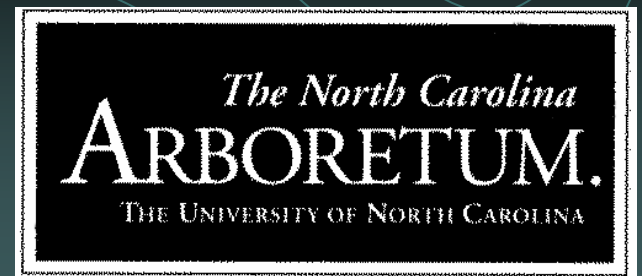


Stormwater Wetland Installation at the PPLG, The North Carolina Arboretum

Jon Calabria, Landscape Architect
NCSU Water Quality Group



Starts in the Watershed

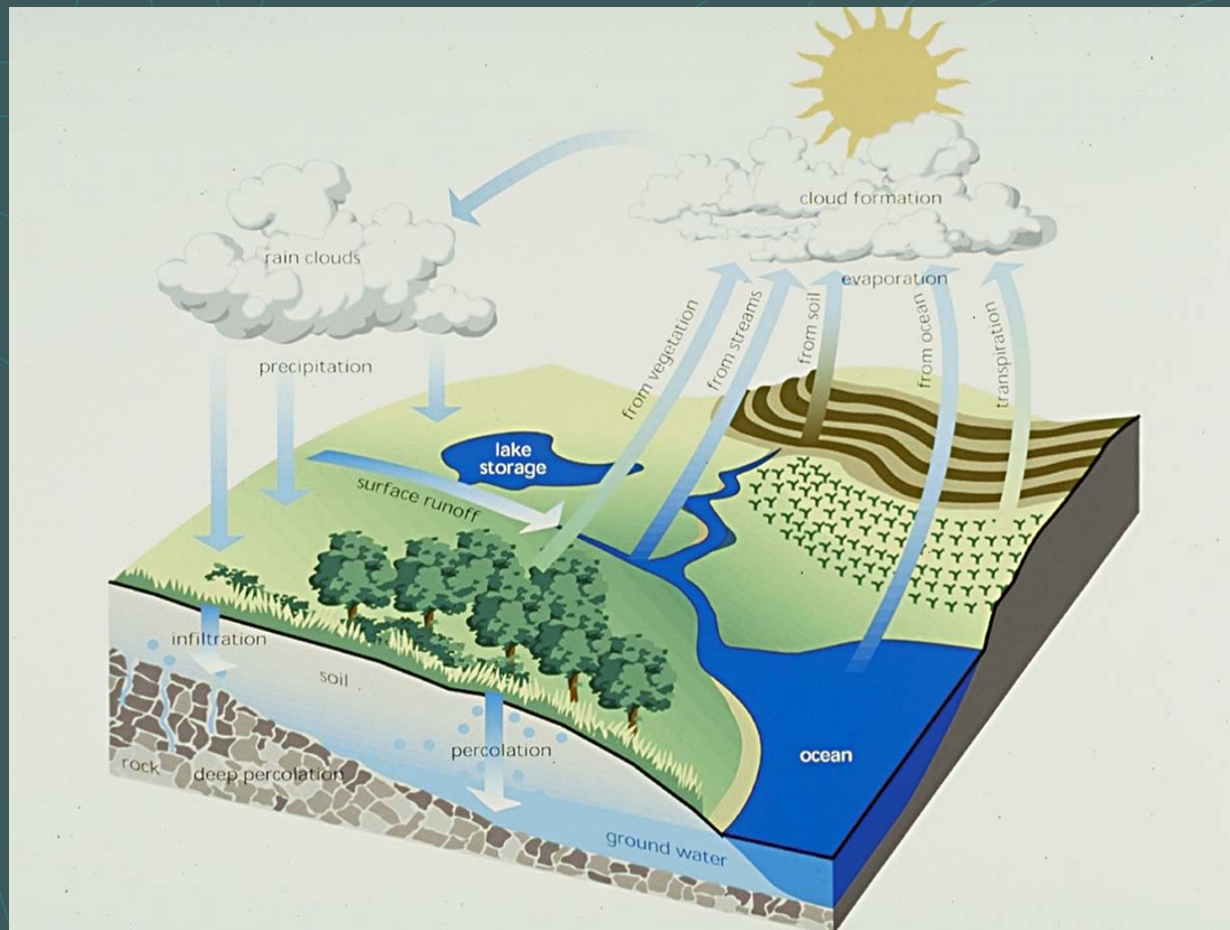




Low Impact Development

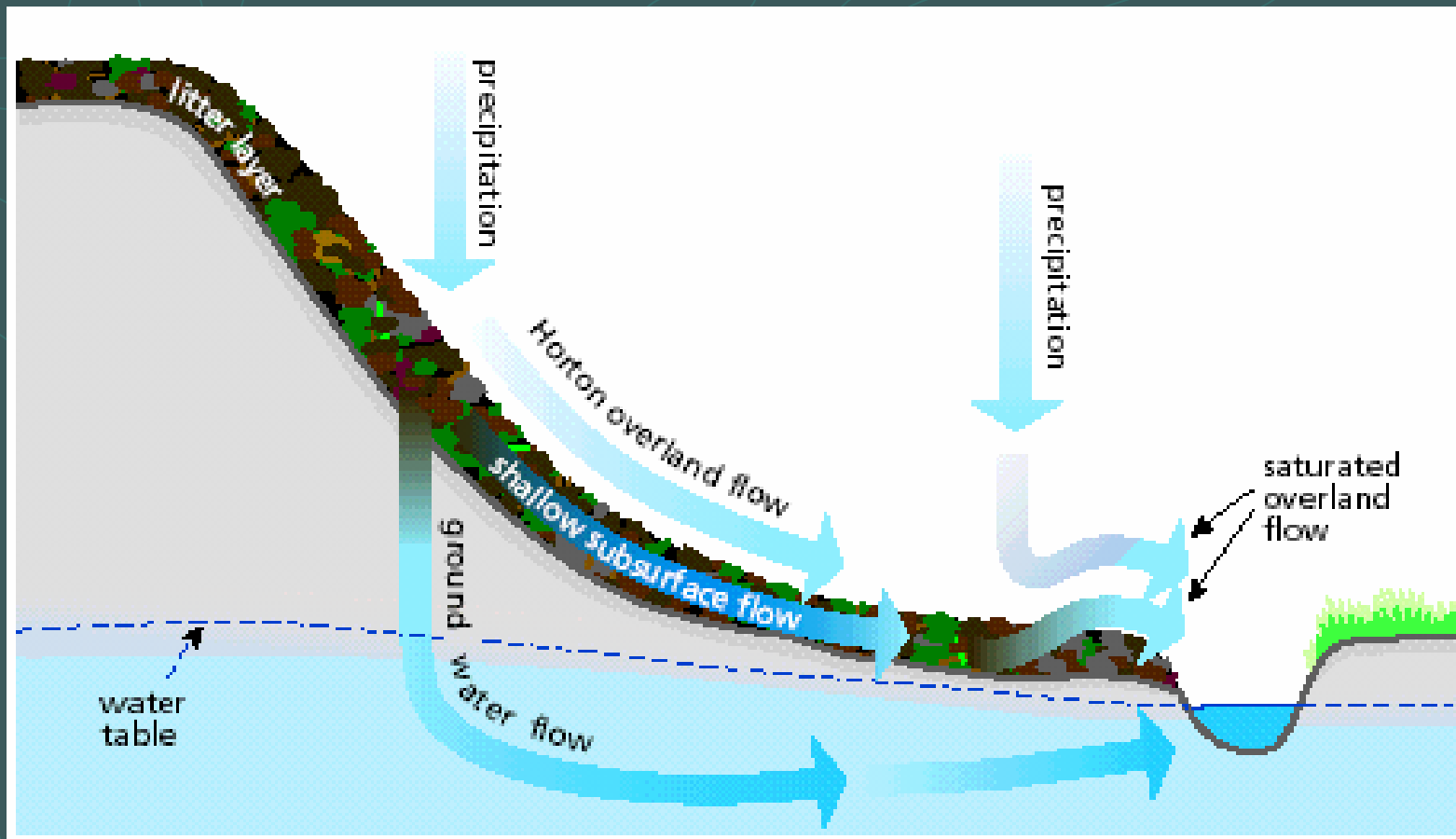
- LID is a site design strategy with a goal of maintaining or replicating the redevelopment hydrologic regime through the use of design techniques to create a functionally equivalent hydrologic landscape.
- Hydrologic functions of storage, infiltration, and ground water recharge, as well as the volume and frequency of discharges are maintained through the use of integrated and distributed micro-scale stormwater retention and detention areas, reduction of impervious surfaces, and the lengthening of flow paths and runoff time (Coffman, 2000).
- Make it like it was. (Calabria, 2003)

Hydrologic Cycle



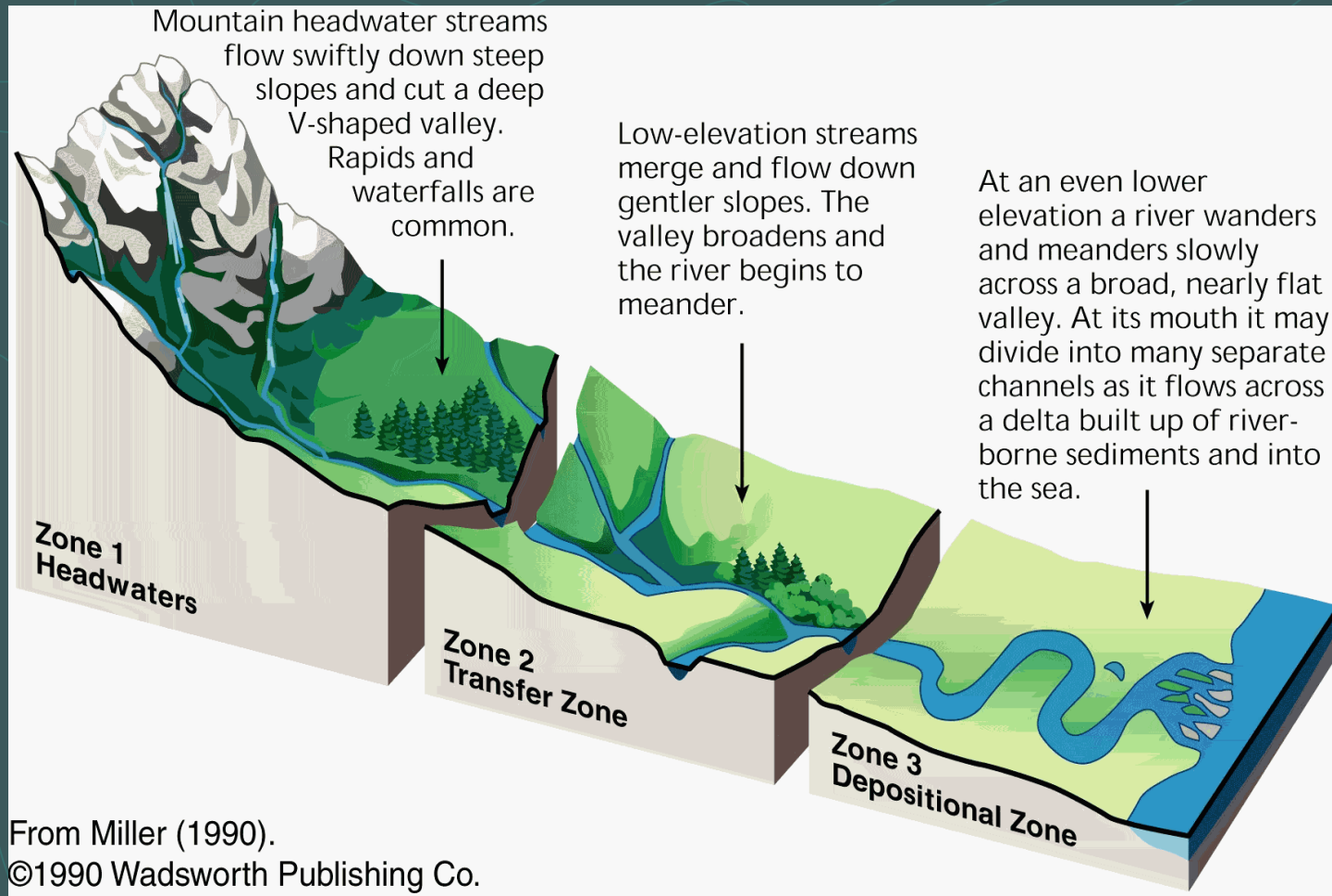
Stream Corridor Restoration: Principles, Processes, and Practices, 10/98, by the Federal Interagency Stream Restoration Working Group (FISRWG)."

Runoff Flow Pathways



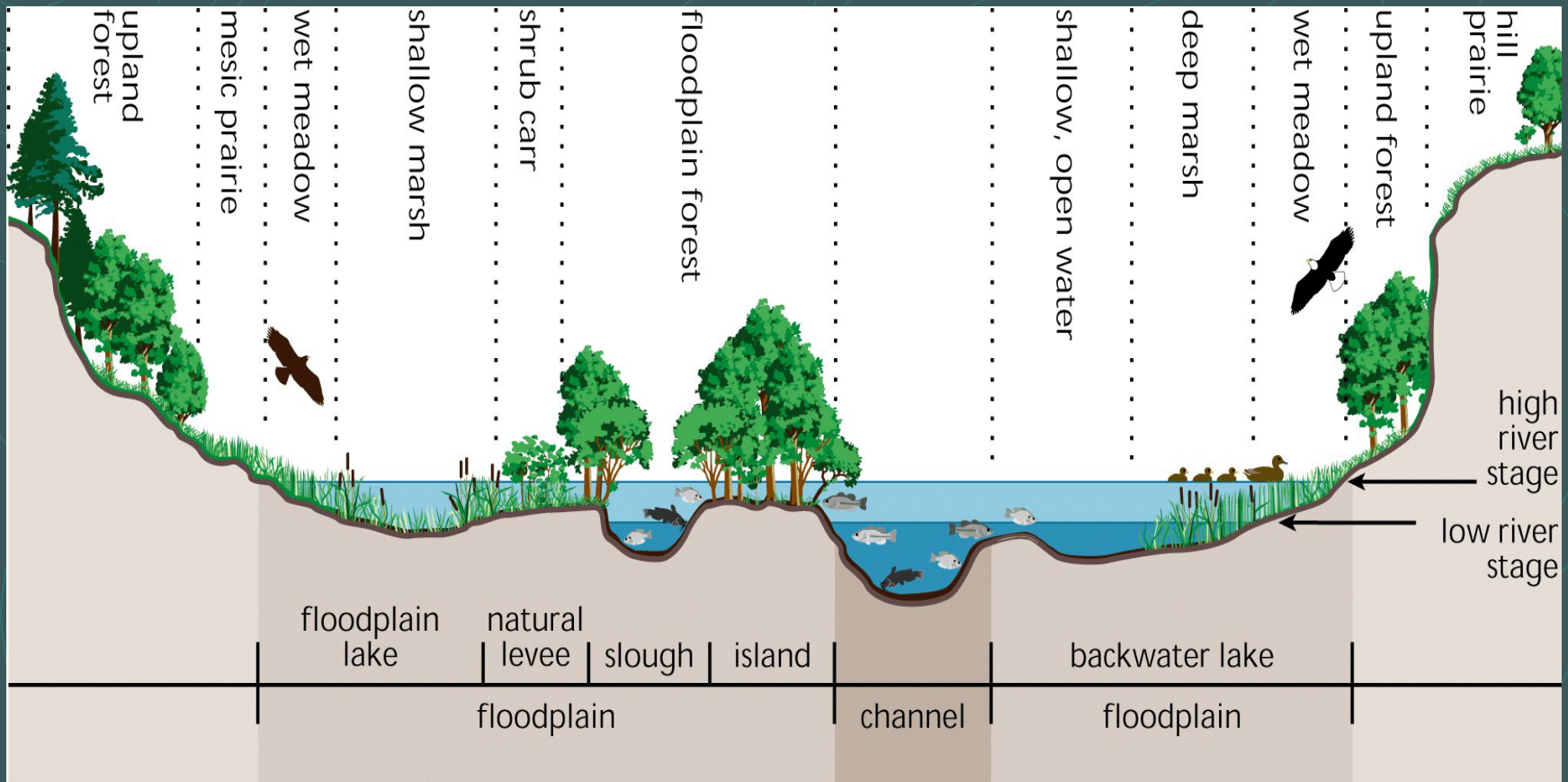
Stream Corridor Restoration: Principles, Processes, and Practices, 10/98, by the Federal Interagency Stream Restoration Working Group (FISRWG)."

Stream Longitudinal Profile



Stream Corridor Restoration: Principles, Processes, and Practices, 10/98, by the Federal Interagency Stream Restoration Working Group (FISRWG)."

Stream Cross Section



Stream Corridor Restoration: Principles, Processes, and Practices, 10/98, by the Federal Interagency Stream Restoration Working Group (FISRWG)."



Low Impact Development (LID)

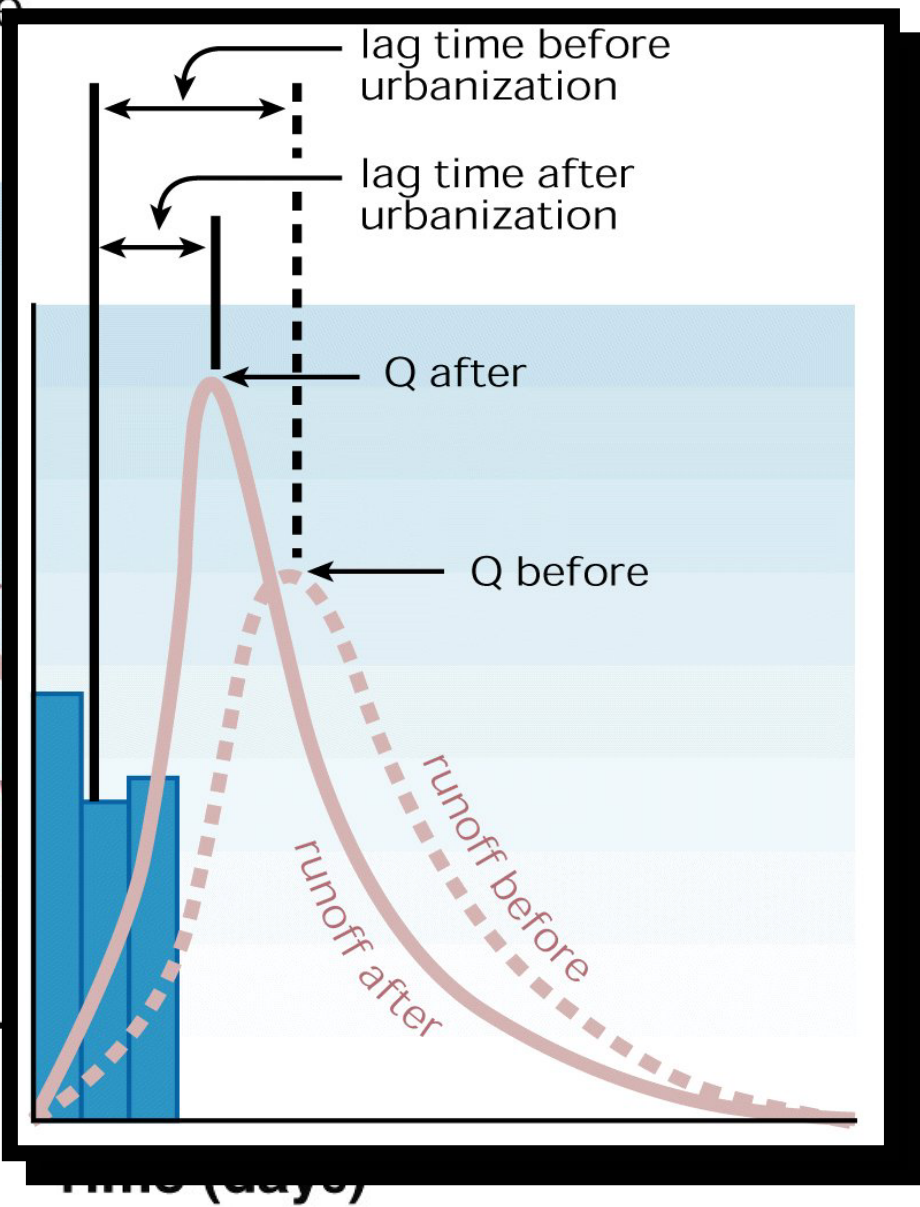
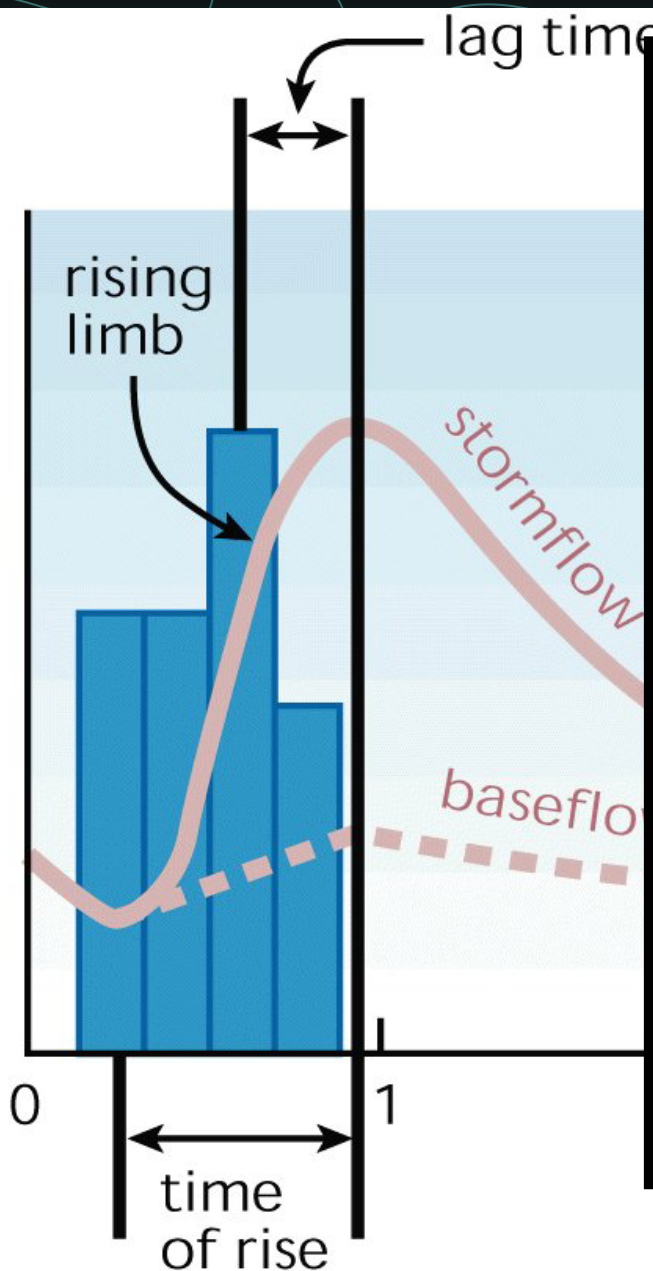
- The LID "functional landscape" is designed to mimic the predevelopment hydrological conditions.
 - Stormwater Best Management Practices (BMP's)
 - New Construction
 - Retrofit Existing Infrastructure
 - Conservation Design



How does LID work?

- The LID "functional landscape" is designed to mimic the predevelopment hydrological conditions.
 - through runoff volume control,
 - peak runoff rate control,
 - flow frequency/duration control and
 - water quality control.

Rainfall Intensity (inches/hr)
Stream Discharge (cfs)



Federal Interagency Stream Restoration Working Group (FISRWG). 1998. Stream Corridor Restoration: Principles, processes, and Practices. PB98-158348LUW.



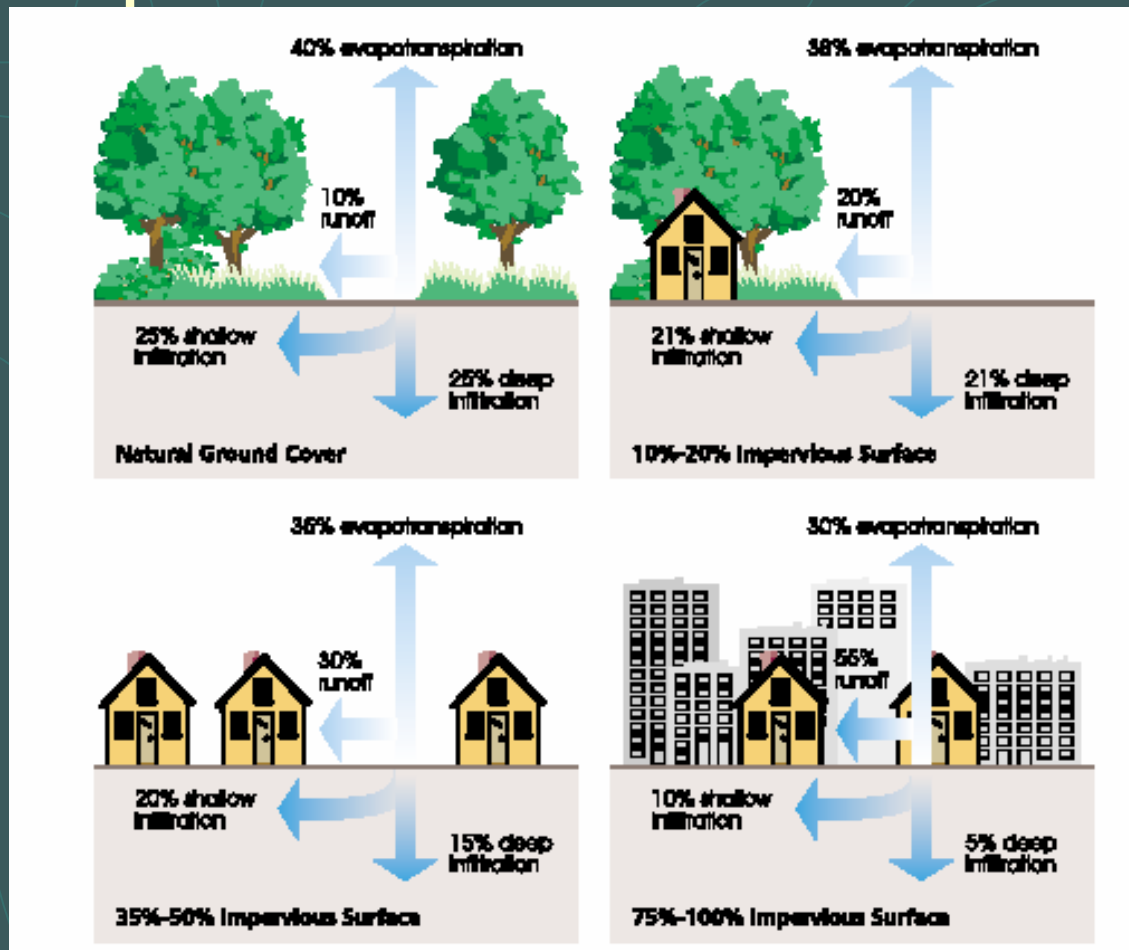
Hydrologic Disruption

- A change in the hydrology or hydrologic cycle in one part of the watershed will manifest itself as a change either there or somewhere else in the watershed.
 - Stream channel shape and size
 - Runoff: quantity, quality, and timing
 - Evaporation and Transpiration
 - Soil moisture
 - Infiltration
 - Ground water

Dr. Richard Burns

Hydrologist, Retired, USFS

Runoff Variability As Impervious Surfaces Increase



Federal Interagency Stream Restoration Working Group (FISRWG). 1998. Stream Corridor Restoration: Principles, processes, and Practices. PB98-158348LUW.

Conventional Stormwater Practices





LID Principles

- Conservation of natural features
- Minimization of impervious surfaces
- Hydraulic disconnects
- Disbursement of runoff
- Phytoremediation



LID Practices (1 of 2)

- LID practices perform both runoff volume reduction and pollutant filtering functions
 - Bioretention
 - Rain Garden
 - Sand Filter
 - Stormwater Wetland



LID Practices (2 of 2)

LID practices perform both runoff volume reduction and pollutant filtering functions

- grass swales and channels
- vegetated rooftops
- rain barrels, cisterns
- infiltration strips
- permeable pavements
- conservation design



LID Practices

- Bioretention
- grass swales and channels
- vegetated rooftops
- rain barrels, cisterns
- infiltration strips
- permeable pavements
- conservation design

A vertical strip on the left side of the slide shows a topographic map with contour lines and a yellow highlighted path. The rest of the slide has a dark teal background with faint, light blue contour lines.

LID Practices

- Bioretention/Rain Garden
- Storm Water Wetland





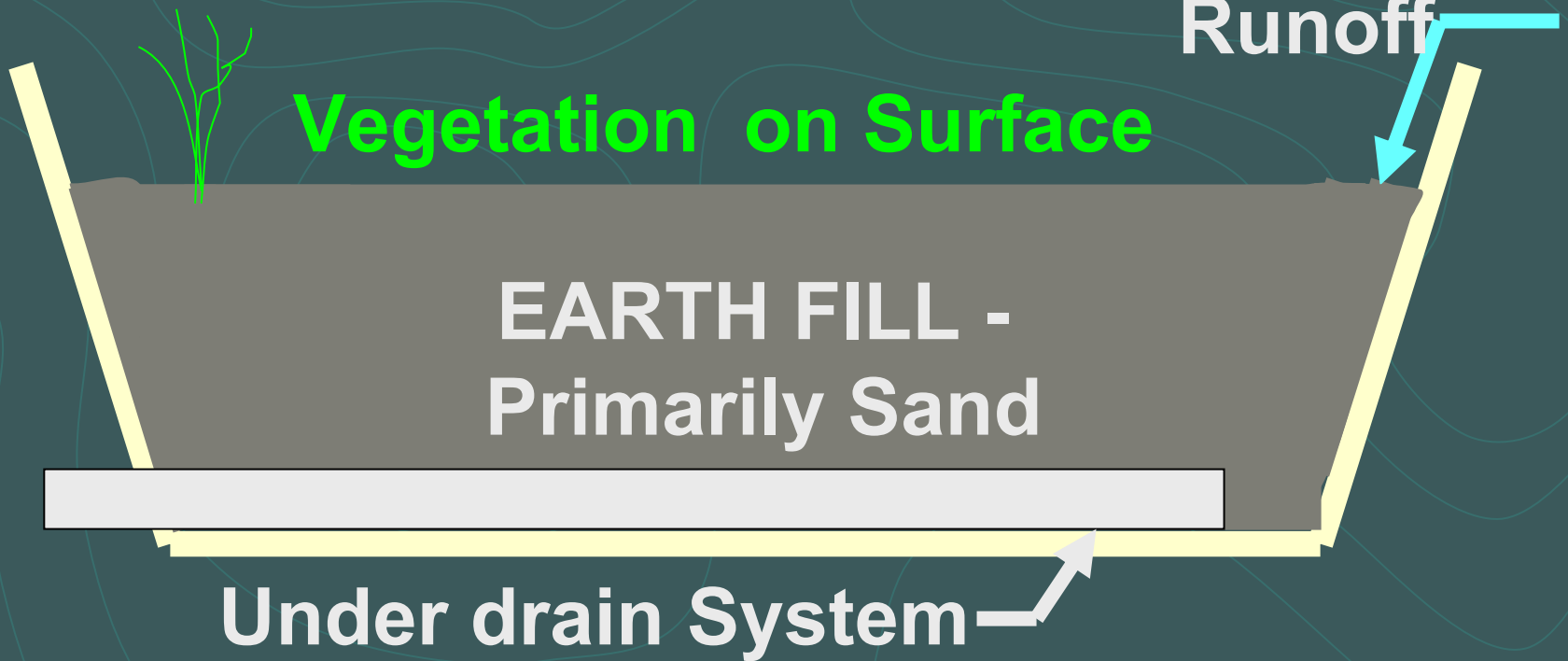
Bio-Retention Schematic

Inflow
Runoff

Vegetation on Surface

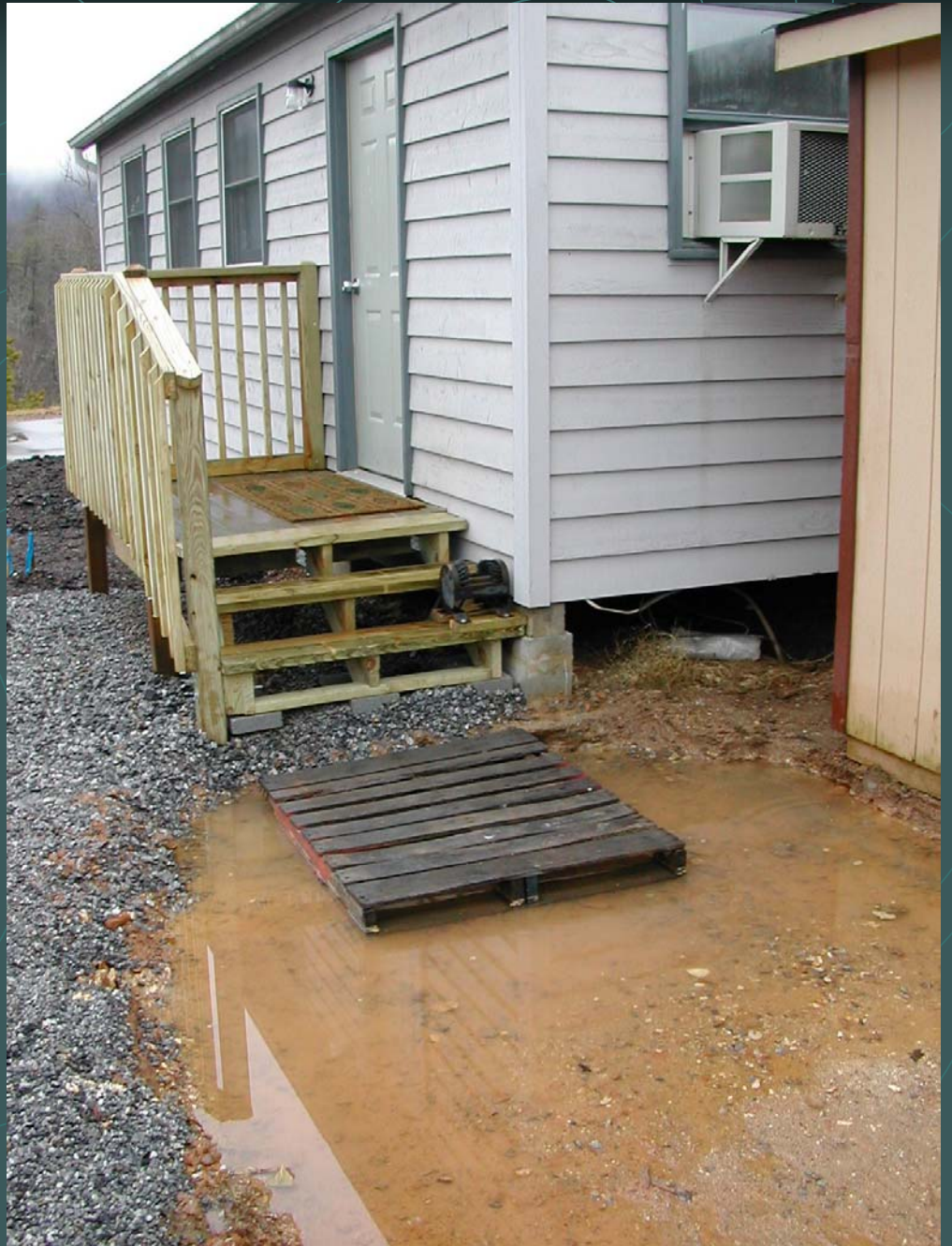
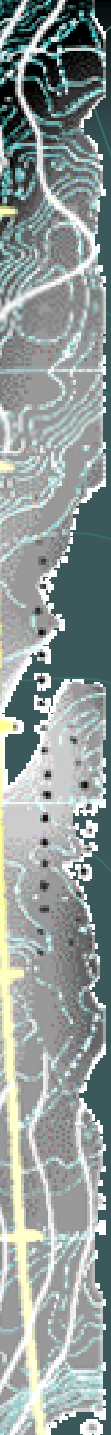
EARTH FILL -
Primarily Sand

Under drain System











A vertical strip on the left side of the slide shows a topographic map of a landscape. A yellow path or stream flows from the top left towards the bottom left, following the contours of the terrain. The map is detailed with contour lines and a grid.

LID Practices

- Rain Gardens
- grass swales and channels
- vegetated rooftops
- rain barrels, cisterns
- infiltration strips
- permeable pavements
- conservation design



LID Practices

- Rain Gardens
- grass swales and channels
- vegetated rooftops
- rain barrels, cisterns
- infiltration strips
- permeable pavements
- conservation design





A vertical strip on the left side of the slide shows a topographic map of a landscape. A yellow path or road winds through the terrain, and a stream or river flows through it. The map is overlaid on a dark teal background with light teal contour lines.

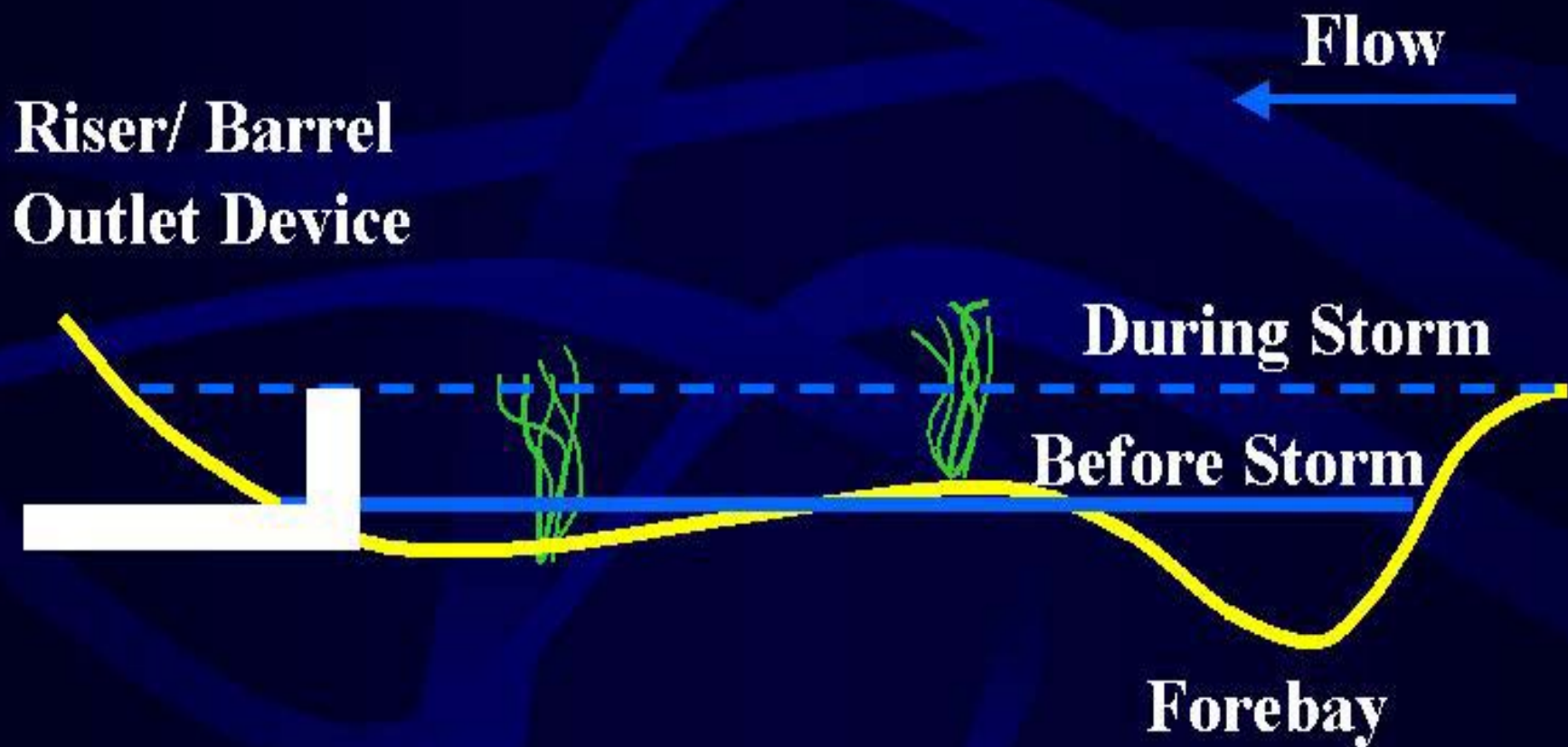
LID Practices

- Stormwater Wetlands
- grass swales and channels
- vegetated rooftops
- rain barrels, cisterns
- infiltration strips
- permeable pavements
- conservation design

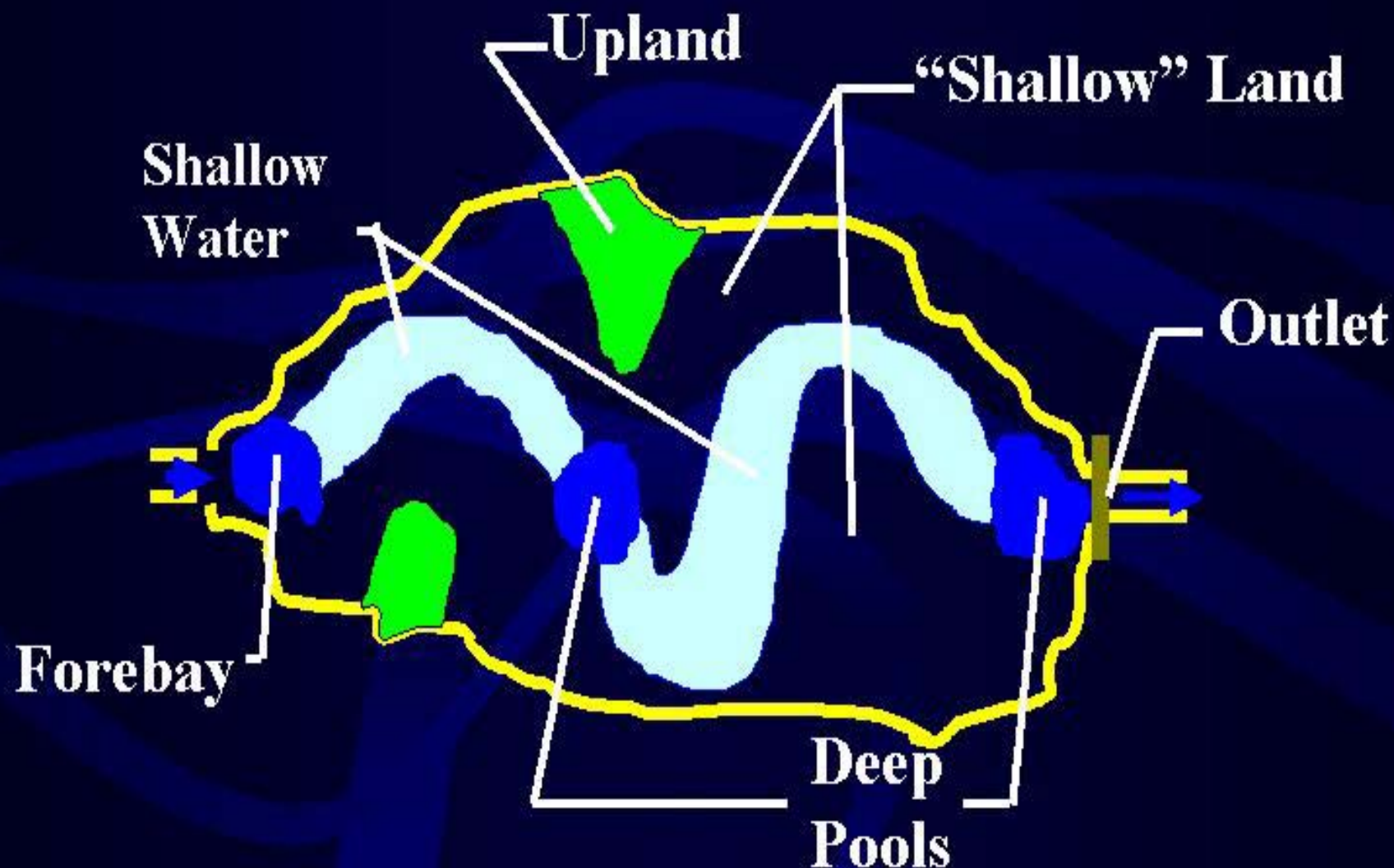
Site Selection

- **Availability of Water**
- **Depth to Water Table (Coastal Plain & Sandhills)**
- **Flatness**
- **Proximity to Unattended Children**
- **Forested or Cleared Land**
- **Outlet for Water**
- **Ease in Maintenance**

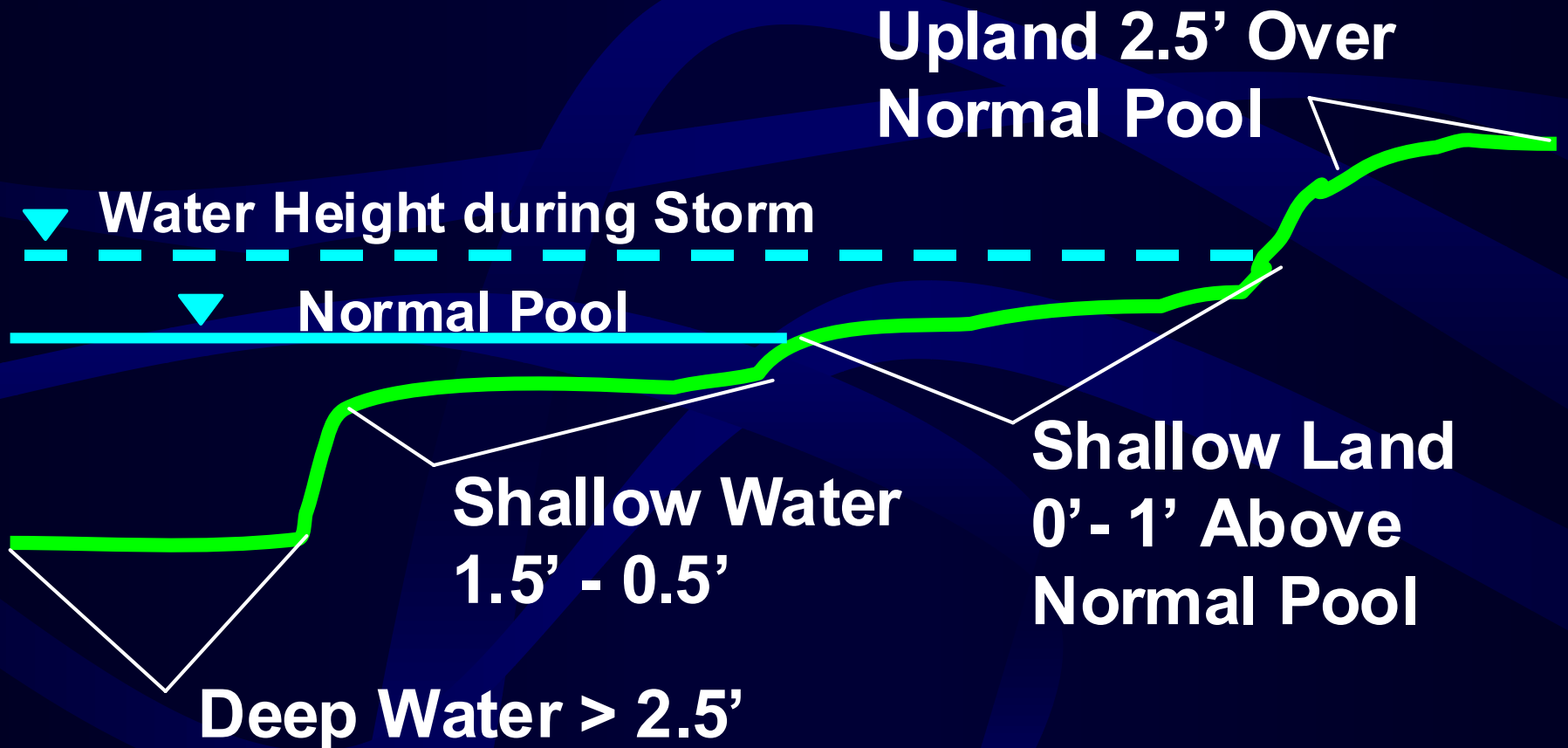
Wetland Cross Section



Stormwater Wetland Features



Internal Features





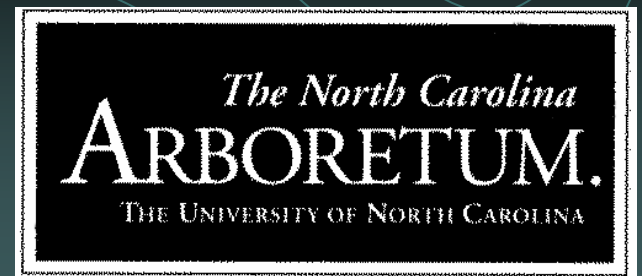




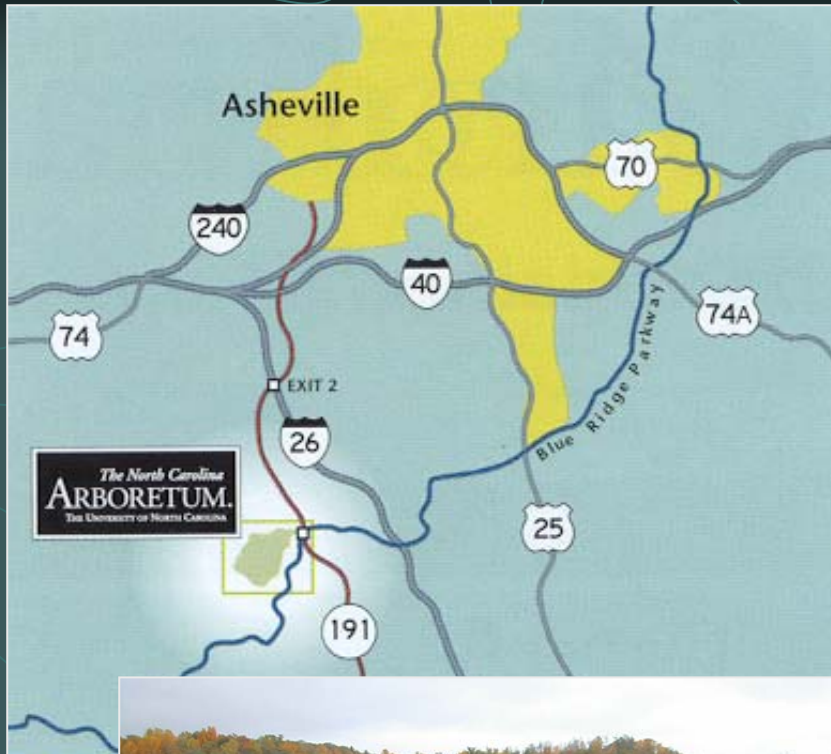


Stormwater Wetland Installation at the PPLG, The North Carolina Arboretum

Jon Calabria, Landscape Architect
NCSU Water Quality Group







Introduction

In the summer of 2002, a stormwater wetland was installed at the Plant Professional Landscape Garden (PPLG) located at The North Carolina Arboretum (TNCA) in Asheville, NC. The stormwater wetland is an example of an end of the pipe, best management practice (BMP) retrofit. It treats pollutants carried in stormwater from a roof top, parking lot and lawn area and also reduces peak discharge, minimizing erosion downstream. This project was designed by the Water Quality Group at North Carolina State University (NCSU), implemented by The North Carolina Arboretum Grounds Crew. Funding was provided by the Environmental Protection Agency's Section 319 grant program, which is administered through the North Carolina Department of Environment and Natural Resources.

Pollutant



Watershed

Existing Condition

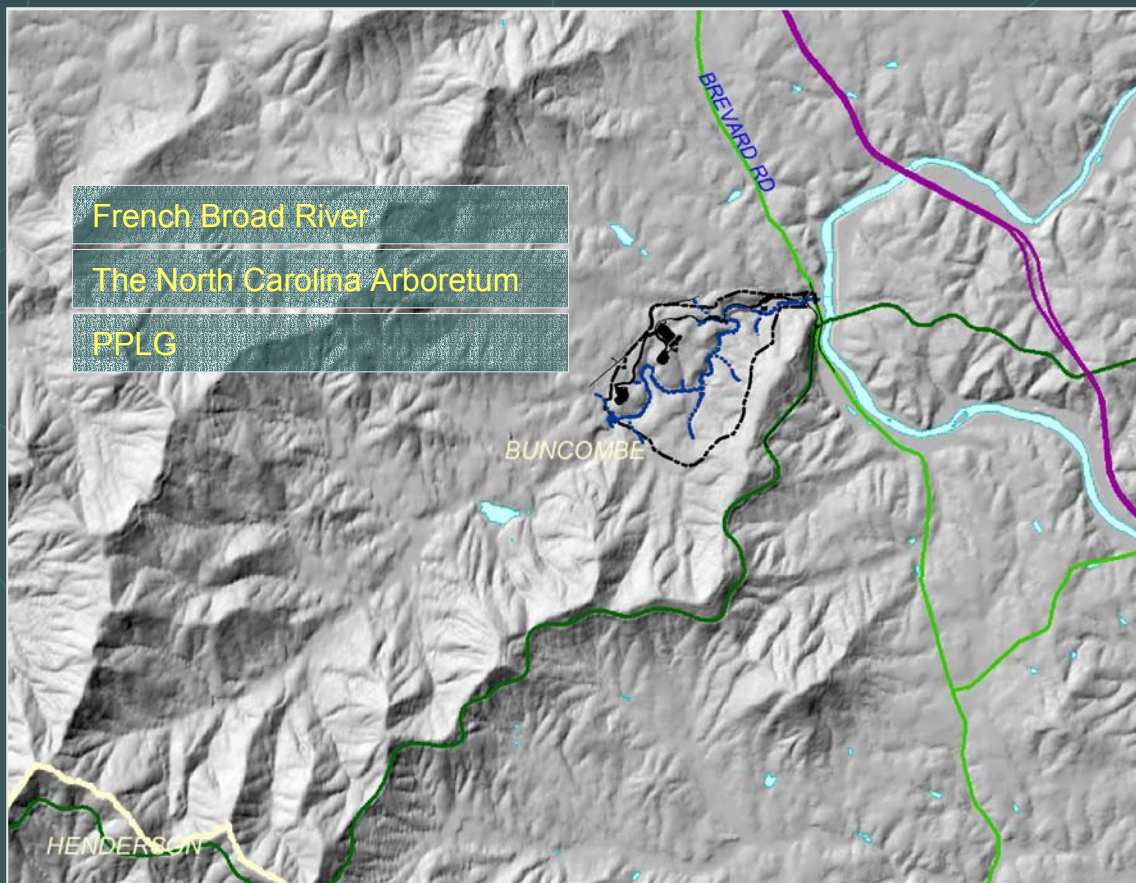
- Prior to the installation of the stormwater wetland, stormwater from a roof top, parking lot and lawn area was released without treatment, causing erosion and degrading water quality. Stormwater was directed into a culvert, which was daylighted near the entrance of the Plant Professional Landscape Garden.
- Rip-rap had been placed to dissipate the velocity at the end of the culvert. Shortly after exiting the culvert, water recollected into an eroded swale, a portion of which was armored with river stone and geotextile fabric to minimize additional erosion.
- The stormwater flows into a small, jurisdictional wetland, into Bent Creek, and then to the French Broad River.



Planning

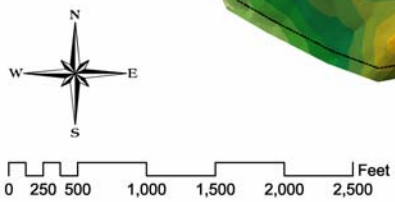
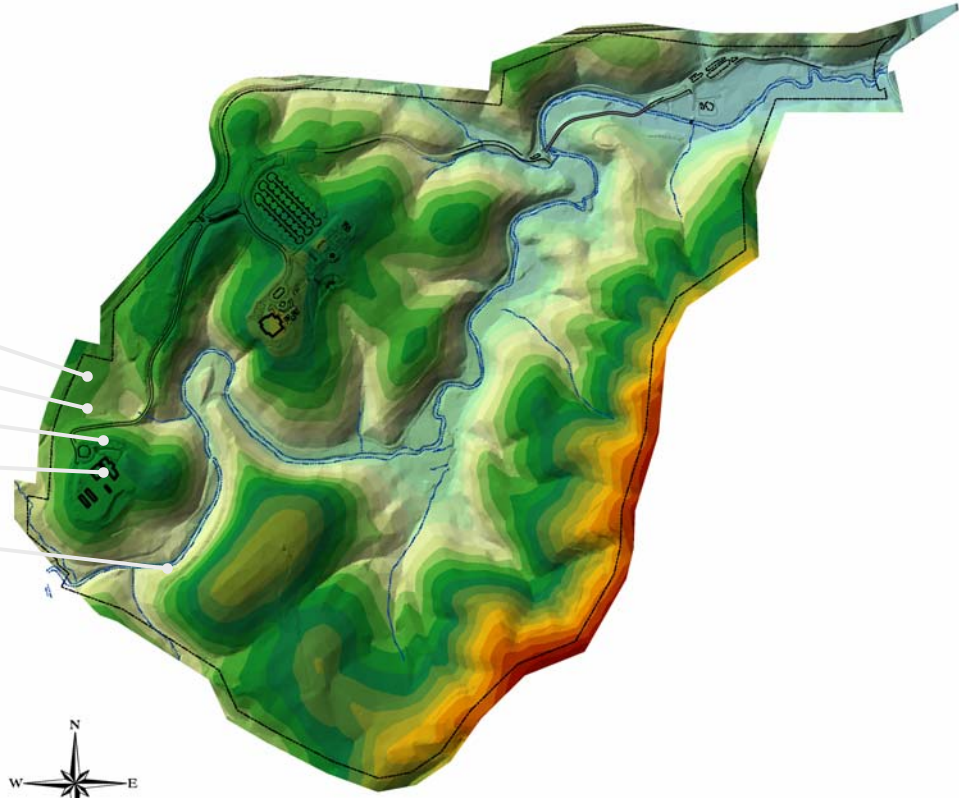
- The North Carolina Arboretum expressed a desire to address the unsightly culvert outfall at the entrance of the newly installed Plant Professional Landscape Garden (PPLG). The PPLG is a demonstration garden that also serves as a testing site for green industry professional training and certification.
- Design opportunities were sought to make the area attractive and improve water quality. Several design options were considered, including retrofitting BMP's higher in the watershed to minimize the erosive flows and armoring the existing swale up to the culvert outfall. However, a stormwater wetland was the most cost-effective option providing the maximum water quality benefit.
- The stormwater wetland would also serve as an aesthetically pleasing entrance to the PPLG and demonstrate the use of indigenous plant materials.

Bent Creek Watershed



The North Carolina Arboretum

- PPLG
- SW Wetland
- Parking Lot
- Buildings (Typ.)
- Bent Creek



Existing Condition



After One Year



Implementation

The stormwater wetland installation began in August 2002 and lasted approximately two weeks. The Department of Corrections, TNCA's staff and volunteers and NCSU Extension provided the labor. The construction sequence included:

- Installing erosion control practices
- Cutting the existing culvert back to increase the footprint
- Clearing and Grubbing
- Rough grading which included the removal of approximately forty yards of soil. Grading equipment included a track hoe excavator, dump truck, and skid loader.
- Stacked stone walls were constructed around the headwall and boulders were placed.
- The existing clay soil was toppedressed with a manufactured soil, composed of part compost and part saprolite, about two inches deep throughout the stormwater wetland.
- Biodegradable, erosion control fabric was placed on steeper slopes and then plants and mulch were installed.

Hours after the stormwater wetland was finished, droughty weather conditions were reversed and it rained!



Shortening Culvert



Grubbing



Rough Grading

Shaping Berm



Spreading Topsoil



Boulder Placement



Constructing Headwall



Installing Matting



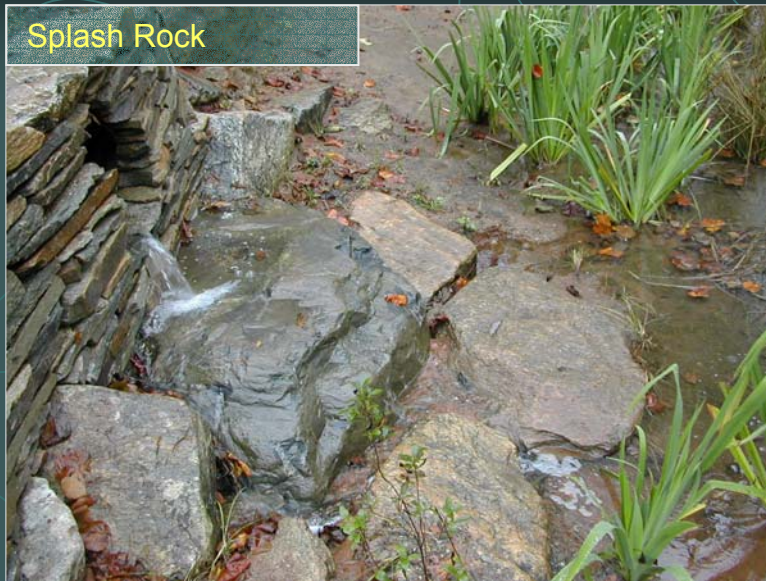
Installing Plugs



Installing Vegetation



Splash Rock



Treating Stormflow



Wetland in Snow



Conducting Tour



Watershed Outlet



Selecting Plants

Source:
Landscaping with
Native Plants

Additional Resources:
Exotic Plant Guidelines,
NC Park and Recreation,
NC DENR

Native plant recommendations

| Common name | Scientific Name | type | light | water | Common name | Scientific Name | type | light | water |
|-----------------------------------|-------------------------------|------|---------|-------|---------------------------------|-------------------------------|------|---------|-------|
| small tree (up to 25 feet) | | | | | low shrub (under 4 feet) | | | | |
| Serviceberry | <i>Amelanchier arborea</i> | D | ● ● ● ● | ▲ ● ○ | New Jersey tea | <i>Ceanothus americanus</i> | D | ● ● ● ● | ▲ ● ○ |
| *Devils-walkingstick | <i>Aralia spinosa</i> | D | ● ● ● ● | ■ ● ○ | Sweetfern | <i>Comptonia peregrina</i> | D | ● ● ● ● | □ ● ○ |
| Paw paw | <i>Asimina triloba</i> | D | ● ● ● ● | ▲ ● ○ | Snowhill Hydrangea | <i>Hydrangea aborescens</i> | D | ● ● ● ● | ▲ ● ○ |
| American hornbeam | <i>Carpinus caroliniana</i> | D | ● ● ● ● | ▲ ● ○ | Shrubby St. John's Wort | <i>Hypericum profligatum</i> | D | ● ● ● ● | ■ ● ○ |
| Chinquapin | <i>Castanea pumila</i> | D | ● ● ● ● | □ ● ○ | Drooping leucothoe | <i>Leucothoe fontanesiana</i> | E | ● ● ● ● | ▲ ● ○ |
| Eastern Redbud | <i>Cercis canadensis</i> | D | ● ● ● ● | ▲ ● ○ | Carolina rose | <i>Rosa carolina</i> | D | ● ● ● ● | ▲ ● ○ |
| Fringetree | <i>Chionanthus virginicus</i> | D | ● ● ● ● | ▲ ● ○ | Swamp rose | <i>Rosa palustris</i> | D | ● ● ● ● | ■ ● ▲ |
| Pagoda dogwood | <i>Cornus alternifolia</i> | D | ● ● ● ● | ▲ ● ○ | Cranberry | <i>Vaccinium macrocarpon</i> | E | ● ● ● ● | ■ ● ▲ |
| Flowering dogwood | <i>Cornus florida</i> | D | ● ● ● ● | ▲ ● ○ | Lowbush blueberry | <i>Vaccinium pallidum</i> | D | ● ● ● ● | ▲ ● ○ |
| Washington hawthorn | <i>Crataegus phaenopyrum</i> | D | ● ● ● ● | ▲ ● ○ | Maple-leaf Viburnum | <i>Viburnum acerifolium</i> | D | ● ● ● ● | ▲ ● ○ |
| Parashimom | <i>Diospyros virginiana</i> | D | ● ● ● ● | ▲ ● ○ | | | | | |
| Carolina silverbell | <i>Halesia carolina</i> | D | ● ● ● ● | ▲ ● ○ | | | | | |
| Common witch-hazel | <i>Hamamelis virginiana</i> | D | ● ● ● ● | ▲ ● ○ | | | | | |
| American holly | <i>Ilex opaca</i> | E | ● ● ● ● | ▲ ● ○ | | | | | |
| Red cedar | <i>Juniperus virginiana</i> | E | ● ● ● ● | □ ● ○ | | | | | |
| Umbrella tree | <i>Magnolia impetata</i> | D | ● ● ● ● | ▲ ● ○ | | | | | |
| Hop-hornbeam | <i>Ostrya virginiana</i> | D | ● ● ● ● | ▲ ● ○ | | | | | |
| Sourwood | <i>Oxydendrum arboreum</i> | D | ● ● ● ● | □ ● ○ | | | | | |
| Hoptree | <i>Ptelea trifoliata</i> | D | ● ● ● ● | ▲ ● ○ | | | | | |
| American plum | <i>Prunus americana</i> | D | ● ● ● ● | □ ● ○ | | | | | |
| Pin cherry | <i>Prunus pensylvanica</i> | D | ● ● ● ● | ▲ ● ○ | | | | | |
| *Cortina Sassafras | <i>Sassafras albidum</i> | D | ● ● ● ● | ▲ ● ○ | | | | | |
| Blackhaw Viburnum | <i>Viburnum rufidulum</i> | D | ● ● ● ● | ▲ ● ○ | | | | | |

| Common name | Scientific Name | type | light | water |
|----------------------------------|--------------------------------|------|---------|-------|
| large tree (over 25 feet) | | | | |
| Red maple | <i>Acer rubrum</i> | D | ● ● ● ● | ■ ● ○ |
| Sugar maple | <i>Acer saccharum</i> | D | ● ● ● ● | ▲ ● ○ |
| Yellow buckeye | <i>Aesculus flava</i> | D | ● ● ● ● | ▲ ● ○ |
| Yellow birch | <i>Betula alleghaniensis</i> | D | ● ● ● ● | ▲ ● ○ |
| Sweet birch | <i>Betula lenta</i> | D | ● ● ● ● | ▲ ● ○ |
| River birch | <i>Betula nigra</i> | D | ● ● ● ● | ■ ● ○ |
| Bitternut hickory | <i>Carya cordiformis</i> | D | ● ● ● ● | ▲ ● ○ |
| Pignut hickory | <i>Carya glabra</i> | D | ● ● ● ● | □ ● ○ |
| Yellowwood | <i>Cladrastis kentuckea</i> | D | ● ● ● ● | ▲ ● ○ |
| Beech | <i>Fagus grandifolia</i> | D | ● ● ● ● | ▲ ● ○ |
| Tulip tree | <i>Liriodendron tulipifera</i> | D | ● ● ● ● | ▲ ● ○ |
| Cucumber tree | <i>Magnolia acuminata</i> | D | ● ● ● ● | ▲ ● ○ |
| Black tupelo | <i>Nyssa sylvatica</i> | D | ● ● ● ● | ▲ ● ○ |
| Sycamore | <i>Platanus occidentalis</i> | D | ● ● ● ● | ■ ● ▲ |
| Red spruce | <i>Picea rubens</i> | E | ● ● ● ● | ▲ ● ○ |
| *Black cherry | <i>Prunus serotina</i> | D | ● ● ● ● | ▲ ● ○ |
| White oak | <i>Quercus alba</i> | D | ● ● ● ● | ▲ ● ○ |
| Chestnut oak | <i>Quercus montana</i> | D | ● ● ● ● | ▲ ● ○ |
| Red oak | <i>Quercus rubra</i> | D | ● ● ● ● | ▲ ● ○ |
| Post oak | <i>Quercus stellata</i> | D | ● ● ● ● | □ ● ○ |
| American linden | <i>Tilia americana</i> | D | ● ● ● ● | ▲ ● ○ |
| Canadian hemlock | <i>Tsuga canadensis</i> | E | ● ● ● ● | ▲ ● ○ |
| Carolina hemlock | <i>Tsuga caroliniana</i> | E | ● ● ● ● | ▲ ● ○ |

| Common name | Scientific Name | type | light | water |
|---|-------------------------------------|------|---------|-------|
| mid-size shrub (4 feet to 10 feet) | | | | |
| Red chokeberry | <i>Aronia arbutifolia</i> | D | ● ● ● ● | ■ ● ○ |
| Black chokeberry | <i>Aronia melanocarpa</i> | D | ● ● ● ● | ▲ ● ○ |
| Sweetshrub | <i>Calycanthus thurberi</i> | D | ● ● ● ● | ▲ ● ○ |
| Cinnamonbark | <i>Clethra acuminata</i> | D | ● ● ● ● | □ ● ○ |
| Silky dogwood | <i>Cornus amomum</i> | D | ● ● ● ● | ▲ ● ○ |
| Hazelnut | <i>Corylus americana</i> | D | ● ● ● ● | ▲ ● ○ |
| Bush-honeysuckle | <i>Diervilla sessilifolia</i> | D | ● ● ● ● | ▲ ● ○ |
| Hearts-a-bustin | <i>Eccorymus americanus</i> | D | ● ● ● ● | ▲ ● ○ |
| Large Fothergilla | <i>Fothergilla major</i> | D | ● ● ● ● | ▲ ● ○ |
| Darlea Hypericum | <i>Hypericum densiflorum</i> | D | ● ● ● ● | ▲ ● ○ |
| Common winterberry | <i>Ilex verticillata</i> | D | ● ● ● ● | ■ ● ▲ |
| Virginia sweetspire | <i>Itea virginica</i> | D | ● ● ● ● | ▲ ● ○ |
| Mountain laurel | <i>Kalmia latifolia</i> | E | ● ● ● ● | □ ● ○ |
| Spicebush | <i>Lindera benzoin</i> | D | ● ● ● ● | ▲ ● ○ |
| Sweet azalea | <i>Rhododendron aborescens</i> | D | ● ● ● ● | ■ ● ▲ |
| Flame azalea | <i>Rhododendron calendulaceum</i> | D | ● ● ● ● | ▲ ● ○ |
| Carolina Rhododendron | <i>Rhododendron carolinianum</i> | E | ● ● ● ● | ▲ ● ○ |
| Mountain rosebay | <i>Rhododendron catawbiense</i> | E | ● ● ● ● | ▲ ● ○ |
| Wild or Printer azalea | <i>Rhododendron periclymenoides</i> | D | ● ● ● ● | ■ ● ○ |
| *Pinkshell azalea | <i>Rhododendron vaseyi</i> | E | ● ● ● ● | ▲ ● ○ |
| *Elderberry | <i>Sambucus canadensis</i> | D | ● ● ● ● | ▲ ● ○ |
| *Coral berry | <i>Symphoricarpos orbiculatus</i> | D | ● ● ● ● | ▲ ● ○ |
| Hobblebush | <i>Viburnum trilobum</i> | D | ● ● ● ● | ▲ ● ○ |
| *Highbush blueberry | <i>Vaccinium corymbosum</i> | D | ● ● ● ● | □ ● ○ |
| Deerberry | <i>Vaccinium stamineum</i> | D | ● ● ● ● | ▲ ● ○ |
| Withered Viburnum | <i>Viburnum cassinoides</i> | D | ● ● ● ● | ▲ ● ○ |

| Common name | Scientific Name | type | light | water |
|-----------------------------------|------------------------------|------|---------|-------|
| large shrub (over 10 feet) | | | | |
| *Tag alder | <i>Alnus serrulata</i> | D | ● ● ● ● | ■ ● ▲ |
| Mountain winterberry | <i>Ilex montana</i> | D | ● ● ● ● | ■ ● ▲ |
| Mock orange | <i>Philadelphus inodorus</i> | D | ● ● ● ● | ▲ ● ○ |
| Rosebay Rhododendron | <i>Rhododendron maximum</i> | E | ● ● ● ● | ▲ ● ○ |
| *Smooth, smecac | <i>Rhus glabra</i> | D | ● ● ● ● | ▲ ● ○ |
| *Silky willow | <i>Salix sericea</i> | D | ● ● ● ● | ▲ ● ○ |
| *Arrowwood | <i>Viburnum dentatum</i> | D | ● ● ● ● | ▲ ● ○ |

| Common name | Scientific Name | type | light | water |
|--------------------|------------------------------------|------|---------|-------|
| vine | | | | |
| Dutchman's pipe | <i>Aristolochia macrophylla</i> | D | ● ● ● ● | ▲ ● ○ |
| Crossvine | <i>Bignonia caprostrata</i> | E | ● ● ● ● | ■ ● ○ |
| Trumpet creeper | <i>Campsis radicans</i> | D | ● ● ● ● | □ ● ○ |
| Virgin's bower | <i>Clematis virginiana</i> | D | ● ● ● ● | ▲ ● ○ |
| Climbing hydrangea | <i>Decumaria barbara</i> | D | ● ● ● ● | ▲ ● ○ |
| Coral honeysuckle | <i>Lonicera sempervirens</i> | D | ● ● ● ● | ▲ ● ○ |
| *Virginia creeper | <i>Parthenocissus quinquefolia</i> | D | ● ● ● ● | ▲ ● ○ |
| Passion flower | <i>Passiflora incarnata</i> | D | ● ● ● ● | ▲ ● ○ |
| Fox grape | <i>Vitis labrusca</i> | D | ● ● ● ● | ▲ ● ○ |

*These plants can be vigorous growers and may need more management to control.

| KEY | LIGHT | TYPE |
|-----|--|--------------------------------|
| | ● = full sun ● = part sun ● = shade | D = deciduous E = evergreen |
| KEY | SOIL MOISTURE | |
| | ■ = hydric; wet, plants periodically or often inundated by water | |
| | ▲ = mesic; moist, adequate soil moisture retention year-round | |
| | □ = sub-xeric; moist to dry, seasonally moist, periodically dry | |
| KEY | ○ = xeric; dry & drought resistant, little moisture retention, excessively drained | |

Introduction to Multiple Use Riparian Plants



Developed by:
Cliff Ruth

Cross County Agricultural Extension
Agent



Qualifiers for Quagmires

Amelanchier canadensis (serviceberry)

Euonymus americana (American euonymus)

Qualifiers for Quagmires: Landscape Plants for Wet Sites

Revised 2/94 -- Author Reviewed 12/98 HIL-8646

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Itea virginica

Virginia Sweetspire



Clethra alnifolia
Sweet Pepperbush



Fothergilla sp.
Fothergilla



Viburnum dentatum

Arrowwood



Cornus amomum
Silky Dogwood



Rosa carolina
Carolina Rose



Xanthorrhiza simplissima
Yellowroot



Lindera benzoin

Spice Bush



Sambucus canadensis

American Elderberry



Asimina triloba

Pawpaw



Corylus americana
American Hazelnut



Ilex opaca
American Holly



Ilex decidua
Possumhaw



Itea virginica

Virginia Sweetspire



Springtime at Stormwater Wetland



Iris virginica
Blue Flag



Full Pool



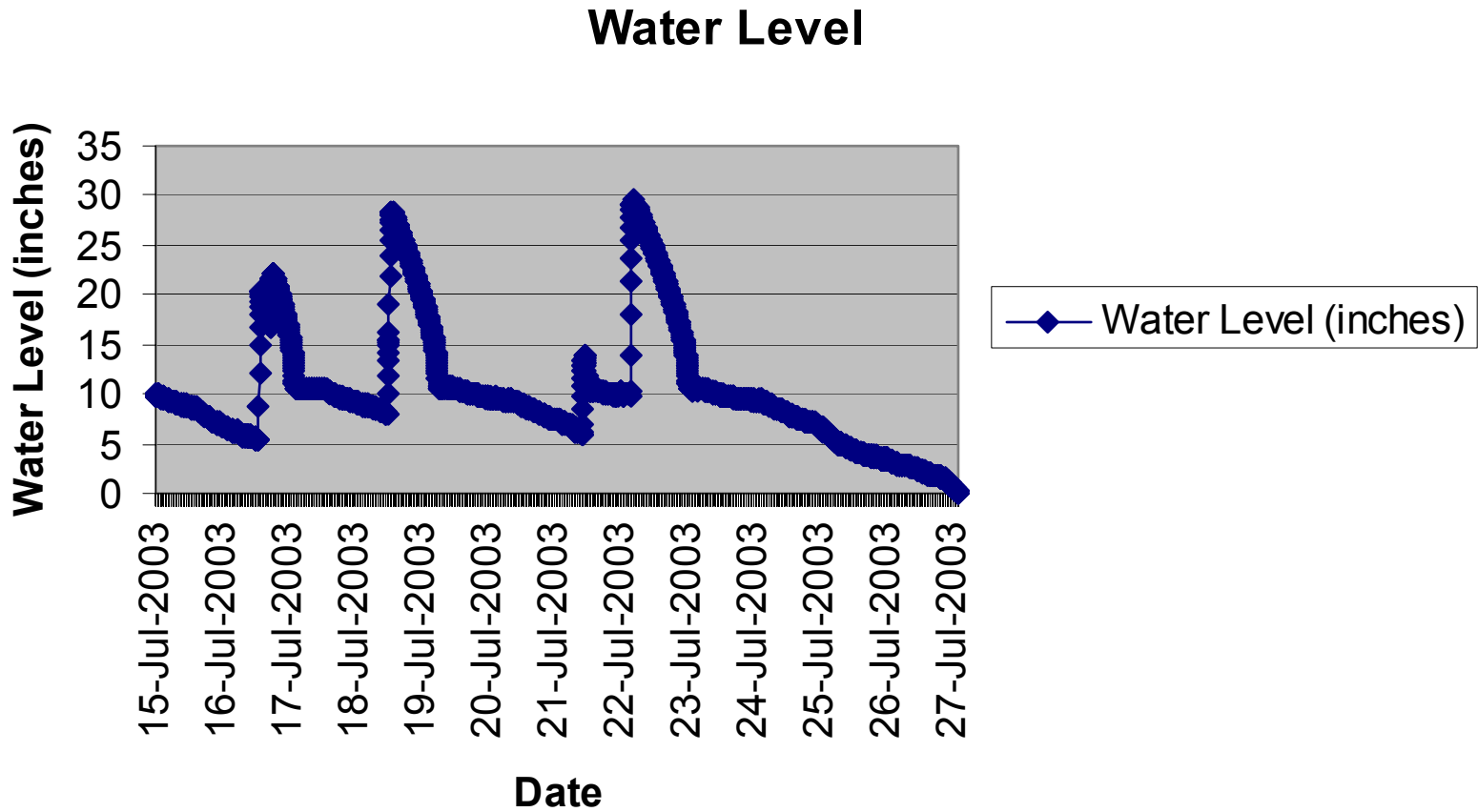
Stormwater Treatment



Draw Down



Water Level



After Draw Down

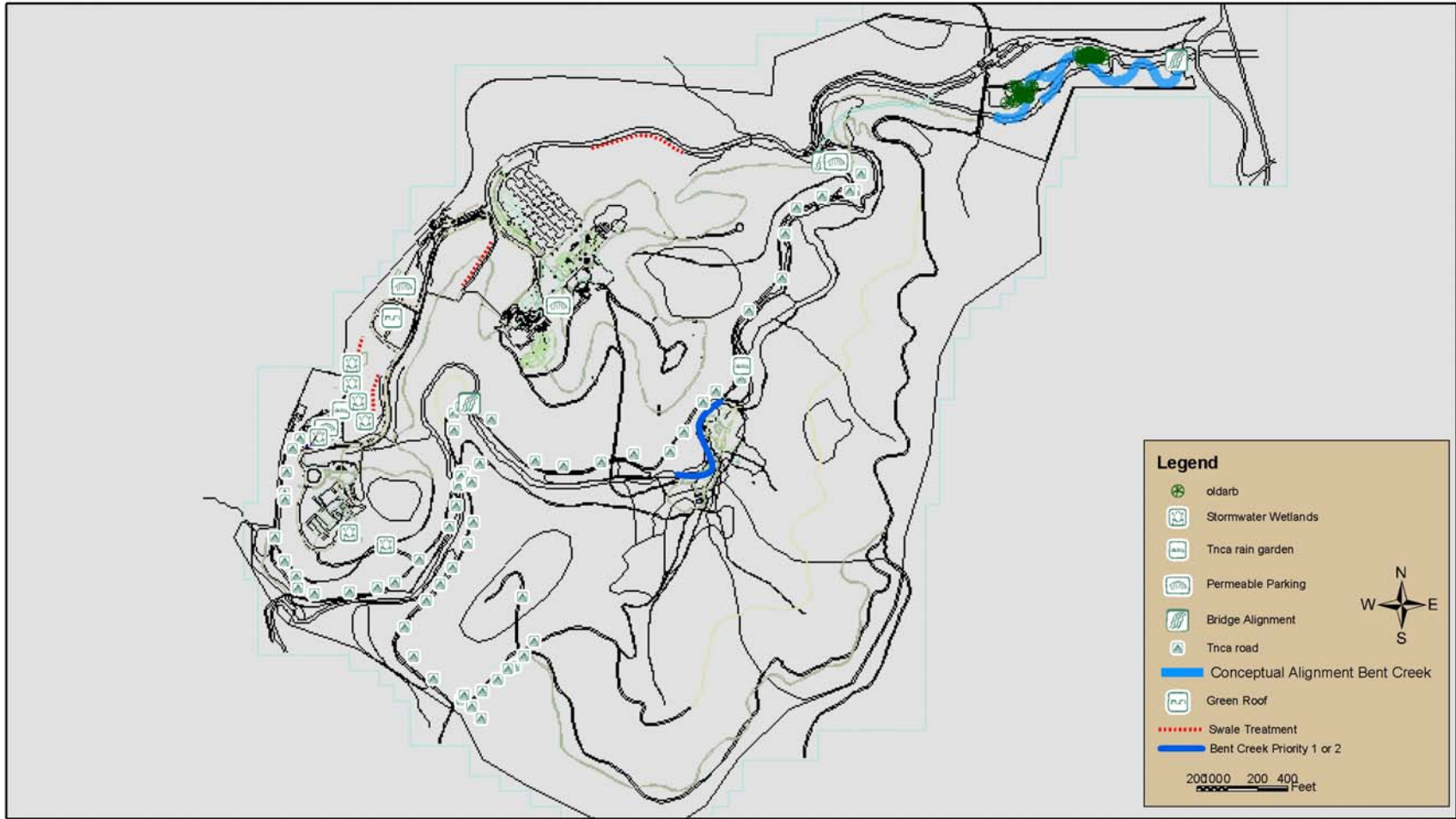


Aggressive Exotic Vegetation



What's next?





Preliminary Plan
319 Bent Creek BMP and Stream Restoration
The North Carolina Arboretum, Asheville, NC

Upper French Broad Watershed Training Center
 Soil and Water Environmental Technology Center
 Water Quality Group, North Carolina State University
 September 2003



Jon Calabria, Landscape Architect
Upper French Broad
Watershed Training Center Coordinator
Water Quality Group,
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