere to the limitations of the applicable buffer protection rule (https://deq.nc.gov/riparian-buffer-rules). ***Nutrient Removal Mechanisms:*** Reforestation and protection of vegetation in the riparian zone improves filtration of overland stormwater runoff, infiltration of runoff, and denitrification in shallow groundwater flow prior to discharge to receiving waters. Pollutant removal varies with the width of the buffer and the volume of flow treated by the buffer, either from adjacent upland areas that contribute sheetflow to the buffer or flows that are routed from upgradient to areas to the buffer as concentrated flow. Concentrated flows require use of a level spreader outside of the required minimum buffer width to provide diffuse flow through the buffer.  |
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| **Nutrient Credit Overview**Nutrient reductions are credited via two mechanisms: land conversion and throughput treatment by the buffer. Land conversion is credited by calculating the reduction in nutrient export based on the conversion of managed pervious grass area to forest using the North Carolina Stormwater Nitrogen and Phosphorus (SNAP) Tool or a subsequent Division-approved tool. Throughput treatment is credited by applying percent removal efficiencies that vary by buffer width to project-site nitrogen and phosphorus loading estimates calculated also using the SNAP Tool or subsequent Division-approved tool.Using this method, the ranges of estimated nutrient removal for the most likely set of restoration scenarios are: 2.6 lbs/ac buffer/yr to 46.3 lbs/ac buffer/year for total nitrogen (TN) and 0.8 lbs/ac buffer/yr to 10.3 lbs/ac buffer/year for total phosphorus (TP). Theses ranges are based on the natural drainage area of the buffer. Where catchments are artificially larger through development, the reductions may be greater. |
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**Practice Design and Implementation**

1. **Qualifying Conditions, Requirements & Limitations for All Projects**Buffer improvement projects in developed areas shall meet the site conditions, design requirements, use limitations, and vegetation plan described below in order to qualify for the nutrient reduction credits identified in this document. These criteria and use limitations meet, and in some cases, exceed those required by nutrient strategy buffer protection and mitigation rules.Any protections beyond the buffer rules are included to achieve and maintain the nutrient removal functions that allow this practice to serve as a creditable load-reducing practice in developed settings. Applicants for credits may propose alternate project parameters and crediting, but will required detailed supporting documentation that will allow DWR to judge such a proposal.

**Qualifying Site Conditions and Limitations for All Projects**

1. Nutrient credit assignments described in this document apply to buffer improvement projects along perennial or intermittent streams, ephemeral channels, qualifying ditches, and perennial waterbodies.
	1. Perennial and intermittent streams are those that follow definitions established under DWR’s Surface Water Identification Training Course (SWITC). Stream determinations applying those definitions may be made by any person who is certified by the State for intermittent and perennial stream identification. A perennial waterbody is one connected to any perennial or intermittent stream.
	2. Ephemeral channel is defined in the Buffer Mitigation Rule 15A NCAC 02B .0295 (o)(7).
	3. Ditch is defined, and qualifying criteria for buffer restoration on ditches are set out in the Buffer Mitigation Rule 15A NCAC 02B .0295 (o)(8).
2. Qualifying projects shall drain areas predominantly composed of “developed” land, where the majority of the non-forested acreage would consist of impervious or managed pervious cover types as further described in guidance materials for the credit accounting tool. Characteristic land uses include urban, suburban, rural residential, commercial, industrial, open space, golf courses and athletic fields. A minor proportion of these areas may include lands supporting activities subject to nutrient strategy agriculture rules.
3. Sites qualifying for buffer restoration credit shall meet the definition of “Restoration Site” found in rule 15A NCAC 02B .0295 (b)(12), which is as follows: “riparian zone sites that are characterized by an absence of trees and by a lack of dense growth of smaller woody stems (i.e., shrubs or saplings) or sites that are characterized by scattered individual trees such that the tree canopy is less than 25 percent of the cover and by a lack of dense growth of smaller woody stems (i.e., shrubs or saplings).”
4. Sites qualifying for enhancement credit shall meet the definition of "Enhancement Site" found in rule 15A NCAC 02B .0295 (b)(4) which is as follows: “a riparian zone site characterized by conditions between that of a restoration site and a preservation site such that the establishment of woody stems (i.e., tree or shrub species) will maximize nutrient removal and other buffer functions.” A "Preservation Site" is defined in rule 15A NCAC 02B .0295 (b)(11) and means “a riparian zone sites that, as determined by a site visit conducted by the Authority, are characterized by a forest consisting of the forest strata and diversity of species appropriate for the location.” Enhanced areas may comprise the entirety of the total buffer improvement area.
5. The permitting authority will determine whether the site is a current candidate for restoration or enhancement prior to project implementation, and determine whether any Buffer Protection Rule violations may have occurred. Restoration/enhancement credit may not be awarded in those areas.
6. Minimum restored or enhanced buffer width, not including pre-existing forest, shall be 20 ft on a given side of the stream or waterbody. Improvement can be added adjacent to pre-existing forest.
7. Maximum creditable buffer width including restored, enhanced, and pre-existing forest shall be 200 ft on a given side of the stream or waterbody. This does not include space needed for any level spreaders, which would be placed landward of the improved area.
8. Existing sewer easements within Zone 2 of the buffer are allowed per the requirements specified in the Buffer Mitigation Rule 15A NCAC 02B .0295 (l)(4); sewer easements are not included in credit calculations. As specified in the Buffer Protection Rules, Zone 1 is the inner 30 feet of buffer closest to the waterbody and Zone 2 is 20 feet wide, starting at the outer edge of Zone 1.
9. This practice may be used in settings with incised or non-incised streams.

**General Design Guidance and Performance Standards for All Projects**

All improvement projects shall meet the following design requirements, which in some cases exceed those found in nutrient buffer protection rules:

1. Pre-existing concentrated flows going through the buffer (that are not associated with a stream and not diffused as part of the improvement project) may continue crossing the buffer unaltered.
2. Tributary streams crossing the buffer may not be diffused; existing instability problems should be addressed using stream restoration or streambank stabilization, which shall be eligible for credit under those separate practice standards.
3. All very small/minor concentrated flows (e.g., roof drains) daylighting within 10 ft of the improvement area, or inside of the improvement area, shall be diffused with a splash pad or other method of energy dissipation to prevent erosion at least 50 ft away from the stream or waterbody, or as far from the stream as is practicable, consistent with the requirements of the Buffer Protection Rules.
4. A buffer improvement plan approved by DWR is required for all projects. The plan shall meet the requirements of NCAC 02B .0295 Sub-paragraph (n):
	1. A detailed map of the proposed improvement site, including the planting area and area draining through diffuse flow to the planting area, delineated by the types of land covers described in the credit calculation. For projects where a level-spreader is used, the map will include areas draining to the level-spreader, also delineated by land cover type. All catchment areas draining through the buffer by concentrated flow are to be excluded from the catchment area delineation.
	2. An Improvement Plan with success criteria and an implementation schedule, that includes plant establishment, grading, soil improvement/erosion control, fertilization, and weed/pest control plans as applicable. (Described below.)
	3. A monitoring plan to document whether the site meets the success criteria defined in the restoration plan.
	4. Documentation that the buffer meets success criteria shall be submitted annually for the first5 years for both perpetual and time-limited credit and then every 5 years thereafter for the duration of time-limited credit.

**Buffer Use Limitations for All Projects**

To ensure sustained nutrient function of this practice, the Buffer Protection Rule for the watershed where the project is located will apply to the entirety of the improved buffer area, including areas beyond the area regulated by the Buffer Protection Rule. Where the applicable buffer rule has multiple zones, the outer zone restrictions shall apply to the improved buffer outside of the area regulated by the rule. The following additional constraints and general requirements apply on all projects:

1. Aside from activities necessary to meet improvement project purposes, only the following activities are authorized in the buffer: "non-intensive outdoor recreation," existing utility maintenance and management, forestry activities, and buffer inspection and maintenance activities. “Non-intensive outdoor recreation” is defined as dispersed, non-commercial and non-motorized recreational activities that do not generally rely on buildings and have minimal impact on renewable natural resources. Such activities include but are not limited to, hiking, bird watching, camping, picnicking, mountain biking and lawful hunting and fishing, but do not include horseback riding.
2. Trails to support non-intensive recreation, including those suitable for non-motorized vehicles, may be installed but shall not exceed 4 feet in width, shall not exceed 10% of the improved area, and installation or use shall not result in removal of trees. Trails shall be designed to minimize erosion and managed to prevent compaction by users.
3. Improvement areas shall be managed to minimize soil erosion and compaction, and to minimize transport or dispersal of invasive plant species into the buffer from contiguous, pre-existing utility easements through the buffer.
4. Fencing and other physical barriers such as tree tubes may be installed to protect trees and shrubs from damage or injury. Installation shall not result in removal of trees.
5. There shall be no storage or dumping of trash, garbage, abandoned vehicles, appliances, or machinery, or other unsightly or offensive material, hazardous substance, or toxic waste.
6. Any new development that occurs adjacent to or upgradient of the buffer after improvement may not rely on the buffer for stormwater treatment. New concentrated flows after improvement through the buffer are prohibited.

**Improvement Plan and Success Criteria for All Projects**

Forest restoration shall follow a DWR-approved restoration plan and shall be planted in forest species native to North Carolina. “Planting” may be accomplished by natural regeneration/volunteer seeding if success criteria are met. The final success criteria at the end of five years shall include a minimum of four native hardwood tree species or four native hardwood tree and native shrub species, where no one species is greater than 50 percent of stems**.** Trees and shrubs shall be planted at a density sufficient to achieve a density of 260 stems per acre after five years. Native hardwood tree and shrub volunteers may be included to meet the standard for success. If vegetative success criteria are not met, supplemental plantings may be required. The Division may approve alternative vegetation plans upon consideration of factors, including site wetness and plant availability, to meet the vegetation requirements.

Sites shall be graded in a manner to ensure diffuse flow through the entire riparian buffer. The restoration plan will describe plant establishment, grading plans and any plans to correct for compacted soils, prevent soil erosion, provide for a one-time initial fertilization to establish vegetation, and the recommended methods to control competing weeds and pest/disease species if necessary. A schedule of implementation will be included in the plan.

**Inspection and Maintenance for All Projects**

An inspection and maintenance plan shall detail the activities proposed to ensure a final performance standard of 260 stems per acre after five years. This plan should describe action levels at which point additional planting will be undertaken to maintain adequate stem density, methods for identifying and removing invasive plant species, and methods to protect young trees from injury by herbivory, disease, foot or vehicular traffic, landscaping activities, etc.

Vegetation surveys shall be conducted to demonstrate that an adequate vegetation density is being maintained. These shall be conducted annually for the first five years for all projects. Additional monitoring is required every fifth year thereafter for the duration of time-limited projects (projects not protected with a permanent easement). Vegetation surveys shall include permanently-marked 10mx10m plot(s), with data collected between June 1 and September 1, in which all living stems of trees and shrubs are counted and identified to species. Locations of plots should be documented with GPS coordinates. Each project shall have a minimum of one 10mx10m monitoring plot per acre of restored/enhanced area that is representative of conditions in that area.

During the first five years after planting, the party awarded credit shall ensure that the buffer is inspected at least annually, maintained as necessary, that inspection and maintenance actions are documented by written means, and that the Division will be provided access to the practice with proper notice. In addition to surveying the plotted area, annual inspections should include a visual inspection of the entire buffer improvement site to assess overall health of the vegetation as well as identify areas of disturbance and impacts to planted stems that may require action (e.g., evidence of trees with suppressed growth or death from encroachment by competing vegetation, animal damage, or disease).

For time-limited projects, inspections, reporting, and remedial actions are required at least every five years thereafter. Reporting requirements for this option are described below.

**Credit Award and Verification for All Projects**

For each of the first 5 years, in order to release credits, a vegetation survey must be submitted to DWR documenting vegetation density and condition. If the target density is not maintained, the next allotment of credits will not be released until remedial action has been taken.

Upon submittal and approval of all appropriate documentation by DWR, credits for this practice will become available in accordance with the following credit release schedule. The percentages shown in Table 1 are the proportion of total credit released (not including adjustments specified elsewhere):

**Table 1: Credit Release Modifiers for Each Reporting Period After Project Implementation**

|  |  |
| --- | --- |
| **Reporting Period** | **Credit Release Modifier** |
| Initial implementation | 50% of full credit |
| 1 year after implementation | 60% of full credit |
| 2 years after implementation | 70% of full credit |
| 3 years after implementation | 80% of full credit |
| 4 years after implementation | 90% of full credit |
| 5 years after implementation | 100% of full credit |
| >5 years after implementation | 100% of full credit |

Where permanent conservation easements are used, the easement holder will make the site and maintenance/inspection records available to DWR staff for auditing purposes. However, no further reports are required to be submitted.

Where permanent conservation easements are not used, vegetation survivorship surveys, or an alternative approach acceptable to the Division, shall be conducted at least at the end of every 5-year period and submitted to DWR to document calculation of credits applying to that period. If the required vegetation density is not maintained, corrective action should be taken. DWR may adjust credits if vegetation densities are not maintained. Credit may be reduced for that reporting year proportional to the deficiency in tree density. The party shall seek to identify and determine, if possible, when the impacts to the buffer began or occurred, remedy causes for the attrition, and replant as indicated to ensure success criteria are met. The party shall recommence annual inspections and reports on the newly planted stems for a period of no less than 3 years and take appropriate corrective actions considering the identified causes of attrition.

If only one inspection is conducted for a second or later 5-year period, and it is not possible for the party to determine when the impact to the buffer occurred, it shall serve as the sole basis for judging credits for the previous 5 years, and reduced credits may apply to all 5 years. DWR will consider the results of the inspection and other information developed by the party to assist in its determination for any reduction in the credit over the previous 5 years. Documented annual inspections are encouraged to trigger prompt corrective action and to best protect credits. To reduce administrative burden, annual inspection records may be retained and submitted to DWR at least every five years.

**General Implementation Recommendations for All Projects**

The following guidance is offered to help improve likelihood of success but is advisory in nature and not required to obtain credit.

1. In order to get a forest established that can tolerate urban conditions, it is recommended that fast-growing or early-successional native species are used that will quickly shade out nonnative competitors.
2. In cases where the stream is incised, facultative or facultative upland plant species should be used rather than facultative wetland species or species otherwise known to tolerate drier conditions.
3. Consider high density planting and supplemental planting to allow natural attrition to select the hardiest individuals.
4. Where animal damage is anticipated, in the initial years consider mowing the grass or using pesticides to suppress grass directly around young trees to reduce space for gnawing animals to hide.
5. In situations with severe stream incision and/or bank erosion, stream restoration or streambank shaping and stabilization should be considered.
6. For ephemeral streams, regenerative stormwater conveyance or bioswales should be considered, which may involve some amount of riparian buffer improvement.
7. **Design Requirements for Optional Use of Level Spreaders to Diffuse Concentrated Flows**

Projects may elect to diffuse buffer-crossing concentrated flows to receive greater credit by treating more stormwater. Such projects shall meet the following design specifications:

1. Only concentrated flows from stormwater sources may be diffused. Flow from perennial and intermittent streams, including those arriving via piped flow, may not be diffused.
2. Level-spreaders shall be designed and installed according to Minimum Design Criteria for all SCMs and for Level Spreader-Filter Strips (Rules 15A NCAC 2H .1050 and 2H .1059), without the use of an accompanying filter strip.
3. Additionally, level spreaders shall be designed to the standard of 65 ft of length/peak flow (cfs), and placed directly upslope of a forested buffer area with no re-collection of overland flow.
4. Level spreaders may be installed no closer than 50 ft to the stream or waterbody and outside of any restored or enhanced buffer areas. (Level spreaders are allowed closer to correct an identified erosional threat to existing infrastructure, but with the structure located as far away from the stream or waterbody as practicable. These installations are not eligible for this credit and must have different credit amounts proposed by the project designer.)
5. Where multiple level spreaders are deployed along a restored buffer, they shall be evenly dispersed along the improvement area to the maximum extent practicable.
6. Flow volumes greater than design specifications, such as for large drainage areas, may be directed to the level spreader but shall have flow split to meet the maximum flow requirements.
7. Overflow conveyances shall use preexisting drainage ditches or swales provided flows do not alter the ditch or swale, or result in the need to alter the conveyance, and are managed to minimize the sediment, nutrients, and other pollution conveyed.
8. Maximum slope of the buffer area and Level Spreader shall be 8 percent.
9. **Specifications Regarding Project Lifetime: Perpetual vs. Time Limited Projects**

Projects may be implemented as perpetual or time-limited in temporal scope. Credits generated from perpetual lifetime projects may be used to meet New Development rule offset needs or Existing Development rule credit needs. These projects are designed and assumed to be a permanent and protected feature of the landscape. Credits generated from time-limited projects may not be used to meet New Development rule nutrient offset needs, but may be used to meet Existing Development rule compliance needs. These credits require “renewal” at regular intervals to maintain the credit. The following sections describe project requirements specific to these two types of project.

**Requirements Specific to Perpetual Improvements**

Perpetual lifetime projects shall be adequately inspected and maintained and have adequate protections and financial assurances to ensure continued health of the forested buffer in perpetuity. Projects shall meet the requirements set forth in Sub-paragraph (l)(2)(A) through (l)(2)(C) of 15A NCAC 02B .0295 and include the following elements in their Buffer Improvement Plan:

1. A perpetual conservation easement or similar preservation mechanism for perpetual stewardship that protects the site’s nutrient removal and other water quality functions.
2. A non-wasting endowment or other dedicated financial surety to provide for the perpetual land management and maintenance.
3. Financial assurance in the form of a completion bond, credit insurance, letter of credit, escrow, or other acceptable financial vehicle in the amount sufficient to ensure that the property is secured in fee title or by easement, and that planting or construction, monitoring and maintenance are completed as necessary to achieve the success criteria specified in the plan.

**Requirements Specific to Time-Limited Improvements**

Unlike permanent buffer projects, time-limited buffer improvement projects do not require a permanent conservation easement or financial assurances for monitoring and maintenance. At the end of every 5-year period, after notifying DWR of intent, the property owner or entity seeking credit may allow areas outside of Zone 1 of the buffer to be converted to another use with concurrent loss of credit. Areas within Zone 1 must be maintained as forest to meet requirements of the relevant Buffer Protection Rule.

**Nutrient Credit Estimation**

1. **Nutrient Load Reduction Credit Mechanisms**

There are two basic mechanisms of this practice that contribute to nutrient reduction:

***Land Conversion:*** Land conversion is a change in land use to forest from other pervious landcovers or impervious landcovers. The reduction in nutrient export based on land conversion to forest is the nutrient credit for this mechanism. There is no land conversion credit for the portion of the buffer that is “enhanced”; only the area that is “restored” would receive this portion of the credit.

***Throughput Treatment:*** Buffer treatment may occur by surface filtration and subsurface treatment. Nutrient reduction provided by throughput treatment is represented by the percent mass reductions provided in Table 2.

* + Surface treatment occurs as flows are distributed across the ground surface of the buffer as diffuse flow. Processes that contribute to surface treatment include sedimentation and filtration.
	+ Subsurface treatment occurs as water flows beneath the surface of the buffer. Depending on the site characteristics and nutrient being evaluated, loss processes may include infiltration, evapotranspiration, adsorption or, vegetative uptake, and denitrification.
1. **Credit Calculation Overview**

The two nutrient removal mechanisms have nutrient credit calculated in different ways. The sum of these reductions may be modified depending on the time since the project was completed (credit release), how much of the project is forest enhancement, and whether there were problems with vegetation survival. Table 2 summarizes crediting for the different removal mechanisms and how the total credit may be modified by project conditions.

**Table 2. Summary of Site Crediting Mechanisms and Modifiers for Improvement of Buffers in Developed Areas**

|  |  |
| --- | --- |
| **Land Conversion Credit** | Nutrient Export Difference Due to Project Changes in Land Cover, Inclusive of Buffer |
| **Buffer Treatment Credit** | Treatment Rate Applies to Areas Draining to Buffer, Exclusive of Buffer |
| **Buffer Treatment Rate Based on Buffer Width** |

| **Average Buffer Width****from Top-of-Bank (feet)** | **Percent Nitrogen Reduction** | **Percent Phosphorus Reduction** |
| --- | --- | --- |
| 20-29 | 20% | 20% |
| 30-49 | 25% | 25% |
| 50-74 | 30% | 30% |
| 75-99 | 32% | 32% |
| 100-199 | 35% | 35% |
| 200+ | 40% | 40% |

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| **Enhancement Modifier** | 50% of Total Credit |
| **Credit Release Modifier** | Initial Implementation: 50% of full credit1 Year After Implementation: 60% of full credit2 years After: 70% of full credit3 Years After: 80% of full credit4 Years After: 90% of full credit5 Years After and beyond: 100% of full credit |
| **Survivorship Modifier** | Case-Specific Determination – Applies to Total Credit |

1. **Credit Calculation for Land Conversion**

Nutrient credit provided by land conversion is the reduction of nitrogen and phosphorus export in pounds per acre per year post-project when compared to the pre-project condition.

*Specific Notes on the Land Conversion Calculation*

* The whole site, including existing forest, utility easements, and improved buffer area, is used to account for all land conversion changes that may occur as part of the project.
* Areas drained by concentrated flow pre-project that as part of the project will be diffused by level spreaders are included in the total project area.
* Enhanced areas do not get land conversion credit. Enhanced areas are considered to already be forest in the pre-project condition.
* Pre-project and post-project export values are determined using different methods for developed areas and agricultural areas.
* Utility easements are assumed to be managed (other) pervious for their entire width in both the pre- and post-project state, whether they are presently cleared to that width or not.

*Nutrient Loads from Developed and Forested Areas*

In the developed and forested portions of the drainage area, nutrient loads are calculated using the latest version of the North Carolina Stormwater Nitrogen and Phosphorus (SNAP) Tool or a subsequent Division-approved tool. Land covers in the buffer and drainage area should be classified into the types defined in that tool: Roof, Road, Parking/Sidewalk, Protected Forest, and Other Pervious. See the Tool or its Manual for land cover definitions.

*Nutrient Loads from Agricultural Areas*

Where a minor component of the drainage area leading to the buffer is in crop or pasture, the acreage of crop and pasture and multiplied by the export rates in Table 3 to determine nutrient loads exported from agricultural areas:

**Table 3. Agricultural Land Cover Nutrient Export Rates for Land Conversion and Buffer Treatment Credit Calculation**

|  |  |  |
| --- | --- | --- |
| **Agricultural Land Cover** | **N loading rate (lb/ac/yr)** | **P loading rate (lb/ac/yr)** |
| Crops | 8 | 2 |
| Pasture | 5 | 1 |

*Initial Land Conversion Credit Calculation*

To calculate the credit from land conversion, add pre-project developed area loads to pre-project agricultural area loads, then do the same for post-project loads. Initial land conversion credit is determined by subtracting post-project loads from pre-project loads for the land conversion credit.

1. **Credit Calculation for Buffer Throughput Treatment**

Nutrient credit provided by buffer throughput treatment is the reduction of nitrogen and phosphorus in runoff from the upslope drainage area. Percent removal efficiencies that vary by buffer width are applied to the loads leaving the upslope drainage area. The percent reduction is not applied to all nutrient load leaving the buffer, only to the runoff that flows through the buffer from outside of it.

*Nutrient Loads from the Upslope Drainage*

As with the land conversion credit, determine the nutrient load shed by the area draining to the buffer via diffuse flow post-project. This area will include areas draining to level spreaders above the buffer, if they are employed. Split this calculation into developed areas (using the SNAP Tool) and agricultural areas (using the agricultural export rates in Table 3) and sum the results together as necessary. In all cases for this calculation, exclude the areas inside the buffer, whether these are newly reforested, existing forest, or parts of a utility easement.

*Specific Notes on the Buffer Treatment Calculation*

* Only the area draining by diffuse flow to the buffer is used to calculate buffer treatment credit. Pre-existing forested buffer and easements that cross the buffer are not included in this area.
* Other than removing areas in the buffer, assumptions/procedures for handling utility easements and areas draining to level spreaders are the same as for the land conversion credit.
* Other than removing areas in the buffer, post-project export values are determined using methods for developed areas and agricultural areas as described for the land conversion credit.

*Buffer Treatment Percent Reduction*

Where the project is reforesting the buffer starting at the stream/lake edge, use Table 4 to determine the appropriate percent reduction to apply to the post-project calculated loads.

**Table 4. Percent Mass Reductions (Throughput Treatment) for Buffer Restoration (Average Widths from Top-of-Bank on a Given Side)**

| **Average Buffer Width** **from Top-of-Bank (feet)** | **Percent Nitrogen Reduction** | **Percent Phosphorus Reduction** |
| --- | --- | --- |
| 20-29 | 20% | 20% |
| 30-49 | 25% | 25% |
| 50-74 | 30% | 30% |
| 75-99 | 32% | 32% |
| 100-199 | 35% | 35% |
| 200+ | 40% | 40% |

*Incremental Buffer Treatment Percent Reduction*

If the project has intervening forest or other area (such as sewer easement), the net difference in buffer nutrient treatment rates (incremental rate) must be determined for application to the loads exported from areas draining to the buffer. Pre-existing forest is not included in the throughput treatment calculations, which credit the incremental increase in efficiency provided by the added buffer width as applied to the remaining catchment area.

Where the entire buffer is not improved, or where improvement does not start directly adjacent to the stream (such as where areas of utility easement or existing forest are present), then the net difference in buffer nutrient treatment rate (incremental treatment rate) must be determined. The incremental increase is calculated as the removal efficiency for the total buffer width minus the removal efficiency for the pre-project buffer width, using percent removals in Table 4.

***Incremental Removal Rate*** *= removal efficiency for the “outer” width – removal efficiency for the “inner” width*

Areas that are improved adjacent to an existing, fully functioning riparian buffer that is at least 20 feet wide are credited assuming an incremental percent removal efficiency calculated as

***Incremental Removal Rate*** *= Removal efficiency for post-project buffer width – Removal efficiency for the pre-project buffer width*

*Initial Buffer Treatment Credit Calculation*

To calculate the credit from buffer treatment, sum the drainage area nutrient loads from developed areas and agricultural areas. Multiply this value by the percent reduction from Table 4 or the incremental removal rate as appropriate to get the initial nutrient reduction provided by buffer treatment.

1. **Final Credit Calculation and Credit Modifiers**

The above credit calculations are modified by how far the project has progressed relative to the credit release schedule, when buffer enhancement is employed, and when stem density (vegetation survivorship) has failed to meet targets. Progression along the credit release schedule modifies the credit by the percentages shown in Table 1. Enhancement areas only receive 50% of the credit of restored areas, consistent with the Buffer Mitigation Rule 15A NCAC 02B .0295 (m). Enhancement areas also do not receive any credit for land conversion (that portion of the project is converting from forest to denser forest). When stem density fails to meet targets, credit modifiers are determined on a case-by-case basis.

* Credit Release – this credit modifier is based on the time that has passed since initial implementation of the project. See Table 3 for the Credit Release Schedule and modifiers.
* Enhancement – this credit modifier represents what proportion of your project is enhancement versus restoration, and includes the 50% discount of enhancement, to be applied to nutrient load that passes through the buffer. *Enhancement modifier = [1 \* (proportion of restored area)] + [0.5 \* (proportion of enhanced area)].* If 100% of the project is restoration, the result will equal 100% (no reduction due to enhancement areas).
* Vegetation Survivorship – this credit modifier is determined on a case-by-case basis if the project is not meeting stem density/survivorship criteria at the end of each five-year reporting period.

*Calculating the Total Credit*

To calculate the total credit available for the project at the time of reporting, sum the land conversion credit and the buffer treatment nutrient reduction amounts. Depending on the situation, apply the credit release, enhancement, and/or vegetation survivorship modifiers. These percentages are multiplicative, not additive (e.g., a 70% credit release and a 50% enhancement modifier for a particular project mean the sum of land conversion and buffer treatment reductions is multiplied by 0.35 (35%)).

 **Reductions Obtained**

For this practice the nutrient reduction credit varies based on the width of the completed buffer, the width of the pre-project fully functioning buffer, the percent of the project that is restored, the percent of the project that is enhanced, the size of the drainage area treated by the buffer, and the types land covers generating nutrient load in the drainage area.

Example ranges for this practice are provided in Table 3 for illustrative purposes, and individual site designs may result in different values depending on the combination of land use classes, drainage area treated, etc. Because buffer improvement has different treatment mechanisms depending on site conditions, the percent reductions will depend on buffer width, the amount of built upon area, the event mean concentrations of the land use draining to the practice, etc. The nutrient reductions (or credits) are provided in the table as pounds per acre per year (lbs/ac buffer/yr) for a given site condition.

For these examples, a 6acre residential site was used with built upon areas ranging between 10 percent and 50 percent. The ranges in reductions provided in Table 4 assumes a drainage area size of 6 acres. Where catchments are artificially larger through development or use of level spreaders just outside the buffer (per this credit) to disperse concentrated flows, the reductions may be greater.

**Table 4. Example Load Reductions per Acre of Buffer Restoration**

|  |  |  |  |
| --- | --- | --- | --- |
| **Buffer Width from Top-of-Bank (feet)** | **Percent N & P Reduction (from Table 2)** | **Nitrogen Reductions****Per Acre of Buffer(lbs/Buffer ac/yr)** | **Phosphorus Reductions****Per Acre of Buffer(lbs/Buffer ac/yr)** |
| 20 | 20 | 13.7 – 46.3 | 3.9 – 10.3 |
| 30 | 25 | 11.0 - 30.0 | 3.1 – 8.3 |
| 50 | 30 | 7.9 – 21.5 | 1.6 – 6.0 |
| 100 | 35 | 4.6 – 12.6 | 1.4 – 3.5 |
| 200 | 40 | 2.6 – 7.4 | 0.8 – 2.0 |

Table 5 provides examples of the nutrient reduction credit that would be generated using the approach described in Example 1 in residential areas for buffers of various widths on projects sites ranging from 10 percent to 50 percent built upon area (BUA). These reduction credits were calculated assuming a 6-acre project site located in Wake County.

**Table 5. Example Nutrient Credits for 500’ of Full Buffer Restoration on a Non-Incised Perennial or Intermittent Channel in a Developed Area**

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **Buffer Width from Top-of-Bank (feet)** | **Buffer Length (feet)** | **Built Upon Area**  | **Percent Reduction (from Table 2)** | **Nitrogen Load Reduction (lbs/Buffer ac/yr)** | **Percent Phosphorus Reduction (from Table 2)** | **Phosphorus Load Reduction (lbs/Buffer ac/yr)** |
| 20 | 500 | 10% | 20% | 13.7 | 20% | 3.9 |
| 30 | 500 | 10% | 25% | 11.0 | 25% | 3.1 |
| 50 | 500 | 10% | 30% | 7.9 | 30% | 1.6 |
| 100 | 500 | 10% | 35% | 4.6 | 35% | 1.4 |
| 200 | 500 | 10% | 40% | 2.62 | 40% | 0.80 |
|  |  |  |  |  |  |  |
| 20 | 500 | 20% | 20% | 19.0 | 20% | 5.2 |
| 30 | 500 | 20% | 25% | 15.8 | 25% | 4.4 |
| 50 | 500 | 20% | 30% | 11.3 | 30% | 3.2 |
| 100 | 500 | 20% | 35% | 6.6 | 35% | 1.9 |
| 200 | 500 | 20% | 40% | 3.7 | 40% | 1.1 |
|  |  |  |  |  |  |  |
| 20 | 500 | 50% | 20% | 46.3 | 20% | 10.3 |
| 30 | 500 | 50% | 25% | 30.0 | 25% | 8.3 |
| 50 | 500 | 50% | 30% | 21.5 | 30% | 6.0 |
| 100 | 500 | 50% | 35% | 12.6 | 35% | 3.5 |
| 200 | 500 | 20% | 40% | 7.4 | 40% | 2.0 |

**Example Credit Calculations**

**Example #1 – Basic Buffer Restoration Example**

The following is an example of how to calculate the nutrient load reduction credits for restoring a 30’ wide buffer along 500’ of a perennial stream for a six-acre residential drainage area. This example includes calculating the credit achieved by both land conversion and treatment by the restored buffer.

For this example, assume the project site has the following characteristics:

* Site is existing residential development with 20% Built Upon Area
* Entire area draining via overland flow, including the buffer, is 6 acres (261,360 sqft)
* Roof makes up 10% (26,136 sqft). This example assumes roof drains simply diffuse their flow in each yard.
* Roadway makes up 10% (26,136 sqft). This example assumes road runoff drains to vegetated ditches that disperse flow away from the Road. Roads with stormdrain collection systems that do not disperse flow should be excluded.
* Other Pervious (Grass) Area takes up 80% (209,088 sqft)
* Project is in Year 6 of credit release schedule (100% credit release)
* The 15,000 sqft of buffer to be planted presently only has grass (Other Pervious)
* The most applicable precipitation station for the site is Durham

The SNAP tool allows the user to input the area of each land use type before and after restoration (the “project”). The reduction in nutrient export based on land conversion to forest is the nutrient credit for this mechanism.

*Data Entry for Land Conversion Credit*

1. On the Project Info sheet in SNAP, enter the entire drainage as Project Area, also select “Durham” as the Precipitation Station.
2. On the Land Cover Characteristics sheet:
3. In the Pre-Project column enter the roof, roadway, and other pervious grass area.
4. In the Post-Project column enter the footprint of the buffer area as Forest (15,000 sqft), and the remaining Other Pervious grass area (194,088 sqft). If you have converted any other areas (such as planting to forest or removing impervious surfaces) you would enter these changes in the Post-Project column.

On the *Overall Summary* page, in the *Nutrient Export Summary*, the *Total Nitrogen* & *Phosphorus Load Leaving Site* (lbs/yr) shows the following values:

**Pre-Project Conditions**  **Post-Project Conditions w/BMPs**

*Total Nitrogen Load (lbs/yr)* = 21.48 *Total Nitrogen Load (lbs/yr)* = 21.22

*Total Phosphorus Load (lbs/yr)* = 5.01 *Total Phosphorus Load (lbs/yr)* = 4.83

Subtract the Post-Project Load from the Pre-Project Load to calculate the credits (reductions in annual load) achieved via land conversion:

*Reduction in Nitrogen via Land Conversion -> 21.48 – 21.22 = 0.28 lbs/yr*

*Reduction in Phosphorus via Land Conversion -> 5.01 – 4.83= 0.18 lbs/yr*

*Data Entry for Treatment of Runoff through the Restored Buffer*

1. On the Project Info sheet, change the Project Area to the total minus the area converted to forest (261,360 – 15,000 = 246,360 sqft). Keep the same precipitation station.
2. On the Land Cover Characteristics sheet, in the Post-Project column enter the roof, roadway and remaining other pervious area (194,088 sqft).

On the *Overall Summary* page, in the *Nutrient Export Summary*, the *Total Nitrogen* & *Phosphorus Load Leaving Site* (lbs/yr) shows the following values:

**Post-Project Conditions w/BMPs**

*Total Nitrogen Load (lbs/yr) = 21.06*

*Total Phosphorus Load (lbs/yr) = 4.83*

To calculate the credits for throughput treatment, apply the appropriate percent removal efficiency value from Table 2. In this case with an average 30’ buffer along a stream, the removal efficiency is 25% for both nitrogen and phosphorus resulting in the following reductions:

*Reduction in Nitrogen via Buffer Treatment = 21.06 lbs/yr \* 25% = 5.27 lbs/yr*

*Reduction in Phosphorus via Buffer Treatment = 4.83 lbs/yr \* 25% = 1.21 lbs/yr*

*Combine Land Conversion Credit and Runoff Treatment Credit*

The total reduction credit in this example is the sum of the land conversion credit and runoff treatment credit:

*Total Nitrogen Reduction = 0.28 lbs/yr + 5.27 lbs/yr =* ***5.55 lbs/yr***

*Total Phosphorus Reduction = 0.18 lbs/yr + 1.21 lbs/yr =* ***1.39 lbs/yr***

**Example #2: Applying Credit Modifiers to Buffer Restoration Projects**

For this example, we assume the project site is similar to the one in Example #1. In this case however, the project is only in year 1 of the credit release schedule. Only 60% of the credits may be released for this project.

Data entry for land conversion credit and treatment through the buffer would be the same. All three types of credit modifiers - credit release, vegetation survivorship, and enhancement - apply to the entire nutrient reduction credit.

Calculate the adjusted throughput treatment credit by applying the credit release modifier to the previously-calculated total reductions. Other modifiers such as for poor vegetation survival or for using enhancement would be applied the same way.

*Adjusted Total Nitrogen Reduction = 5.55 lbs/yr \* 60% = 3.33 lbs/yr*

*Adjusted Total Phosphorus Reduction = 1.39 lb/yr \* 60% = 0.83 lbs/yr*

**Example #3: Net Percent Reduction Example - Project with Pre-Existing Forest**

Areas that are improved adjacent to an existing, fully functioning riparian buffer that is at least 20 feet wide are credited assuming an incremental percent removal efficiency:

**Incremental Removal Efficiency = (Removal efficiency for post-project buffer width) – (Removal efficiency for the pre-project, fully functioning buffer width)**

The following is an example of how to calculate the nutrient load reduction credits for restoring a 30’ wide buffer abutting 20’ of existing forest along 500’ of a perennial stream for a six-acre residential drainage area, calculated as:

***Incremental Removal Efficiency = 30% (percent removal for 50ft wide buffer) – 20% (percent removal for 20ft wide buffer)***

For this example, the project area is similar to that in Example #1, but there is 20ft of existing forested buffer right along the stream for the 500ft project length (10,000 sqft), and only 199,088 sqft of existing Other Pervious (grass)This project is adding an additional 30ft outside of the existing forest.

*Data Entry for Land Conversion Credit*

1. On the Project Info sheet in SNAP, enter the entire drainage as Project Area, also select “Durham” as the Precipitation Station.
2. On the Land Cover Characteristics sheet:
	1. In the Pre-Project column enter the roof, roadway, pre-existing forest, and other pervious grass area.
	2. In the Post-Project column enter the footprint of the new forested buffer area plus existing forest (25,000 sqft), with the remaining other pervious grass area (184,088 sqft). If you have converted any other areas (such as planting to forest or removing impervious surfaces) you would enter these changes in the Post-Project column.

On the *Overall Summary* page, in the *Nutrient Export Summary*, the *Total Nitrogen* & *Phosphorus Load Leaving Site* (lbs/yr) shows the following values:

**Pre-Project Conditions**  **Post-Project Conditions w/BMPs**

*Total Nitrogen Load (lbs/yr)* = 21.31 *Total Nitrogen Load (lbs/yr)* = 21.05

*Total Phosphorus Load (lbs/yr)* = 4.89 *Total Phosphorus Load (lbs/yr)* = 4.71

Subtract the Post-Project Load from the Pre-Project Load to calculate the credits (reductions in annual load) achieved via land conversion:

*Reduction in Nitrogen via Land Conversion -> 21.31 – 21.05 = 0.26 lbs/yr*

*Reduction in Phosphorus via Land Conversion -> 4.89 – 4.71 = 0.18 lbs/yr*

*Data Entry for Treatment of Runoff through the Restored Buffer with Existing Forest*

1. On the Project Info sheet, change the Project Area to the total minus the area converted to forest and the existing forest buffer combined (261,360 – (10,000 + 15,000) = 236,360 sqft). Keep the same precipitation station.
2. On the Land Cover Characteristics sheet, in the Post-Project column enter the roof, roadway and remaining other pervious area (184,088 sqft).

On the *Overall Summary* page, in the *Nutrient Export Summary*, the *Total Nitrogen* & *Phosphorus Load Leaving Site* (lbs/yr) shows the following values:

**Post-Project Conditions w/BMPs**

*Total Nitrogen Load (lbs/yr) = 20.78*

*Total Phosphorus Load (lbs/yr) = 4.71*

To calculate the credits for throughput treatment, apply the appropriate net percent removal efficiency value. In this case, adding a 30-foot buffer to an existing 20-foot buffer along a stream, the net removal efficiency is 10% for both nitrogen and phosphorus resulting in the following reductions:

*Reduction in Nitrogen via Buffer Treatment = 21.06 lbs/yr \* 10% = 2.11 lbs/yr*

*Reduction in Phosphorus via Buffer Treatment = 4.83 lbs/yr \* 10% = 0.48 lbs/yr*

*Combine Land Conversion Credit and Runoff Treatment Credit*

The total reduction credit in this example is the sum of the land conversion credit and runoff treatment credit:

*Total Nitrogen Reduction = 0.26 lbs/yr + 2.11 lbs/yr =* ***2.37 lbs/yr***

*Total Phosphorus Reduction = 0.18 lbs/yr + 0.48 lbs/yr =* ***0.66 lbs/yr***

**Co-Benefits**

In the case of buffer improvement, additional benefits may include further reducing other pollutants including Total Suspended Solids (TSS), metals, and bacteria; reducing flooding; improving habitat; sequestering carbon; reducing streambank erosion in downstream reaches; and providing stream shading that reduces light available for algal and periphyton growth in streams and reduces stream water temperatures.

**Supporting Technical Information**

**Documentation of Credit Development Process**

This credit document was created through a joint effort between the Upper Neuse River Basin Association (UNRBA) and the Division of Water Resources (DWR). The design specifications and nutrient accounting methodologies described in the document went through several revisions during a collaborative review process that spanned more than two years. The following technical documentation serves to summarize key questions and factors that were researched and addressed during document development, and explains the considerations and rationale behind key decisions made impacting the design standards and nutrient credit awarded for this practice.

**You already have a buffer restoration credit, why do you need this one and how do I know which one to use?**

The nutrient credit methodology for buffer restoration projects used by the Division of Mitigation Services and private nutrient offset banks was designed for projects that occur in rural settings, including agricultural lands. That method is based on assumptions that do not apply to developed lands, such as the assumption that agricultural lands maintain watershed hydrology comparable to undeveloped settings, thus maximizing nutrient reduction provided by forested riparian buffers. The method also assumes the area draining to the buffer will have an average mix of undeveloped and agricultural lands, including the typically higher nutrient export from croplands and pasture. In contrast, the credit method provided in this practice document was specifically developed to credit buffer improvement projects that occur on developed lands, and uses nutrient export rates based on studies of urban land cover types. Local governments subject to the Falls Lake and Jordan Lake Existing Development Rules have indicated the desire for a method they can implement in developed settings to provide options for achieving nutrient reductions under their respective rule requirements. This credit method should be used in situations where the majority of the area draining to the improved buffer is already developed or intensifying development.

**Why do you require anything different than the buffer mitigation rule requires for restoration? This just over-complicates the whole field of buffer regulation.**

This credit document hews as closely as possible to the existing requirements established in the buffer mitigation rule (02B NCAC .0295) to make implementation simple and familiar to practitioners who have implemented buffer mitigation projects in the State. Practice requirements differ from those in the buffer mitigation rule in ways to ensure that the buffers implemented will achieve nutrient reductions in developed settings, and continue to achieve nutrient reductions for the time the practice is in place. The practice requirements have been designed to be able to be implemented and reviewed by local governments with auditing by the State, rather than requiring review and approval by the State. The different requirements also add flexibility not provided for under the mitigation rule such as allowing for time limited projects that do not require permanent conservation easements, making it a more attractive practice to local governments and institutions.

**How can you justify such small values for the buffer percent removal efficiencies when the literature is full of nitrogen removals in the 70% to 90% range?**

Most buffer research literature presents results in terms of overall gross nutrient reduction efficiency of buffers as measured in terms of inputs and outputs. As such they only address how much nutrients have been reduced in total as runoff crosses the buffer condition in question. The concern of this credit is determining what the *improvement* in nutrient reduction provided by reforesting a buffer is compared to the unforested condition – the net reduction in nutrients. It is assumed the unforested buffer condition is removing some amount of nutrients, approximated by using gross removal efficiencies of grassy buffers since this is the most likely land cover conversion to forest. Gross removal efficiencies of grassy buffers were compared to those of forested buffers to estimate the improvement provided by reforestation to get the net removal. Using net reductions results in an overall lower removal % relative to the previously existing condition, but provides a more accurate accounting of the actual improvement in nutrient reduction from the activity of restoring or improving a buffer.

**This practice is worth so little credit, why would anyone want to use it?**

Nutrient processing in riparian zones is not well understood, even in rural settings. Urban environments add the complication that they are often comparatively impaired in their functioning. However, in urban settings reforestation of stream buffers often addresses multiple resource management objectives, only one of which is nutrient reduction. The nutrient reduction practice described in this document provides an additional tool for local governments to earn credit towards their existing development nutrient reduction goals and has been identified by local governments as a practice with high implementation potential. This practice also represents a flexible credit opportunity since it can be implemented as either a permanent or temporary project. The temporary option serves to make it much more attractive in certain situations where the local government does not want to tie up land in permanent conservation easements. Additional flexibility is provided with this practice in that natural regeneration is an available option and in some cases the local government may already own the land which would help reduce the overall cost for implementing this practice.

**Why were percent reduction efficiencies used for such a complex set of processes such as nutrient processing through riparian zones?**

Several different methods of calculating the nutrient removal of improved buffers were explored during the development of this practice document. Early drafts attempted to calculate nutrient reductions by modeling the multiple nutrient removal processes in a buffer but were found to be overly complicated and did not accurately model the different modes of surface and subsurface nitrogen and phosphorus removal by the practice. Further literature review found a wide array of studies that looked at how site variables may affect the gross nutrient removal efficiency of a buffer, but insufficient information to tease out how reforestation provided a net nutrient reduction benefit and how site variables may impact that. After this review, given the complexity of these other approaches and the inability to support the results they generated, we decided to rely upon the simple percent reductions provided in a paper produced for DEQ by NCSU researchers to estimate net nitrogen loss when reforesting buffers. These values are already in use in the Nitrogen Loss Evaluation Worksheet (NLEW), and this method is a more justifiable approach that can be easily applied to the already familiar stormwater runoff estimates generated using the SNAP Accounting Tool.

**How can you justify using the same reduction efficiencies for P as for N when the two nutrients behave so completely differently on the landscape?**

Most of the available buffer research focuses on how effective these systems are at processing nitrogen. There are few studies available that consider phosphorus processing in buffers, and even fewer that are specific to developed environments. Since riparian buffers remove sediment from runoff, it is expected that a buffer that is effective in removing sediment should also remove the majority of phosphorus in runoff. Sediment removal varies with width, slope, cover type/condition, and particle size. A model of sediment removal in buffers would require information for these variables at a minimum, and in practice would result in implementation and calculation requirements complex enough to strongly inhibit use of this nutrient reduction method. In order to provide a reasonable level of predictability when planning buffer improvement projects and to avoid site specific credit calculations of excessive complexity, it was determined that assuming nitrogen and phosphorus are removed by a buffer at similar efficiencies would be the best approach, and should be revisited when we have studies that can better generalize how phosphorus is removed in buffers.

**The proposed credit values diminish so greatly with increasing width, how can you justify rules to protect buffers any wider than 30 feet?**

Buffers provide a large number of ecosystem services, with provision of each type associated with different average minimum widths spanning from 10 feet to over 300 feet. However, the credit mechanism described in this document is tuned to management of nutrient reduction alone, and not to awarding credit for any of the other ecosystem services that buffers provide. We understand the concern to be the diminishing improvements in nutrient reduction that can be obtained as the width of improved buffer increases. Even at 50 feet this credit provides a 30% reduction in nutrient export, which is comparable to typical stormwater control measures. This credit mechanism does not imply that there is no value to buffers greater than 30 feet in width, only that we are best able to scientifically document the *net improvement* in nutrient processing as asymptotically converging on a maximum net improvement.

Current Buffer Protection Rules allow clearing of buffers to within 30 feet of the regulated waterbody, provided the remaining 20 feet of buffer is returned to vegetation of some sort and is minimally impacted (e.g. follows the requirements of the applicable Buffer Protection Rules). This nutrient reduction credit method is largely consistent with the view that, at a minimum, 30 feet of the buffer should be forested, with an allowance of only 20 feet in forest for the more restrictive and limiting reforestation opportunities available in urban settings. The goal of this credit is to maximize buffer reforestation in these more restrictive settings, where there may be many conflicting uses and existing infrastructure close in to the waterbody.

**Why is the minimum creditable buffer width set at 20 feet?**

The width of a buffer can vary depending on what resource or ecosystem service you are trying to protect. Some studies have shown efficient buffer widths ranging from 10 feet for bank stabilization and stream shading, to over 300 feet for wildlife habitat. The necessary width for an individual site may be less or more than the average recommendations depending on soil type, slope, land use, and other factors. A 20 foot minimum buffer width is required in this practice document to ensure a stable buffer that will provide long term nutrient reduction functions credit. Studies have found an average minimum buffer width of 15 feet is necessary for sediment control, and the mode of phosphorus reduction in buffers is commonly held to be through trapping insoluble phosphorus attached to particles. Since buffer reforestation is implemented in 10-foot-wide belts, 20 feet is considered the effective minimum width to have any measurable improvement in phosphorus retention in the buffer. For nitrogen, the paper produced for DEQ by NCSU researchers to estimate net nitrogen loss when reforesting buffers (the Nitrogen Loss Evaluation Worksheet) does not estimate net nitrogen reductions for buffer widths less than 20 feet.

**Should buffer restoration on an incised stream really be worth as much nutrient credit as one on a stable, unincised reach?**

Channel incision is a common problem in urban streams. Channel incision lowers water tables in the near-stream zone to a level well below the root zone, maintaining more aerobic conditions in an area of lower soil carbon, and potentially limiting the amount of denitrification that can occur in these areas. Earlier versions of this credit considered whether unincised streams would provide better nitrogen removal when reforested than incised streams. However, while we were able to find literature that supported the idea of a difference in gross nitrogen processing in incised vs. unincised situations, we could not find any support for the idea that *improvement* in nitrogen reduction provided by reforestation (net reduction) would differ between incised and unincised situations. That is, we found no literature suggesting that changing from grass to forest increased denitrification given an otherwise unchanging groundwater level relative to the root zone. We do expect that projects that increase the groundwater level, such as stream restoration projects that raise the streambed and/or reconnect the floodplain, would result in such improvement. However, that credit concept is outside the scope of buffer-only restoration.

**Why do some projects require the use of a level spreader?**

This credit concept operates on the idea that buffers reduce nutrients in runoff crossing the buffer as diffuse flow. Many developed areas have concentrated runoff crossing the buffer, preventing the removal of nutrients through diffuse flow. These concentrated flows may continue to flow across the buffer after improvement, but the runoff conveyed by these drainageways is excluded from nutrient removal credit calculation. However, level spreaders may be employed to increase the proportion of runoff that is directed across the buffer as diffuse flow, thereby increasing the potential credit. Level spreaders are designed to uniformly distribute concentrated flow over a large area and using them helps reduce concentrated flows and serves to improve the nutrient removal effectiveness of buffers. Level spreaders are not required in any projects and are an optional addition to allow for greater nutrient removal. However, level spreaders for this credit must be designed to a more protective standard compared to the State’s Minimum Design Criteria (MDC). This standard has been chosen to address the problem that forested buffers have a greater likelihood of reconcentrating flows compared to the grassy filter strips that are otherwise required in the MDC.

**Why is it necessary to have a credit release schedule?**

Forested buffers take time to establish and realize their full nutrient reduction potential. Successful buffer improvement projects include vegetation survivorship surveys to document vegetation density over time and steps to correct insufficient tree density as the project matures. A credit release schedule recognizes the incremental nature of improving buffer function and the successful completion of each stage of development while providing an avenue for incentivizing any necessary actions to address deficiencies in tree density over time.

**Contributors and Reviewers**

Development of the nutrient credit document for this practice was a collaborative effort that included representatives from the following organizations who comprised the technical workgroup referenced below:

* North Carolina Department of Environmental Quality Division of Water Resources: Rich Gannon, MEM, CPM; John Huisman; Trish D’Arconte; and Amin Davis, PWD
* North Carolina Department of Environmental Quality Division of Energy, Mineral and Land Resources: Annette Lucas, PE
* North Carolina Department of Environmental Quality Division of Mitigation Services: Katie Merritt and Karen Higgins
* North Carolina State University Biological & Agricultural Engineering Stormwater Engineering Group: Bill Hunt, Ph D, PE
* Upper Neuse River Basin Association: Forrest Westall, PE
* The Center for Watershed Protection, Inc.: Neely Law, Ph D
* Cardno: Alix Matos, PE

**Summary of Studies**

Twenty-two publications were used to populate the riparian buffer database for this practice, but eight were excluded for inclusion in this analysis for the following reasons:

* Five of the studies were review papers that summarized and analyzed existing literature on riparian forest buffers (Klapproth and Johnson 2013; Castelle et al. 1994; Mayer et al. 2006; Mayer et al. 2007; Sweeney and Newbold 2014). Although they were excluded from the crediting analysis, they are referenced below where appropriate as they provide insight into the water quality benefits and design specifications for riparian buffers that are useful when considering the development of a credit as described in the Proposed Crediting section below.
* Orzetti et al. (2010) collected samples from within the stream only and not from the surface or subsurface flow across the studied buffers.
* Ice et al. (2004) presented a GIS approach to estimate the extent of alternative riparian area management schemes and the economic consequences.
* NCSU (2013) provided guidance on the rehabilitation and maintenance of riparian vegetation, but did not include information on appropriate buffer widths or nutrient removal.

Fourteen publications were selected for inclusion in the analysis. Many of these studies were conducted in rural/agricultural areas in the coastal plain, as is the case with much of the available literature on riparian buffers. Nine publications included monitoring studies or summarized crediting programs outside of the coastal plain.

Coastal Plain Studies:

* Four of the studies were completed in the coastal plain portion of the Tar Pamlico River Basin in North Carolina (Johnson et al. 2013; Messer et al. 2012; Tilak et al. 2014; Wiseman et al. 2014). One of the studies (Tilak et al. 2014) was used to support a 33 year modeling projection using information from the field sampling study (Messer et al. 2012).
* The other studies were from the Delmarva Peninsula, Maryland (Jordan et al. 1993) and Goldsboro, North Carolina (Wu et al. 2012).
* Due to the location of the studies within the coastal plain, sandy soils and high water tables made infiltration and denitrification a main focus. This limits their direct application to the Piedmont region; however, these processes remain relevant to the function of nitrate removal from forested buffers and are therefore included for review. All of the studies focused on subsurface nitrate removal, with the exception of Tilak et al. (2014) that also included a modeled estimate of surface TN removal.
* Subsurface nitrate removal was reported as a percent reduction in nitrate concentration, with only two studies (Messer et al. 2012; Tilak et al. 2014) also reporting a percent reduction in nitrate load.
* In terms of subsurface nitrate removal, authors found that landscape position is a more important defining variable for buffer site selection than buffer width – removal is higher in areas with greater denitrification potential.
	+ Johnson et al. (2013) found that water quality improvement did not occur until groundwater flow passed into an existing hardwood buffer situated within the active floodplain of the stream.
	+ Jordan et al. (1993) found that most of the change in nitrate occurs in the riparian buffer where the hillslope ends and the floodplain begins - groundwater comes in contact with tree roots and organic-rich surface soils become water-logged, producing low redox conditions favoring denitrification.
* Even when denitrification conditions are favorable, low incoming groundwater nitrate concentrations may limit the potential for nitrate removal (Messer et al. 2012).
* The addition of organic matter to riparian soil was found to be effective at promoting nitrate loss (Wu et al. 2012).
* Jordan et al. (1993) observed high phosphate concentrations near the streambank. The authors hypothesize that the highly reducing conditions suitable for denitrification near the streambank also favor reduction of iron oxyhydroxides, which can release bound phosphorus and increase the phosphate that is exported from the buffer.
* Wiseman et al. (2014) studied a 150 ft buffer in the NC Coastal Plain. Subsurface nitrate concentrations were measured at three locations in the buffer, and reductions ranged from 76 percent to 92 percent. However, the authors determined that much of the apparent reduction was likely due to dilution as concentrations of a conservative tracer were reduced by 48 percent to 65 percent.

Non-Coastal Plain Publications (Piedmont (Pennsylvania and Chesapeake Bay) and Flint Hills, KS):

* Weller et al. (2011) developed statistical models to predict stream nitrate concentration and evaluate buffer effects from 113 tributaries in the piedmont and 111 tributaries in the coastal plain of the Chesapeake Bay watershed. The models were based on water quality samples taken at the watershed outlets and the results are presented as an average of all watersheds aggregated based on physiographic region. On average, buffers in coastal plain watersheds had a higher relative nitrate removal potential (95% of inputs from cropland) than piedmont buffers (35% of inputs). Buffers in the piedmont had a median width of 34 m (110 ft). Aggregate nitrate removal by riparian buffers was less than suggested by many studies of field-to-stream transects and may be due to transect studies providing an idealized view of buffer removal under optimal conditions. The authors hypothesized that the piedmont buffers were found to remove lower percentages of their inputs than coastal plain buffers due to existing buffers being bypassed or dysfunctional in some piedmont settings.
* In comparison, to Weller et al. (2011), Sweeney and Newbold (2014) found that subsurface nitrate removal varied proportionally with buffer width, and sites with water flux >50 l/m/day had a median removal efficiency of 55% for buffers <40 m (130 ft) wide and 89% for buffers >40 m (130 ft) wide. The observed 35% efficiency reported by Weller et al. (2011) would correspond to a water flux of 215 l/m/day.
* Newbold et al. (2009) found that a 35-m wide 3-zone riparian forest buffer system (USDA Forest Service specification that consists of a 5 m wide permanent woody vegetation for habitat protection, 18-20 m of reforested hardwoods, and a 6-10 m grass filter strip with a level spreader) removed 26% of the subsurface nitrate and 43% of the suspended sediments delivered from upslope. The influence of tree growth on nitrate removal became apparent approximately ten years after planting. The grass filter strip functioned effectively to remove sediment. Low subsurface nitrate removal was hypothesized to be a function of averaging the removal that occurred prior to the influence of reforestation (i.e., mostly grass buffer) together with the higher rate once reforestation occurred. It could also be due to flow that was preferentially constrained to the shallow saprolite with significant flow through the underlying bedrock.
* Properly designed and maintained buffers with widths less than those typically recommended (NRCS guidelines in KS require a minimum average buffer width of 23 m to a maximum of 46 m) may be adequate for water-quality improvement. Mankin et al. (2007) found that vegetation type, rather than width, was the fixed effect that was shown to influence mass removal of TP and TN. Grass-shrub riparian buffer plots (natural selection grasses, natural selection/plum shrub, and native grasses/plum shrub) were evaluated and all were found to provide excellent mass reductions of outflow runoff (>77%), sediment (>99%), TP (>85%), and TN (>85%). Infiltration was found to be the primary mechanism for pollutant removal.
* Belt et al. (2014) summarize the recommendations of the expert panel on the removal rates for riparian forest buffers. Buffers that are at least 35 feet in width are eligible for crediting, but the expert panel indicates that buffers that are 50 feet to 100 feet in width offer more consistent water quality benefits. In the Piedmont, forested buffers that are at least 35 feet wide earn TN credits of 46 percent and 56 percent for schist/gneiss and sandstone soils, respectively; TP credits for these soils range from 36 percent to 42 percent.
* Halley (2002) summarizes buffer literature as part of his thesis on Watershed Management and Riparian Buffer Analyses Using Remotely Sensed Data. His literature review indicates that width strongly affects TSS and nitrogen removal, and that buffers that the first 60 feet of a buffer may remove 70 to 90 percent of subsurface total nitrogen loads.
* Gregory (2008) presented information during a 2008 presentation that included a table of buffer widths and reported reductions in runoff concentrations of sediment, nitrogen, and phosphorus. Wider buffers consistently reduced runoff concentrations compared to narrow buffers over the range of data summarized (15 ft to 92.5 ft) and noted that the maximum removal of dissolved nutrients occurred subsurface.
* Mayer et al. (2007) summarized the buffer literature to assess the effect of width on nitrogen removal rates. Studies included vegetated filter strips and riparian buffers. The authors concluded that wider buffers showed more consistent nitrogen reductions than more narrow buffers. The summary suggests that 13 ft buffers may achieve 50 percent nitrogen removal, 160 ft buffers achieve 75 percent nitrogen removal, and 490 ft buffers achieve 90 percent nitrogen removal. The authors note the large variability associated with these predictive efficiencies attributed to additional factors other than width also affect nitrogen removal including soil type, subsurface hydrology, and subsurface biogeochemistry; vegetation type was not found to significantly affect nitrogen reductions.

**Review of NC Existing Crediting Systems for Riparian Buffers**

North Carolina has several existing programs that apply to buffer improvement whether that is a single approved design for stormwater credits, nutrient offset and mitigation, or agriculture accounting. These existing programs are described below.

NCBMP Design Manual

The NCBMP design manual currently offers load reduction credits for TSS of 60%, TN of 30%, and TP of 35% for riparian buffers that have a minimum width of at least 50 ft (30 ft forested buffer + 20 ft grass). Width still appears to be the most practical metric for assigning a riparian buffer credit as it remains to be supported in the scientific literature as the main proxy for pollutant removal, with the exception of nitrate which is also affected by denitrification. Buffer width is important for trapping particulates and filtering nutrients that are particulate-bound and for infiltrating and storing water in the soils.

Nutrient Offset and Riparian Buffer Mitigation Program

The NC Division of Water Resources (DWR) nutrient offset and riparian buffer mitigation program provides for the use of nutrient offset payments in the Neuse and Tar Pamlico basins, along with the Falls and Jordan watersheds as an option to meet nutrient reduction requirements for new development and redevelopment. The predominant practice used by those seeking to generate nutrient reduction credits for sale is the establishment of riparian forested buffers where none exists due to their cost effectiveness. The credit calculation for riparian buffers is currently based on a formula developed in 1997 by the Division of Water Quality that assumed the restoration of riparian wetland area to calculate nutrient reductions based on three elements: 1) nutrient reductions from upslope drainage (limited to 10.8 acres of upslope area for every 1 acre of buffer restored), 2) deposition of nitrogen from overbank flooding, and 3) land use change to forest. Buffers that are at least 50 feet wide and adjacent to agricultural lands are eligible for these credits: 75.77 lb-N/ac/yr and 4.88 lb-P/ac/yr.

Agricultural Accounting

Agricultural areas in nutrient strategy watersheds track and report estimated nutrient losses from farms annually. To do this agricultural technicians utilize the Nutrient Loss Evaluation Worksheet (NLEW), an accounting tool used to estimate nitrogen loss from agriculture lands. This tool was developed by a team of researchers and policy makers (Osmond et al., 2007). NLEW uses nutrient inputs, soils, cropping data and management practice information to estimate nutrient losses from farms. Best management practices, such as the implementation of forest buffers, are assigned nitrogen reduction efficiencies and can be implemented and tracked with NLEW to account for reductions in nutrient losses from agricultural lands.

NLEW reduction efficiencies for forest buffers are set by the NLEW committee. Current buffer efficiencies are provided in Table 5. These efficiencies were established after a review of net nitrogen removal rates by the committee upon review of a number of North Carolina research (Osmond et al., 2011). These efficiencies represent a reduction of 10 to 20% over the prior version of NLEW and are based on buffer gross reduction efficiencies. In its reduction accounting, NLEW applies these reductions to a composite agriculture loading based on the county data at a ratio of 1:1 (i.e., one acre of buffer reduces the nitrogen load from 1 acre of land). NLEW does not estimate reductions to Phosphorus.

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| **Table 5. NLEW Net N Reduction Efficiencies** |
| **Buffer Width (ft)** | **NLEW v5.53b** **% N Reduction** |
|
| 20 | 20% |
| 30 | 25% |
| 50 | 30% |
| 100 | 35% |

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