15. Restored Riparian Buffer

Description

Restored riparian buffers are natural or constructed low-maintenance ecosystems adjacent to surface water bodies, where trees, grasses, shrubs, and herbaceous plants function as a filter to remove pollutants from overland stormwater flow and shallow groundwater flow prior to discharge to receiving waters.

Regulatory Credits

Pollutant Removal

60%	Total Suspended Solids
30%	Total Nitrogen
35%	Total Phosphorus

Water Quantity

no	Peak Flow Attenuation
no	Volume Capture

Feasibility Considerations

Med	Land Requirement
Med	Cost of Construction
Low	Maintenance Burden
Low	Treatable Basin Size
High	Possible Site Constraints
High	Community Acceptance

Advantages

- Offers numerous aesthetic and passive recreational benefits.
- Provides water quality treatment, erosion control, and water temperature benefits.
- Maintaining trails that are constructed, marked, and signed well can build support for greenways within riparian buffers in urban and suburban watersheds.

Disadvantages

- Sometimes seen as unkempt public areas.
- Can be perceived as interfering with views of streams, especially with shrubby bank-side vegetation.
- In the worst cases, can be abused as places for dumping trash and litter.

Major Design Elements

Required by the NC Administrative Rules of the Environmental Management Commission. Other specifications may be necessary to meet the stated pollutant removal requirements.	
1	Sizing shall take into account all runoff at ultimate build-out including off-site drainage.
2	BMP shall be located in a recorded drainage easement with a recorded access easement to a public ROW.

Major Design Elements (Continued)

Required by DWQ policy. These are based on available research, and represent what DWQ considers necessary to achieve the stated removal efficiencies.	
3	The buffer must be constructed directly adjacent to a perennial or intermittent surface water as shown on the most recent NRCS Soil Survey or the USGS 1:24,000 scale (7.5 minute) quadrangle topographic map.
4	The existing riparian buffer must be "impaired." An "impaired" riparian buffer includes: fields and pastures that have been actively used within the last 3 years, and wooded buffers that have been cutover within the last 5 years or where the woody vegetation is absent or sparse (less than 100 stems per acre that are greater than 5 inches diameter at breast height).
5	The restored riparian buffer must be used only when the flow to the level spreader is less than 3 cfs. This flow could be coming directly from the drainage area during the one inch per hour storm or the drawdown flow from another BMP.
6	Level spreaders (designed in accordance with Chapter 8 of this Manual) are required if it cannot be proven that the stormwater entering the riparian buffer is sheet flow.
7	The width shall be 50 feet, which must be divided into two zones. The 30 feet closest to the stream (Zone 1) must be wooded and the outer 20 feet (Zone 2) must be grassed.
8	The buffer must be a minimum of 13 feet and a maximum of 130 feet in length, and is set by the level spreader length requirements.
9	The slope of a riparian buffer must not be greater than 6%.

15.1. General Characteristics and Purpose

Riparian buffers are natural vegetated areas along a streambank (see Figure 15-1). They improve riparian habitat by:

- Providing food and cover for wildlife and aquatic organisms,
- Stabilizing stream banks,
- Filtering pollutants from stormwater,
- Attenuating the rate of runoff into streams, and
- Increasing infiltration and recharge to groundwater and surface water bodies.

Figure 15-1
Forested Riparian Buffer with Well-Developed Streambank Vegetation.

15.2. Meeting Regulatory Requirements

To receive the pollutant removal rates listed in the front of this Section, the restored riparian buffer must meet all of the major design requirements listed in the beginning of this Section. If restored riparian buffer will not meet the regulatory requirements of the site by itself, other BMPs can be used in conjunction to provide enhanced pollution removal rates or volume control capabilities.

Pollutant Removal Calculations
A properly sited, designed, constructed and maintained restored riparian buffers has the following associated pollutant removal rates:

- 60% Total Suspended Solids
- 30% Total Nitrogen
- 35% Total Phosphorus

Construction of a restored riparian buffer also passively lowers nutrient loading since it is counted as pervious surface when calculating nutrient loading.

Volume Control Calculations
A restored riparian buffer typically does not provide any active volume capture or peak flow attenuation. A restored riparian buffer provides some passive volume control capabilities by providing pervious surface and therefore reducing the total runoff volume to be controlled.

15.3. Design

15.3.1. Siting Requirements

All of the following siting requirements must be met in order for a restored riparian buffer to be constructed and receive the stated pollutant removal efficiencies:

1. They may only be constructed directly adjacent to a perennial or intermittent surface water. A perennial or intermittent surface water is considered to be present if the feature is approximately shown on either the most recent version of the Soil Survey Map prepared by the Natural Resources Conservation Service of the United States Department of Agriculture or the most recent version of the 1:24,000 scale (7.5 minute) quadrangle topographic maps prepared by the United States Geologic Survey (USGS).

2. The existing riparian buffer must be "impaired." An "impaired" riparian buffer includes: fields and pastures that have been actively used within the last 3 years, and wooded buffers that have been cutover within the last 5 years or where the woody vegetation is absent or sparse (less than 100 stems per acre that are greater than 5 inches diameter at breast height).

3. The slope of the riparian buffer must not be greater than 6 percent.

4. The restored riparian buffer must be used only when the flow to the level spreader is less than 3 cfs. This flow could be coming directly from the drainage area during the one inch per hour storm or the drawdown flow from another BMP.

All restored riparian buffers must be placed in permanent easement so it will not later be decreased or removed from the site.

15.3.2. Length and Width

The restored riparian buffer must a total of 50 feet in width and it must be composed of a zone of grass (20 feet wide) and a zone of forest vegetation (30 feet wide) as described in Section 15.3.3 below.

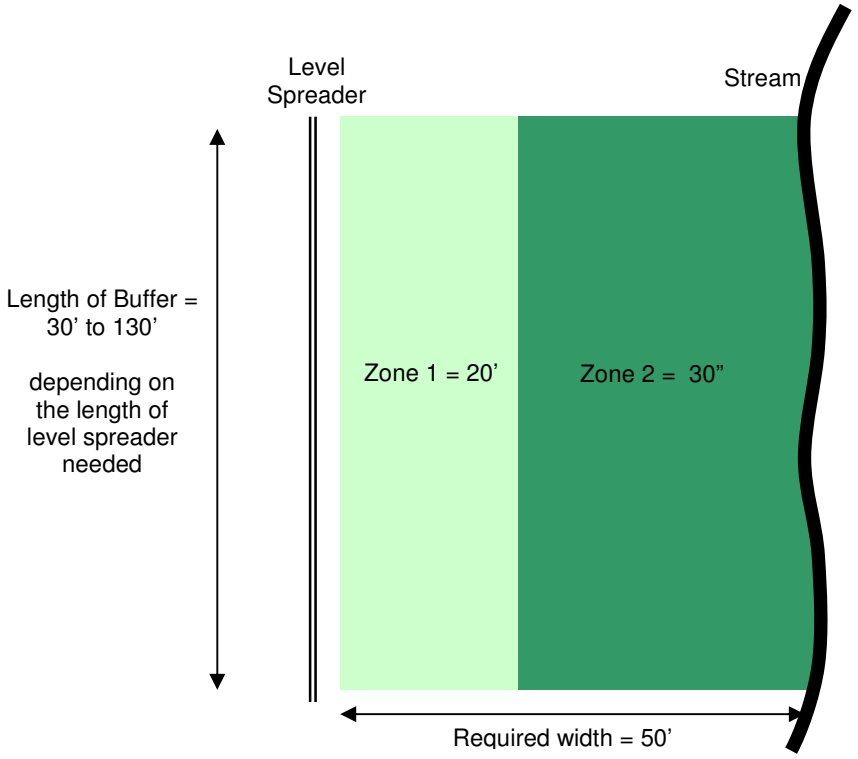
The length of level spreader is determined by calculating the weighted average of the lengths required for each vegetation type as shown below.

$$(20/50) \times (13 \text{ ft}/1\text{cfs}) + (30/50) \times (65 \text{ ft}/1 \text{ cfs}) = 44.2 \text{ or } 44 \text{ feet per cfs of flow}$$

Since the maximum length of a level spreader is 130 feet, this means that each restored riparian buffer is able to treat 3 cfs of flow. The level spreader may be designed to treat the one inch per hour storm with a bypass channel or the 10-year, 24-hour storm without a bypass channel. See chapter 8 for information about properly designing level

spreaders. A restored riparian buffer will not receive approval from DWQ unless it is accompanied by a properly designed level spreader or it is proven that the flow entering the restored riparian buffer is already diffuse.

Figure 15-2
Restored Riparian Buffer Diagram

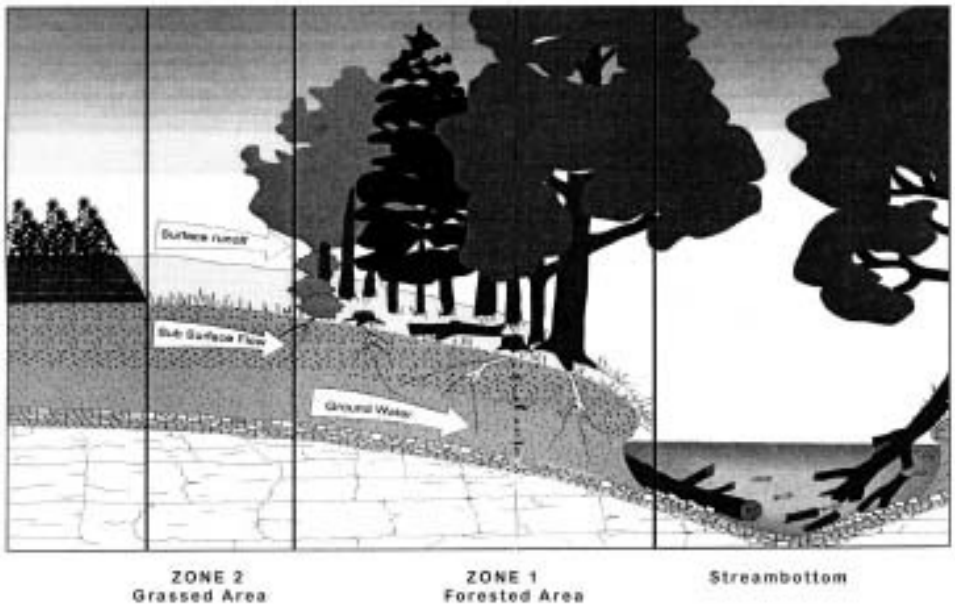


Designers have the option of placing two or more restored riparian buffers adjacent to one another along a stream channel in order to treat higher flows of stormwater. Restored riparian buffers can be used downslope of a detention/retention BMP, which will attenuate the flow from a larger drainage area and allow the drawdown flow to receive additional treatment without overwhelming the level spreader and restored riparian buffer.

15.3.3. Two-Zone Riparian Buffer System

Restored riparian buffers must be 50 feet wide and include two zones of vegetation. Zone 1 starts from the top of bank for streams (and from mean high water for other waterbodies) and extends landward a distance of 30 feet perpendicular to the stream. Zone 1 consists primarily of wooded vegetation that may not be disturbed except for removal of nuisance vegetation (see Section 15.3.6). Zone 2 extends a minimum of 20 additional feet beyond Zone 1. Zone 2 is intended to diffuse and infiltrate runoff and filtering of pollutants. It may be grassed, and other vegetation and periodic maintenance are allowed.

Figure 15-3
Two Zone Buffer (modified from Lowrance *et al*., 1995)



15.3.4. Site Assessment

The riparian area to be restored should be evaluated with respect to these factors that control the viability of riparian plants:

- Soil moisture
- Soil pH
- Soil texture
- Seasonal high water table depth
- Flooding potential
- Aspect, topography, and microtopographic relief

15.3.5. Zone 1 Planting Requirements

Based on the site assessment, the designer should choose 10-12 species of native trees and shrubs appropriate for site based on site assessment and reference conditions. Typically, there should be at least three or four understory trees for every canopy tree to provide structural diversity similar to mature forests. Where shrub species are incorporated into the planting plan, they should be distributed more densely at outer edge of riparian buffer to reduce light penetration and recolonization by invasive exotic species.

Please refer to Table 15-1 below for plant lists broken down by plant type, physiographic region, and hydrologic zone. Most plants for the buffer should be compatible with Zone 4, Upland Area, with some plants, depending on the site, from

Zone 3, Shallow Land. Please note that these lists are alphabetical and do not take into account the assemblages of plants found in nature.

Trees should be planted approximately at a density sufficient to provide 320 trees per acre and shrubs should be planted at a spacing to provide 1,200 shrubs per acre. To achieve this density, trees should be planted at a spacing of 8x8 to 10x10 feet. Shrubs should be planted at a spacing of 3x3 to 5x5 feet.

The minimum size for trees that are planted in the restored riparian buffer is 2.5 inches dbh (diameter breast height). Trees should be bare root or balled and burlapped (not containerized stock). The minimum size for shrubs planted in the restored riparian buffer is a one-gallon container.

Table 15-1
Planting List for Zone 1 (Ecosystem Enhancement Program 2004)

Native Regions		Light Requirements		Moisture Requirements	
M=	Mountains	S=	Shade	L=	Low Moisture
P=	Piedmont	P=	Partial Sun	M=	Moderate Moisture
C=	Coastal Plain	F=	Full Sun	H=	High Moisture
				A=	Aquatic

Scientific Name	Common Name	Region			Light			Moisture			
		M	P	C	S	P	F	L	M	H	A
Medium to Large Trees											
Acer barbatum	Southern sugar maple		X	X	X	X			X		
Acer saccharinum	silver maple		X		X	X	X		X		
Acer saccharum	sugar maple	X				X	X		X		
Betula alleghaniensis	yellow birch	X			X	X			X		
Betula lenta	cherry birch, sweet birch	X			X	X			X		
Betula nigra	river birch	X	X	X		X	X		X	X	
Carya aquatica	water hickory			X		X	X			X	
Carya cordiformis	bitternut hickory	X	X	X	X	X	X		X	X	
Carya glabra	pignut hickory	X	X	X	X	X	X	X	X		
Carya ovata	shagbark hickory	X	X	X	X	X	X		X		
Carya tomentosa	mockernut hickory	X	X	X	X	X	X	X	X		
Celtis laevigata	sugarberry, hackberry		X	X	X	X			X		
Chamaecyparis thyoides	Atlantic white cedar			X		X	X		X	X	
Cladrastis kentuckea	yellowwood	X			X	X			X		
Diospyros virginiana	persimmon	X	X	X	X	X	X	X	X		
Fagus grandifolia	American beech	X	X	X	X	X			X		
Fraxinus americana	white ash	X	X	X	X	X			X		
Fraxinus pennsylvanica	green ash	X	X	X	X	X			X	X	
Fraxinus profunda	pumpkin ash, red ash		X	X		X				X	
Juglans nigra	black walnut	X	X	X	X	X			X		
Liriodendron tulipifera	tulip poplar, yellow poplar	X	X	X	X	X	X		X		
Magnolia acuminata	cucumber magnolia	X	X		X	X			X		
Magnolia fraseri	Fraser magnolia	X				X			X		
Nyssa aquatica	water tupelo			X	X	X	X			X	X
Nyssa sylvatica	black gum	X	X	X	X	X	X	X	X		
Nyssa sylvatica var. biflora	swamp black gum			X	X	X	X			X	
Oxydendrum arboreum	sourwood	X	X	X		X	X	X	X		
Picea rubens	red spruce	X			X	X	X		X		
Pinus echinata	shortleaf pine	X	X	X		X	X	X			
Pinus palustris	longleaf pine		X	X			X	X	X		
Pinus rigida	pitch pine	X					X	X			

Scientific Name	Common Name	Region			Light			Moisture			
		M	P	C	S	P	F	L	M	H	A
Pinus serotina	pond pine			X			X		X	X	
Pinus strobus	white pine	X	X			X	X		X		
Platanus occidentalis	sycamore	X	X	X		X	X		X	X	
Populus deltoides	eastern cottonwood		X	X			X			X	
Populus heterophylla	swamp cottonwood			X		X	X			X	
Prunus serotina	black cherry	X	X	X	X	X	X	X	X		
Quercus alba	white oak	X	X	X		X	X	X	X		
Quercus bicolor	swamp white oak		X		X	X				X	
Quercus coccinea	scarlet oak	X	X		X	X		X			
Quercus falcata	Southern red oak	X	X	X	X	X		X	X		
Quercus pagoda	cherrybark oak		X	X	X	X			X	X	
Quercus laurifolia	laurel oak			X	X	X	X		X	X	
Quercus lyrata	overcup oak		X	X	X	X				X	
Quercus margaretta	sand post oak			X		X	X	X			
Quercus marilandica	black jack oak	X	X	X	X	X		X			
Quercus michauxii	swamp chestnut oak		X	X	X	X	X		X	X	
Quercus nigra	water oak		X	X	X	X	X	X	X		
Quercus phellos	willow oak		X	X	X	X	X		X	X	
Quercus prinus	chestnut oak	X	X		X	X		X			
Quercus rubra	Northern red oak	X	X		X	X		X	X		
Quercus shumardii	shumard oak		X	X	X	X			X	X	
Quercus stellata	post oak	X	X	X	X	X		X			
Quercus velutina	black oak	X	X	X	X	X		X			
Quercus virginiana	live oak			X		X	X	X			
Robinia pseudoacacia	black locust	X	X	X		X	X		X		
Taxodium ascendens	pond-cypress			X		X	X				X
Taxodium distichum	bald-cypress			X		X	X				X
Tilia americana var. heterophylla	basswood	X	X		X	X			X		
Tsuga canadensis	Eastern hemlock	X	X		X	X	X		X		
Tsuga caroliniana	Carolina hemlock	X	X			X	X	X			
Ulmus alata	winged elm		X	X	X	X	X	X	X		
Ulmus americana	American elm	X	X	X	X	X			X		
Small Trees											
Amelanchier arborea	downy serviceberry, shadbush	X	X	X	X	X			X		
Amelanchier canadensis	Canada serviceberry			X			X		X	X	
Amelanchier laevis	smooth serviceberry	X				X	X	X	X		
Asimina triloba	pawpaw	X	X	X	X	X			X		
Carpinus caroliniana	ironwood, American hornbeam	X	X	X	X	X			X	X	
Cercis canadensis	eastern redbud	X	X	X	X	X			X		
Chionanthus virginicus	white fringetree, old man's beard	X	X	X		X	X		X		
Cornus alternifolia	alternate-leaf dogwood	X			X	X			X		
Cornus florida	flowering dogwood	X	X	X	X	X		X	X		
Crateagus crus-galli	cockspur hawthorn	X	X	X		X	X	X	X		
Crateagus flabellata	fanleaf hawthorn	X	X			X			X		
Crateagus flava	October haw	X	X	X		X	X		X		
Cyrilla racemiflora	titi			X		X	X		X	X	
Fraxinus caroliniana	water ash			X	X	X				X	
Gordonia lasianthus	loblolly bay			X	X	X	X		X	X	

Scientific Name	Common Name	Region			Light			Moisture			
		M	P	C	S	P	F	L	M	H	A
Halesia tetraptera (H. carolina)	common silverbell	X	X		X	X			X		
Ilex opaca	American holly	X	X	X	X	X		X	X	X	
Juniperus virginiana	Eastern red cedar	X	X	X		X	X	X	X		
Magnolia tripetala	umbrella tree	X	X		X				X		
Magnolia virginiana	sweetbay magnolia		X	X	X	X	X		X	X	
Morus rubra	red mulberry	X	X	X	X	X			X		
Osmanthus americana	wild olive, devilwood			X	X	X			X		
Ostrya virginiana	Eastern hop-hornbeam	X	X		X	X			X		
Persea borbonia	red bay			X	X	X	X	X	X		
Persea palustris	swamp bay			X	X	X	X		X	X	
Pinus pungens	table mountain pine	X					X	X			
Prunus americana	American wild plum	X	X			X			X		
Prunus caroliniana	Carolina laurel-cherry			X		X	X	X	X		
Quercus incana	bluejack oak			X		X	X	X			
Quercus laevis	turkey oak			X		X	X	X			
Rhus glabra	smooth sumac	X	X				X	X	X		
Rhus hirta (Rhus typhina)	staghorn sumac	X					X	X			
Salix caroliniana	swamp willow	X	X	X		X	X		X	X	
Salix nigra	black willow	X	X	X		X	X		X	X	
Sassafras albidum	sassafras	X	X	X		X	X	X	X		
Staphylea trifolia	bladdernut		X		X				X	X	
Symplocos tinctoria	horse-sugar, sweetleaf	X	X	X	X	X		X	X		
Ulmus rubra	slippery elm	X	X		X	X			X		
Shrubs											
Aesculus sylvatica	painted buckeye	X	X		X	X			X		
*Alnus serrulata**	common alder	X	X	X	X	X	X			X	X
Aronia arbutifolia	red chokeberry	X	X	X	X	X			X	X	
Baccharis halimifolia	silverling		X	X			X	X	X	X	
Callicarpa americana	American beautyberry		X	X	X	X	X		X		
Calycanthus floridus	sweet-shrub	X	X		X	X			X		
Castanea pumila	Allegheny chinkapin	X	X	X	X	X	X	X			
Ceanothus americanus	New Jersey tea	X	X	X		X	X	X			
Cephalanthus occidentalis	buttonbush	X	X	X		X	X				X
Clethra acuminata	mountain sweet pepperbush	X			X	X			X		
Clethra alnifolia	sweet pepperbush			X	X	X			X	X	
Comptonia peregrina	sweet fern	X	X			X	X				
Cornus amomum	silky dogwood	X	X	X	X	X				X	X
Cornus stricta	swamp dogwood			X	X	X				X	
Corylus americana	American hazel, hazelnut	X	X		X	X			X		
Euonymus americanus	hearts-a-bustin', strawberry bush	X	X	X	X	X		X	X		
Fothergilla gardenii	witch-alder			X		X			X	X	
Gaylussacia frondosa	dangleberry			X	X	X	X		X	X	
Hamamelis virginiana	witch hazel	X	X	X	X	X		X	X		
Hydrangea arborescens	wild hydrangea	X	X		X	X			X		
Ilex coriacea	gallberry			X	X	X			X	X	
Ilex decidua	deciduous holly, possumhaw		X	X	X	X			X		
Ilex glabra	inkberry			X	X	X	X		X	X	
Ilex verticillata	winterberry	X	X	X	X	X	X		X	X	

Scientific Name	Common Name	Region			Light			Moisture			
		M	P	C	S	P	F	L	M	H	A
Ilex vomitoria	yaupon holly			X	X	X	X	X			
Itea virginica	Virginia willow		X	X	X	X				X	
Kalmia angustifolia var. caroliniana	lamb-kill, sheep-kill			X		X	X		X	X	
Kalmia latifolia	mountain laurel	X	X		X	X		X	X		
Leucothoe axillaris	coastal dog-hobble			X	X	X			X		
Leucothoe fontanesiana	dog-hobble	X	X		X				X		
Leucothoe racemosa	fetterbush		X	X	X	X			X	X	
Lindera benzoin	spicebush	X	X		X				X		
Lyonia ligustrina	northern maleberry	X	X	X		X			X	X	
Lyonia lucida	shining fetterbush			X	X	X			X		
*Myrica cerifera**	Southern wax-myrtle		X	X	X	X	X	X	X	X	
*Myrica cerifera var. pumila**	dwarf Southern wax-myrtle			X		X	X	X	X		
*Myrica heterophylla**	bayberry, evergreen bayberry			X	X	X			X		
Pieris floribunda	evergreen mountain fetterbush	X					X	X	X		
Rhododendron atlanticum	dwarf azalea			X		X			X		
Rhododendron calendulaceum	flame azalea	X			X	X			X		
Rhododendron catawbiense	Catawba rhododendron	X	X		X	X	X	X	X		
Rhododendron maximum	rosebay rhododendron	X	X		X	X		X	X		
Rhododendron periclymenoides	pinxter flower, wild azalea	X	X	X	X	X			X		
Rhododendron viscosum	swamp azalea	X		X		X	X		X	X	
Rhus copallina	winged sumac	X	X	X		X	X	X	X		
Rosa carolina	pasture rose, Carolina rose	X	X	X		X	X	X	X		
Rosa palustris	swamp rose	X	X	X		X	X				X
Rubus allegheniensis	Alleghany blackberry	X	X				X	X			
Rubus cuneifolius	blackberry		X	X		X	X	X	X		
Rubus odoratus	purple flowering raspberry	X				X			X		
Salix humilis	prairie willow	X	X				X	X			
Salix sericea	silky willow	X	X	X		X	X				X
Sambucus canadensis	common elderberry	X	X	X			X		X	X	
Spiraea alba	narrow-leaved meadowsweet	X					X		X		
Spiraea latifolia	broad-leaved meadowsweet	X					X		X		
Spiraea tomentosa	meadowsweet	X	X	X		X	X			X	
Stewartia malacodendron	silky camellia			X	X	X			X		
Stewartia ovata	mountain camellia	X	X		X	X			X		
Styrax grandifolia	bigleaf snowbell		X	X	X	X			X		
Vaccinium arboreum	sparkleberry		X	X	X	X		X	X		
Vaccinium corymbosum	highbush blueberry	X	X	X	X	X	X	X	X	X	
Vaccinium crassifolium	creeping blueberry			X		X			X		
Vaccinium elliottii	mayberry			X	X				X		
Vaccinium stamineum	deerberry, gooseberry	X	X	X	X	X		X			
Vaccinium pallidum	lowbush blueberry	X	X		X	X		X			
Viburnum acerifolium	maple-leaf viburnum	X	X		X	X		X	X		
Viburnum dentatum	Southern arrowwood viburnum	X	X	X	X	X	X		X		
Viburnum nudum	possumhaw viburnum	X	X	X	X	X				X	
Viburnum prunifolium	blackhaw viburnum	X	X	X	X	X			X		
Viburnum rafinesquianum	downy arrowwood		X		X	X			X		
Viburnum rufidulum	rusty blackhaw		X	X	X	X		X			
Xanthorhiza simplicissima	yellowroot	X	X	X	X			X	X		

** These fix nitrogen and should not be used for riparian restoration adjacent to Nutrient Sensitive Waters.*

15.3.6. Zone 2 Planting Requirements

Zone 2 must be planted as a dense cover of grasses. Fescue and bluegrass should not be used because they are invasive species and will compete with native vegetation for nutrients. Do not work under frozen, muddy or saturated conditions. There are a number of acceptable ways to establish grass in Zone 2.

Centipede and Zoysia grasses should be planted in mid-May until late August. If Centipede is being planted, it is ideal to use sod. If plugs are used, they should be 6-12" apart (closer to a 6-inch separation for Zoysia since it doesn't spread as well as Centipede), in a grid or checkerboard pattern. Plugs should be placed at a depth of one inch.

15.4. Construction

Buffer restoration may include stabilization of the stream channel, site preparation, and planting the vegetation. Streambank stabilization involves a combination of vegetative and structural techniques. Vegetative techniques create a natural appearance and provide habitat to aquatic organisms and wildlife. These options include live stakes, tree revetments, live fascines, and brush mattresses. Other features such as boulders, logs, sandbags, or gabions can be combined for additional stability. Structural measures such as riprap and concrete structures are not as desirable but may be needed in some situations to protect infrastructure such as roads and buildings. If streambank stabilization is proposed as part of the project, please contact the North Carolina Division of Water Quality 401 Unit for permitting information at (919) 733-1786.

After the streambank has been stabilized, site preparation, including treatment of existing vegetation and soil preparation, is usually required before planting begins. The degree of site preparation needed depends on the existing vegetation and whether the site is being completely redone or if the existing buffer is merely being "enhanced". They may require mechanical and chemical treatment (proposals for pesticide use should always be reviewed by the North Carolina Division of Water Quality staff to insure compliance with the Neuse and Tar-Pamlico Riparian Buffer Rules). In addition to controlling invasive species, sod-forming grasses such as fescue and Kentucky bluegrass that will compete with plantings for nutrients need to be controlled.

Soil disturbance within the buffer should be minimized (preferably done by hand). Operation of land disturbing equipment within the buffer should be limited to light machinery. If complete reconstruction is being performed, the site should be plowed or ripped to improve compacted soil and/or eliminate areas where channelized flow has developed. After soil disturbance activities, areas of bare soil must be stabilized as quickly as possible using the grass species listed in Table 15-2. Please note that fescue grasses should not be used for soil stabilization. Fescue grasses, particularly tall fescue, are competitive and will inhibit the eventual re-establishment of native species.

When planting seedlings, it is helpful to mark the plants with colored flagging to make them easier to locate during maintenance tasks. The flagging can also be color-coded to mark plants that have died for replacement at a later date.

Tree protectors are also helpful for locating plants. Tree seedlings should be kept moist and should not be exposed for extended periods of time. A correctly planted tree should have the following general characteristics:

- Planted so that the root collar is slightly below the soil surface.
- Have the main roots nearly straight or spread out.
- Have soil firm around the roots.
- Have the tree in an upright position and have it nearly even with the general ground level, not sunk in a hole or raised on a mound.

When planting in Zone 2, scarify native soil to a minimum depth of 4". If required, add additional imported topsoil. All areas for sodding or grass plugs shall be raked to a uniformly fine texture. Moisten prepared lawn areas before planting if soil is dry. Water thoroughly and allow surfaces to dry before planting.

Please note that the Neuse and Tar-Pamlico Riparian Buffer Rules allow for a one-time fertilizer application to establish newly planted vegetation. Ongoing fertilizer application is prohibited.

15.5. Maintenance

15.5.1. Common Maintenance Issues

Riparian buffers require maintenance to fill gullies, remove weeds, repair streambank erosion, and protect against wildlife damage and insect and disease problems. Maintenance must be carried out with minimal impact in Zone 1.

Removal of natural leaf litter from the buffer is strongly discouraged. Where this natural material is not present, organic mulch such as wood chips, tree bark, and pine needles should be maintained at a minimum depth of 2 inches over the entire buffer.

Watering may be necessary in the initial year or during periods of drought, especially if bare root material is installed. Some seedling mortality is expected but replanting may be necessary to maintain the stand density.

After the trees are established, periodic thinning and harvesting of mature trees is recommended to maintain health and growth. Thinning of trees within the buffer can be allowed provided that the minimum tree density requirement specified above is fulfilled and no trees larger than 2-inch diameter are removed except when dead or diseased. The thinning of vines and thick undergrowth to provide a better view or a more aesthetically pleasing natural landscape is allowed.

On-going maintenance activities include selective cutting, replanting to maintain forest structure, and weed control. Fertilization and liming are recommended during plant establishment. Long term fertilization and chemical weed control, however, should not be necessary if the proper vegetation has been selected, and in some cases is not allowed by regulations.

In the early stages of riparian buffer establishment, competition for nutrients by adjacent grasses and herbs will substantially inhibit seedling growth. Release from herbaceous competition has been demonstrated as the most cost-effective method to accelerate the growth of seedlings. The plan for buffer establishment should incorporate control of the herbaceous layer. Options for weed control include four to six inches of well-aged hardwood mulch, weed control fabrics, or pre-emergent herbicide. Typically, mowing to control weeds will be impractical based on the random distribution of plantings. Weed control should be continued for three years from the time of planting, at which time it should be somewhat self-controlling.

It is also necessary to control of invasive, exotic plants that would hinder the re-establishment of woody vegetation. Division of Water Quality staff should review proposals for pesticide use within the Neuse and Tar-Pamlico Riparian Buffer Rules if applicable. Common invasive plants for North Carolina are listed in Table 15-2.

Table 15-2
Common Invasive Plants (Ecosystem Enhancement Program 2004)

Scientific Name	Common Name
Ailanthus altissima	Tree-of-Heaven
Albizia julibrissin	Mimosa
Elaeagnus umbellata	Autumn Olive
Hedera helix	English Ivy
Lespedeza cuneata	Korean or Sericea Lespedeza
Ligustrum sinense	Chinese Privet
Lonisera japonica	Japanese Honeysuckle
Microstegium vimineum	Japanese Grass
Paulownia tomentosa	Princess Tree
Pueraria lobata	Kudzu
Rosa multiflora	Multiflora Rose
Wisteria sinensis	Chinese Wisteria

If the streambank structure is not maintained by riparian vegetation, then additional measures should be used such as live staking, intercepting runoff before it enters the riparian forested buffer, or using stabilization techniques.

In suburban and urban areas, maintenance personnel may require additional training to ensure that riparian buffers are not reduced by aggressive mowing, pruning, or herbicide regimes.

15.5.2. Sample Inspection and Maintenance Provisions

Important maintenance procedures:

- Immediately after the restored riparian buffer is established, any newly planted vegetation will be watered twice weekly if needed until the plants become established (commonly six weeks).
- Once a year, Zone 2 will be reseeded to maintain a dense growth of vegetation
- Stable groundcover will be maintained in the drainage area to reduce the sediment load to the restored riparian buffer.
- Two to three times a year, Zone 2 will be mowed and the clippings harvested to promote the growth of thick vegetation with optimum pollutant removal efficiency. Turf grass should not be cut shorter than 3 to 5 inches and may be allowed to grow as tall as 12 inches depending on aesthetic requirements (NIPC, 1993)..
- Once a year, the soil in Zone 2 will be aerated if necessary.
- Once a year, soil pH will be tested and lime will be added if necessary.

After the restored riparian buffer is established, it will be inspected **quarterly and within 24 hours after every storm event greater than 1.0 inch (or 1.5 inches if in a Coastal County)**. Records of inspection and maintenance will be kept in a known set location and will be available upon request.

Inspection activities shall be performed as follows. Any problems that are found shall be repaired immediately.

Table 15-3
Sample Inspection and Maintenance Provisions for Restored Riparian Buffers

BMP element:	Potential problem:	How to remediate the problem:
The entire filter strip system	Trash/debris is present.	Remove the trash/debris.
The flow splitter device (if applicable)	The flow splitter device is clogged.	Unclog the conveyance and dispose of any sediment off-site.
	The flow splitter device is damaged.	Make any necessary repairs or replace if damage is too large for repair.

Table 15-3, continued
Sample Inspection and Maintenance Provisions for Restored Riparian Buffers

The swale and the level lip	The swale is clogged with sediment.	Remove the sediment and dispose of it off-site.
	The level lip is cracked, settled, undercut, eroded or otherwise damaged.	Repair or replace lip.
	There is erosion around the end of the level spreader that shows stormwater has bypassed it.	Regrade the soil to create a berm that is higher than the level lip, and then plant a ground cover and water until it is established. Provide lime and a one-time fertilizer application.
	Trees or shrubs have begun to grow on the swale or just downslope of the level lip.	Remove them.
The bypass channel	Areas of bare soil and/or erosive gullies have formed.	Regrade the soil if necessary to remove the gully, and then reestablish proper erosion control.
	Turf reinforcement is damaged or ripap is rolling downhill.	Study the site to see if a larger bypass channel is needed (enlarge if necessary). After this, reestablish the erosion control material.
The filter strip	Grass is too short or too long (if applicable).	Maintain grass at a height of approximately three to six inches.
	Areas of bare soil and/or erosive gullies have formed.	Regrade the soil if necessary to remove the gully, and then plant a ground cover and water until it is established. Provide lime and a one-time fertilizer application.
	Sediment is building up on the filter strip.	Remove the sediment and restabilize the soil with vegetation if necessary. Provide lime and a one-time fertilizer application.
	Plants are desiccated.	Provide additional irrigation and fertilizer are needed.
	Plants are dead, diseased or dying.	Determine the source of the problem: soils, hydrology, disease, etc. Remedy the problem and replace plants. Provide a one-time fertilizer application.
	Nuisance vegetation is choking out desirable species.	Remove vegetation by hand if possible. If pesticide is used, do not allow it to get into the receiving water.
The receiving water	Erosion or other signs of damage have occurred at the outlet.	Contact the NC Division of Water Quality 401 Oversight Unit at 919-733-1786.

September 28, 2007 Changes:

1. Major Design Elements: Reformatted to include numbered requirements.
2. Figure 15-2: Numbered (previously unnumbered)
3. Figure 15-3: Renumbered (previously Figure 15-2)