APPENDIX F – Removal Rates

Table D.5: Range of Reported Removal Rates for Stormwater Filters			
Pollutant	**Low End**	**Median**	**High End**
Total Suspended Solids	80	85	90
Total Phosphorus	40	60	65
Soluble Phosphorus	-10	5	65
Total Nitrogen	30	30	50
Organic Carbon	40	55	70
Total Zinc	70	90	90
Total Copper	35	40	70
Bacteria	25	40	70
Hydrocarbons	**80**	**85**	**95**
Chloride	**0**	**0**	**0**
Trash/Debris	**85**	**90**	**95**

Note: Nearly 20 studies have evaluated filtering practices, so reliable removal rates are reported for total suspended solids, total phosphorus, soluble phosphorus, total nitrogen, total zinc, total copper and bacteria. It should be noted that while total nitrogen removal is positive, most filters leak nitrate-nitrogen. Also, performance of vertical sand filters and the MCTT were excluded from the statistical analysis.

Table D.6: Range of Reported Removal Rates for Infiltration Practices			
Pollutant	**Low End**	**Median**	**High End**
Total Suspended Solids	**60**	**90**	**95**
Total Phosphorus	50	65	95
Soluble Phosphorus	**55**	**85**	**95**
Total Nitrogen	0	40	65
Organic Carbon	80	90	95
Total Zinc	65	65	85
Total Copper	**60**	**85**	**90**
Bacteria	**25**	**40**	**70**
Hydrocarbons	**60**	**90**	**95**
Chloride	**0**	**0**	**0**
Trash/Debris	**85**	**90**	**95**

Notes: Performance monitoring data for infiltration practices continue to be limited although the number of studies had doubled since 2000 (N=12). Total phosphorus, total nitrogen and total zinc all meet the minimum five-study test to be included for statistical analysis. Only three studies were available to characterize **total suspended solids, soluble phosphorus and total copper removal rates**. Recent research tends to confirm the range in removal rates (UNHSC, 2005). No data was found for **hydrocarbon, chloride and trash/debris** removal, so these were estimated using the general removal assumptions described earlier. **Bacteria removal rates** were also lacking, so it was once again assumed that they would be similar to those reported for filtering practices.

Table D.3: Range of Reported Removal Rates for Stormwater Wetlands			
Pollutant	**Low End**	**Median**	**High End**
Total Suspended Solids	45	70	85
Total Phosphorus	15	50	75
Soluble Phosphorus	5	25	55
Total Nitrogen	0	25	55
Organic Carbon	0	20	45
Total Zinc	30	40	70
Total Copper	20	50	65
Bacteria	**40**	**60**	**85**
Hydrocarbons	**50**	**75**	**90**
Chloride	0	0	0
Trash/Debris	**75**	**90**	**95**

Notes: 40 monitoring studies were available to define rates for total suspended solids, total phosphorus, soluble phosphorus, total nitrogen, organic carbon, total zinc and total copper for constructed wetlands. Only three studies measured **bacteria removal** by constructed wetlands. Research profiled in Strecker et al. (2004) indicated bacterial removal rates for constructed wetlands is generally positive, but typically lower than wet ponds. It was therefore assumed that bacteria removal rates would be at least 10% lower than in wet ponds.

Table D.4: Range of Reported Removal Rates for Bioretention Areas			
Pollutant	**Low End**	**Median**	**High End**
Total Suspended Solids	**15**	**60**	**75**
Total Phosphorus	-75	5	30
Soluble Phosphorus	-10	5	50
Total Nitrogen	40	45	55
Organic Carbon	**40**	**55**	**70**
Total Zinc	40	80	95
Total Copper	40	80	95
Bacteria	**25**	**40**	**70**
Hydrocarbons	**80**	**90**	**95**
Chloride	0	0	0
Trash/Debris	**80**	**90**	**95**

Notes: Ten new bioretention monitoring studies have been released in the last few years that meet the quality control criteria to be included in the updated database so it is now possible to define removal rates for total phosphorus, soluble phosphorus, total nitrogen, total zinc and total copper. Surprisingly, there were only four studies to define the **total suspended solids removal rate.** Similar pollutant removal mechanisms operate in both bioretention and filtering practices (sedimentation, filtration). The median total suspended solids removal rate for filtering practices is similar to the high end rate for bioretention, which suggests that bioretention rates can be expected to go up as more performance data becomes available. No **bacteria removal rates** were available in the literature as of 2006. Initial research reported by Hunt and his colleagues in 2007 suggest that bacteria removal rates were high. Therefore, it was once again assumed that bioretention would function in the same manner as filtering practices and have similar removal rates. The **phosphorus removal rates** reported for bioretention are clearly bi-modal. Sites where the soil media had high phosphorus content tended to leach phosphorus and experience negative removal rates. Sites where soils with a low P-index volume consistently performed at the upper end of the phosphorus removal range. Again, as more performance data become available and soil media testing becomes standard, the range of rates for bioretention is expected to shift.

Table D.1: Range of Reported Removal Rates for Dry Extended Detention Ponds			
Pollutant	**Low End**	**Median**	**High End**
Total Suspended Solids	20	50	70
Total Phosphorus	15	20	25
Soluble Phosphorus	-10	-5	10
Total Nitrogen	5	25	30
Organic Carbon	15	25	35
Total Zinc	0	30	60
Total Copper	20	30	40
Bacteria	**25**	**35**	**50**
Hydrocarbons	**40**	**70**	**80**
Chloride	**0**	**0**	**0**
Trash/Debris	**65**	**80**	**85**
Notes: Ten monitoring studies evaluated the performance of dry ED ponds for most parameters. Only two monitoring studies were available on **bacteria removal rates** for dry extended detention ponds, so engineering judgment was needed to establish the final removal rates. The primary mechanisms that facilitate bacteria removal are exposure to UV light and gravitational settling (Schueler, 1999). These removal mechanisms have been documented for wet ponds, which have been more extensively monitored for bacteria removal in wet ponds. Since stormwater runoff is not retained within dry ED ponds for as long as wet ponds, settling times and exposure to UV light are reduced. Dry ED ponds also have a greater risk of sediment resuspension than wet ponds, which can reintroduce previously removed bacteria back into the water column. It was therefore assumed that bacteria removal rates for dry ED ponds were approximately half of those measured for wet ponds.			

Table D.2: Range of Reported Removal Rates for Wet Ponds			
Pollutant	**Low End**	**Median**	**High End**
Total Suspended Solids	60	80	90
Total Phosphorus	40	50	75
Soluble Phosphorus	40	65	75
Total Nitrogen	15	30	40
Organic Carbon	25	45	65
Total Zinc	40	65	70
Total Copper	45	60	75
Bacteria	50	70	95
Hydrocarbons	**60**	**80**	**90**
Chloride	0	0	0
Trash/Debris	**75**	**90**	**95**
Note: 46 wet ponds have been monitored over the past two decades so the removal rate range shown above should be reasonably accurate. **Hydrocarbon** and **trash/debris** removal rates should be considered provisional			

Table D.7: Range of Reported Removal Rates for Swales			
Pollutant	**Low End**	**Median**	**High End**
Total Suspended Solids	70	80	90
Total Phosphorus	-15	25	45
Soluble Phosphorus	-95	-40	25
Total Nitrogen	40	55	75
Organic Carbon	55	70	85
Total Zinc	60	70	80
Total Copper	45	65	80
Bacteria	**- 65**	**-25**	**25**
Hydrocarbons	**70**	**80**	**90**
Chloride	0	0	0
Trash/Debris	**0**	**0**	**50**

Notes: 17 studies were available from the database to establish removal rates for total suspended solids, total phosphorus, soluble phosphorus, total nitrogen, total zinc and total copper. Only four studies were available for bacteria removal and all were negative. However, a positive 25% rate was established for the high end, since pollutant removal mechanisms in dry swales should have some capability to remove bacteria in the soil. Several studies monitored chloride and found only negative removal. No removal data was available for trash/debris, although it was presumed to be low due to washout of trash during high flows. A 50% removal rate was established for the high end for swale designs that contain treatment cells with actual trapping capability.

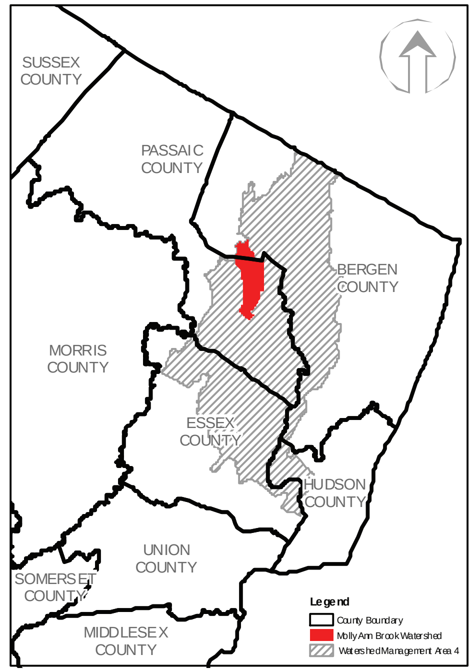
APPENDIX G – Fact Sheet

Molly Ann Brook Watershed Management Plan

Fact Sheet

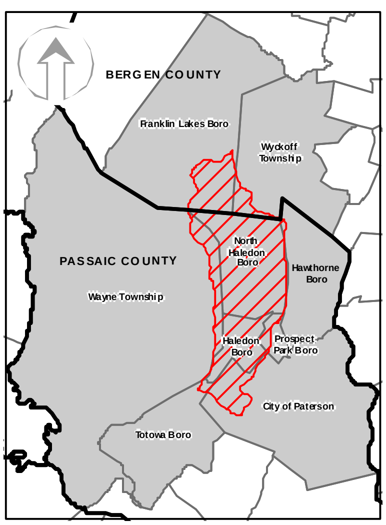
Location: Passaic and Berger Counties, New Jersey/ Watershed Management Area 4
Passaic County Municipalities:
Borough of North Haledon
Borough of Haledon
Borough of Prospect Park
Borough of Hawthorne
Borough of Totowa
Wayne Township
Bergen County Municipalities:
Borough of Franklin Lakes
Wyckoff Township

River Basin: Passaic River
Cataloging Unit: 02030103
14-Digit Hydrologic Unit: 02030103120040
Watershed Area: 7.8 square miles
Contact: Kathleen M. Caren, Passaic County Planning Department, 973.569.4040 or kcaren@passaiccountynj.org
Participants: Passaic County Planning Department, William Paterson University and the Lower Passaic & Saddle River Alliance



Project Overview: The Molly Ann Brook Watershed has been listed as an impaired stream on the New Jersey Department of Environmental Protection 303(d) list since 1998. Fecal coliform bacteria have continued to exceed state total maximum daily load (TMDL) levels, which have adverse effects on the water quality and ecology of the stream and the Passaic River. Elevated fecal coliform levels may indicate the presence of human & avian pathogens, and suggest the entry of fecal pollution. Increased development leads to increased runoff, which can contribute various sources of fecal matter, chemicals, nutrients, wastewater, and excess sediment into the stream. A 319(h) grant, through the USEPA Section 319 Nonpoint Source Management Program, has provided the funding for a program to identify sources of impairment within the Molly Ann Brook Watershed, and prepare a Watershed Management Plan that identifies activities such as best management practices (BMPs), and guidance on means of implementing nonpoint source management activities.

Goal: To restore and enhance the Molly Ann Brook Watershed to improve its water quality
- Allow the watershed to meet its designated use
- Removal from 303(d) List of Water Quality Limited Waters
- Retain water quality needed to attain aquatic life designation



Fecal Coliform Background Information:
- Originate from the intestines of warm-blooded animals & humans; exit through excrement
- In the environment, consume O2 (if aerobic), metabolize nutrients for survival (carbon, nitrogren, phosphorus), and reproduce through cell division (rarely by conjugation)
- Presence of fecal coliform bacteria in a stream can indicate the presence of pathogens (i.e, E. coli); fecal coliforms themselves are harmless.
- Indicators of possible contamination from animal manure, wastewater facilities, septic tanks, or sewage
- Nonpoint sources of fecal coliform enter streams from water runoff
- Various sources: pets, waterfowl, livestock, wildlife, human waste
- Survives well in the fine sediment of streams (weeks - months) as compared to within the water column (6 hours - 3 days), and can be re-suspended into the water column during flashy storm events
- Prefers lower temperatures, low UV light penetration, pH levels between 4.5 – 8.2, high organic matter content, high turbidity (sediment content in the water column), lower stream velocity, and smaller particle size of stream-bottom sediments

% of Municipality within Watershed

Borough of North Haledon:100%	Borough of Hawthorne:1%	Borough of Haledon: 100%
Borough of Totowa: 2%	Borough of Prospect Park: 39%	Wayne Township: 3%
Borough of Franklin Lakes: 11%	Wyckoff Township:5%	

References:
Burton Jr., G.A., D. Gunnison, and G.R. Lanza. 1987. *Survival of Pathogenic Bacteria in Various Freshwater Sediments.* Applied and Environmental Microbiology 53: 633-638.
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Rosen, B.H. 2000. *Waterborne Pathogens in Agricultural Watersheds.* USDA NRCS Watershed Science Institute.
Schumacher, J.G. 2003. *Survival, Transport, and Sources of Fecal Bacteria in Streams and Survival in Land-Applied Poultry Litter in the Upper Shoal Creek Basin, Southwestern Missouri, 2001-2002.* USGS Water-Resources Investigations Report 03-4243.
Stephenson, G.R. and R.C. Rychert. 1982. *Bottom Sediment: A Reservoir of E. cob in Rangeland Streams.* Journal of Range Management 1: 119-123.

APPENDIX H - Brochures

From Rooftop to River
Stormwater Best Management Practices

Introduction

Urban development has a profound effect on the quality of local groundwater and rivers – roof tops, roads, parking lots, and other impervious surfaces do not allow rainwater to soak into the ground. Since this natural storage capacity of stormwater has been lost, local elected officials and decision makers must now address proper stormwater drainage issues.

The cost of improper management of your community's stormwater can be devastating. Uncontrolled flow of stormwater can cause flooding and contaminate ground water and rivers. Every municipality should encourage the use of Best Management Practices (BMPs) by reviewing local ordinances and implementation in planned developments, and redevelopments, to reduce the amount of stormwater drainage into the sewer system and local waterways. Redeveloping neighborhoods provide additional opportunities to implement BMPs where they may not have been used in the past.

BMPs are techniques used to control stormwater runoff, sediment control, and soil stabilization to manage the quantity and improve the quality of stormwater runoff in the most cost-effective manner in your community.

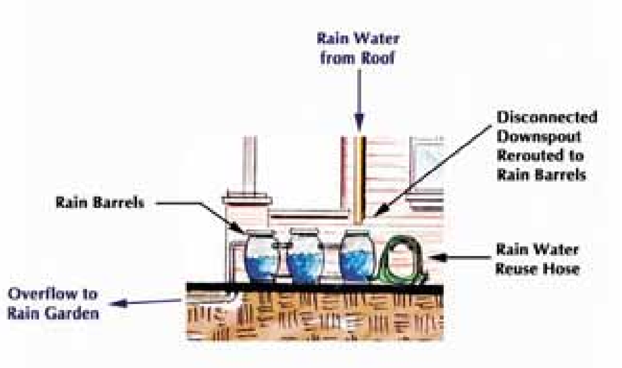
This brochure is titled *From Rooftop to River* to illustrate the need to apply a series of physical stormwater best management practices, or a *treatment train*, as rainwater flows off buildings through the built environment, to our sewers and rivers. Selecting just one BMP will not provide improved water drainage to the extent that a well thought out treatment train will. However, the success of any BMP is highly dependent on local soils and site conditions and proper maintenance.

The subsequent list of BMPs encourages the deceleration of rainwater as it hits roof-top gardens to allow time for absorption before flowing into a natural lake or wetland.

Best Management Practices

Green Roofs – Green roofs are generally planted with drought and wind tolerant vegetation. Green roofs are designed to retain and slow rainwater runoff on the top of roofs while minimizing overall energy usage by insulating the building.

Rain Barrel – A vessel used to capture and temporarily store rainwater. Captured water can be reused for irrigation.



Downspout Disconnect – Downspouts disconnected from the underground storm sewer system discharge rainwater directly onto a grassy area. Rainwater can infiltrate into the ground or flow to a curb inlet or rain garden, helping to slow the time it takes for stormwater to reach the municipal system.

Rain Garden – Shallow, landscaped depressions used to promote absorption and infiltration of stormwater runoff.

Porous Pavement – Load bearing systems comprising durable surfaces and underlying layered structures to cool, filter and temporarily store water. Modular paving blocks is a pavement surface composed of structural interlocking units with void areas filled with porous granular media or grass turf constructed over an underlying permeable media. Porous concrete is an open graded concrete mixture that allows water to infiltrate to lower layers of the system.

Vegetated Swales – a broad, vegetated channel used for the movement and temporary storage of runoff. Swales planted with native vegetation are effective in reducing the volume, rate, and pollution potential of runoff.

Native Landscaping/Filter Strips – Use of natural vegetation, prairie, wetlands, and woodland species to enhance absorption of rainfall and evaporation of soil moisture through the plants' root systems. Filter strips are vegetated areas designed to receive runoff from adjacent impervious surfaces.

Naturalized Detention – Basins designed to temporarily retain runoff after a high intensity storm. Naturalized detentions also act as natural lakes or wetlands and contribute to the creation of wildlife habitats and water pollution control.

Frequently Asked Questions about BMPs

How do the costs for BMPs compare with current practices?
Natural drainage practices and less reliance on impervious designs to manage stormwater can significantly reduce development and long-term maintenance costs. Increased costs to implement a BMP may be offset by reduced costs associated with flooding, pollution mitigation, and public health.

What maintenance issues will I have with porous paving?
A properly designed sub-base is critical for a porous paving system to work properly. Routine cleaning and sweeping as well as periodical replacement of contaminated porous granular media might be required. Snow plowing may require special care due to the slightly uneven surface of the pavement. A properly designed facility can reduce your maintenance costs.

Will the BMPs suggested in this brochure work with my municipality's soil?
Most of these recommended BMPs apply to residential, commercial, and industrial developments. All are effective in reducing the quantity and improving the quality of stormwater runoff. The success of any practice is highly dependent on local soils. Further information on how to implement BMPs is available at the end of this brochure.

Will these BMPs work in winter?
The infiltration capacity and vegetative runoff interception will be reduced during a winter period.
Porous pavement is actually more resistant to frost penetration due to increased latent ground heat and insulating affect of air in the porous pavement.
In locations where a disconnected downspout releases directly onto an impervious surface a simple diverting flap valve can be installed to direct roof water onto pavement during warm weather and into a sewer during winter months to prevent the icing up of the pavement.

Will a rooftop garden affect a building's structural integrity?
A green roof can actually prolong the life of a conventional roof because the vegetation prevents the roof from exposure to UV radiation and cold winds. The structural load-bearing capacity of the roof system will dictate whether a green roof is appropriate.

Won't standing water in rain barrels or vegetated swales attract mosquitoes?
Rain barrels must be sealed during warm weather months to avoid mosquitoes. Infiltration BMPs should be designed to drain within 24 hours and may require periodic removal of sediments to ensure proper functioning of the system.

Will BMPs affect my municipal weed nuisance ordinances?
Some local "weed" ordinances may need to be amended to allow native and taller vegetation. Neighborhood sensitivities and aesthetics should be considered when planning a native landscape. These types of concerns can be addressed through better information and public education.

What next?
Local officials are encouraged to review their stormwater ordinances, identify any barriers to implementation, and encourage the implementation of these BMPs through local planned developments and redevelopments.

Need more help?
Northeastern Illinois Planning Commission www.nipc.org
Chicago Department of Environment
www.cityofchicago.org/environment

From Rooftop to River

Stormwater Best Management Practices

Prepared by the Metropolitan Mayors Caucus
Summer, 2006

This brochure was printed through the generous support of Christopher B. Burke Engineering, Ltd.

Benefits of Riparian Buffers

- *They protect property from eroding away*
- *They provide flood control*
- *They absorb noise from waterfront activities*
- *They provide privacy*
- *They take up nutrients*
- *They filter sediment from runoff*
- *They control water temperature*
- *They provide wildlife food and habitat*
- *They provide recreational value such as fishing and bird watching*

For more information on the Neuse and Tar-Pam Buffer Rules please contact the Division of Water Quality staff:

DENR Washington Regional Office
943 Washington Square Mall
Washington, NC 27889
252-946-6481

DENR Wilmington Regional Office
127 N Cardinal Drive Extension
Wilmington, NC 28405
910-796-7215

DENR Raleigh Regional Office
3800 Barrett Drive, Suite 101
Raleigh, NC 27699
919-571-4700

The rules can be viewed or downloaded from the DWQ website :
Http://h20.enr.nc.us/nps/tarp.htm

The Neuse and Tar-Pamlico Buffer Rules may not be the only regulations that apply to your property. For more information you can contact the following agencies at the DENR Regional Offices:

Divison of Water Quality
Division of Coastal Management
US Army Corp of Engineers

This document was produced with funds provided by the National Oceanic and Atmospheric Administration through the North Carolina Department of Natural Resources, Divison of Water Quality, Coastal Nonpoint Source Program (Award #NA04NOS4190050)

50,000 copies of this publication were printed at a cost of $5553.30 or $0.11.X per copy (G>S> 143-1710.1)

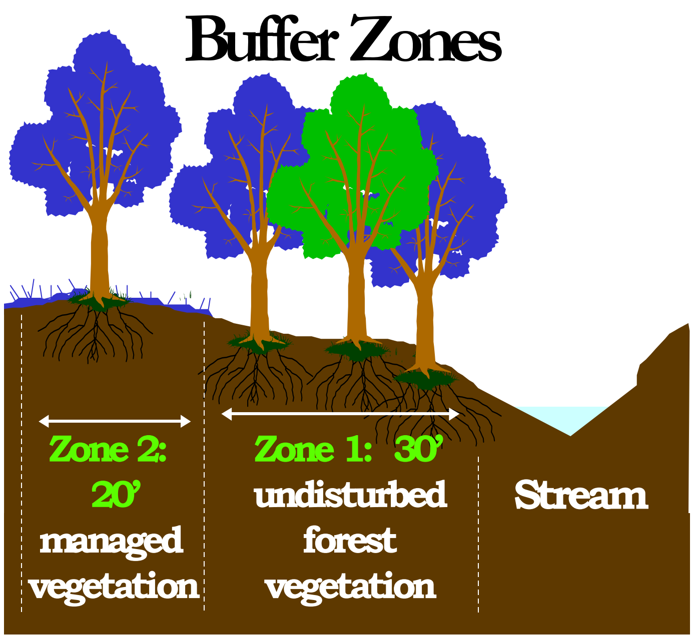
For Prospective Landowners

Understanding Buffer Rules and your Future Property Purchase

What are Riparian Buffers?

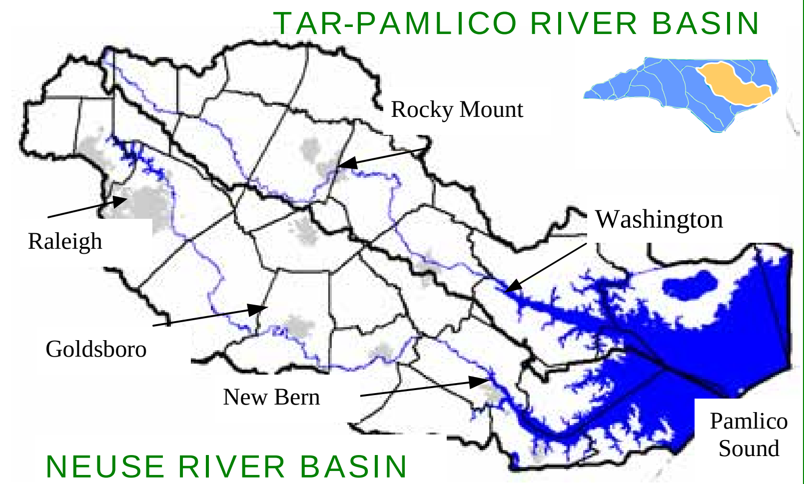
The word *riparian* means next to the banks of streams, rivers, lakes, estuaries or other waters. A riparian buffer is a strip of forested or vegetated land bordering a body of water and is important in protecting water quality. A buffer may be any combination of shrubs, herbs, and native grasses, but the best vegetation for stabilizing streambanks and removing nutrients is deep rooted, woody vegetation.

Riparian buffers are managed as two zones. The zone closest to the water provides streambank and shoreline protection. The outer zone slows and spreads out the flow of water coming from the land, trapping sediment and other pollutants.



Riparian Buffer Protection

The Division of Water Quality's Buffer Protection Rule is a part of the state's nutrient reduction strategy for the Neuse and Tar-Pamlico River Basins. The rule requires protection of existing vegetation in the first 50 feet of riparian area within these basins.



Protect the Buffer? The first 30 feet from the waterbody should be essentially undisturbed. The next 20 feet should be vegetated, however certain uses are allowed.

Is my Property Included?

Intermittent and perennial streams, lakes, ponds and estuarine waters are protected by these rules. If you are unsure whether this includes your property, you can obtain a copy of the county soil survey produced by the Natural Resources Conservation Service and a 1:24,000 scale topographic map prepared by the US Geologic Survey. If the surface water is indicated on one or the other source then the buffer rules apply. The Division of Water Quality will make final determinations.

CONTACT YOUR LOCAL SOIL AND WATER CONSERVATION DISTRICT FOR MAP ASSISTANCE!

What activities are allowed?

You will want to read and understand the rule prior to beginning any activity within the buffer. The following are a few of the allowed activities in the rule.

- Fences if no woody vegetation is removed
- One time fertilizer application to establish replanted vegetation (Ongoing fertilization is not allowed)
- Playground equipment
- Removal of poison ivy, poison oak, vines, honeysuckle
- Planting vegetation to enhance the buffer
- Removal of trees that are dead, dying, or diseased. Verified by a registered forester.
- Removal of trees that are in danger of causing damage to existing structures or human life
- Limited pruning of forest vegetation as long as it doesn't compromise the health of the tree