Protocol 5 Planting Guidelines

A. Purpose of this Protocol

The purpose of the Planting Guidelines (Protocol 5) is to help the designer identify appropriate plant choices for site-specific BMPs (both restorative and structural), and to provide guidance on less familiar planting methods and plant establishment techniques.

B. Vegetated Systems in Stormwater Management

Plants, soils, microorganisms, and water should be understood together as a living system, used to harness natural processes to mitigate stormwater impacts and other benefits. Plants and their relationship to microorganisms and soil structure are an integral component of vegetated BMPs. Choosing the right plants and keeping them healthy will help to ensure that a vegetated BMP performs most effectively. Whether the BMP is protective, restorative, or structural, the major stormwater functions of vegetation are to reduce stormwater volume and velocity by:

- Evapotranspiration primarily from plant leaves
- Infiltration by root channels in the soil
- Slowing and filtering of sediment by aboveground plant mass

C. General Design Strategies

The following are general considerations and design strategies that are now commonly used. Plant selection criteria are detailed in Section 2 below.

1. Native or Non-Native—but Never Invasive Exotic

    a. Although the term "native plant" has become part of the botanical, horticultural, and even the public vocabulary, there is little agreement on its definition. In this manual, native plants are defined as those plants that have evolved with other plants and animals in response to specific conditions of climate, geology, landforms, soils, and water, and that are not genetically altered by human beings.

    b. “Exotic” plants are defined as plant species has been brought from their native habitats and planted during and since settlement of the region. Exotic plants are still being carried away from their native habitats and introduced to new places, by intention or by accident. There is a general consensus in the scientific community that an “exotic” plant, which does not spread aggressively in the landscape or significantly alter existing environmental conditions, is relatively harmless and can be planted.

c. "Invasive exotic," also known as "invasive" or "noxious weeds," are defined as introduced species (also called "non-indigenous, non-native or pest" species). These species are potentially poisonous to livestock, multiply prolifically, and gradually alter or displace the native landscape. They can disrupt and even obliterate native plant communities and significantly change local habitats. Invasive exotic species often are so successful because human beings have reworked and damaged local conditions.

There is also scientific evidence that a non-native "invasive plant," which multiplies and spreads aggressively and has the potential to take over and to eliminate a complex, dynamic eco-system, is problematic. Because of the economic and environmental damage created by these plants, they are not to be used on any project site or for any BMP.
Invasive exotic plants frequently found in eastern Tennessee are listed at:
http://www.tneppc.org/invasive_plants.

The USDA Federal and State Lists of Invasive and Noxious Weeds can be found at:
http://plants.usda.gov/java/noxiousDriver#state.

***Both of these lists are continually updated, so they are not included in this appendix. The project owner and the design team should check proposed plants against these lists to be sure no problematic plants are included in the design.**

d. "Cultivars" and "ornamentals" are non-native plants. Cultivars are plant varieties produced in cultivation by selective breeding. These plants are generally selected for a particular characteristic or combination of characteristics, and when propagated, retain these characteristics. An ornamental plant is a cultivar, grown for decorative purposes and used most frequently in garden and landscape designs for display.

Non-native plants that have originated in environmental conditions that are similar to local environmental circumstances and that are tolerant of local conditions can be particularly useful, both to fulfill the specific demands of certain BMPs and to provide a wider and showier plant palette; however, they are not suited to ecological restoration projects.

2. General Species Selection/Specific Site Variables

Selecting species that are a "good fit" with specific site conditions is a key factor in determining the success of vegetated BMPs of all kinds. Plants that are well-adapted to the unique constraints of a project site and to the specific BMP will thrive and contribute significantly to the repair of the hydrologic system.

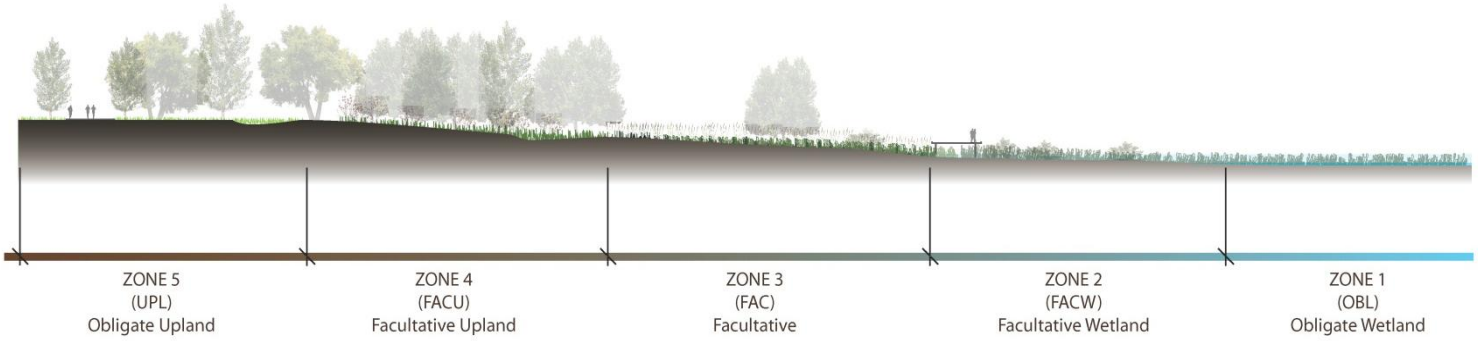
Understanding the specific soils, landforms, exposure, hydrology, and existing natural vegetation is crucial to determining which species will quickly form stable, self-supporting communities and sustain a high-performance landscape. Appropriate species selection should also decrease long-term costs by reducing energy and nutrient inputs.

Refer to the appropriate plant database for the following information:

a. Soil Moisture
Structural BMPs can create large fluctuations in soil moisture. Plants in these engineered facilities need to be able to withstand both temporary inundation and extended drought once established.

Moisture conditions can be described by gradient, described and shown below as a series of zones. As moisture conditions fluctuate, plants can change zones. These zones range from 1, constant standing water to 5, well-drained uplands:

- ZONE 1 – Obligate Wetland (OBL): plants that grow in standing water more than 99 percent of the time. These plants are also called hydrophytes, floating leaved plant communities, and emergent plant communities.
- ZONE 2 − Facultative Wetland (FACW): plants that usually occur in water (67 to 99 percent of the time); occasionally found in non-wetland environments.
  USDA: Usually is a hydrophyte but occasionally found in uplands emergent zone.
- ZONE 3 − Facultative (FAC): plants that are equally likely to occur in wetland or non-wetland environments (34 to 66 percent of the time).
  USDA: Commonly occurs as either a hydrophyte or non-hydrophyte.
- ZONE 4 − Facultative Upland (FACU): plants usually found in uplands (67 to 99 percent of the time); occasionally found in wetland environments.
  USDA: Occasionally is a hydrophyte but usually occurs in uplands.
- ZONE 5 – Obligate Upland (UPL): rarely is a hydrophyte, almost always in uplands (99 percent of the time or more).



b. Flood Tolerance/Drought Tolerance

The ability of a plant to tolerate occasional submersion is an important consideration in the selection of plants for wetlands, stormwater basins, and floodplains. The depth of water and the duration of submersion affect the plants need for air exchange through leaves. Submersion for extended periods of time will kill plants intolerant of low oxygen conditions.

The USDA plant database provides a description of a particular plant's tolerance to drought as well as anaerobic conditions (flood). *http://plants.usda.gov/adv_search.html*

c. Soil pH and Type

For many bioretention facilities, soil specifications call for sand. Most sand from Chattanooga area sources is typically limestone based manufactured sand which result in alkaline soil mixes and cannot be modified to lower its pH by amendments (i.e., sulfur). Additives will drive down pH for a year or two, but eventually the soil reverts back to a higher pH. Neutral or low pH sand will need to be provided from nearby mountain or river sources, or plant choices will need to be tolerant of higher pH. The *USDA plant database provides minimum and maximum pH tolerances for plants*. *http://plants.usda.gov/adv_search.html*

d. Light

All plants require some light to produce food, but not all plants require the same amount of light. Select plants based on need for sunlight and/or shade tolerance. The USDA website above *and TVA website at (http://www.tva.com/river/landandshore/stabilization/plantsearch.htm)* provide assistance in the selection of plants based on light requirements.

e. Microclimate

The climate of a specific place within a larger area needs to be considered as well as plant zone, general winds, etc. Local variations may result in colder, frost-prone environments. Some areas may experience more consistent winds than typical for the larger area. It can be something as

simple as a consistently shady spot on an otherwise sunny site. Careful observation and input from local residents will be helpful.

f. Salt Tolerance
Plants adjacent to roads (especially highways) and pedestrian pathways that receive snow-melt salts should be selected for greater salt tolerance. Salting is infrequent and is generally limited to major arteries, roads at higher elevations, and routes to emergency facilities (fire and police stations, hospitals, etc. Plants have a range of tolerance to salt. *The USDA Plant database provides a description of a particular plant's tolerance to salt.*
http://plants.usda.gov/adv_search.html

g. Height and Spread of Plant and Width and Depth of Root System

h. Consider height, spread, and type/extent of roots at maturity when selecting canopy, understory trees, and large shrubs. Avoid under-drains and other utilities. Shallow rooted trees are more likely to heave pavements and out-compete smaller plants for soil moisture and nutrients. Planting Time

   i. Optimum planting time for turf grasses is spring, between March to May, and fall, from September to November, depending on the weather.
   ii. Optimum planting time for canopy trees, understory trees, shrubs, and woody ground covers is fall-winter, November 15 through February 15, before the first frost, when woody plants are dormant.
   iii. Bare root material should not be planted from April 15 through October 15, due to summer heat and drought stress.
   iv. Containerized stock can be planted at any time soil is workable, but must be watered in hot, dry periods.

i. Establishment Period – Warranty Period
   i. In general, the nursery contractor should match its guarantee period to the establishment period. The length of this establishment period varies with plant type.
      - Turf grasses − 60 days
      - Native (warm season) meadow grasses − 2 to 3 years
      - Perennials − 3 months
      - Trees − 2 years
      - shrubs − 1 year
      - Live stakes − 1 to 2 years
   ii. The warranty period is usually the same as the length of the establishment period. During this time, the contractor may be responsible for watering, etc., and is generally responsible for replacing dead and dying plants.

iii. The period immediately following planting is critical for survival. "Balled and Burlapped" plants have lost roots. Immediately after planting, plants typically require approximately 1 inch of water per week if there is no rain.

iv. Weeding during the establishment period prevents competition from undesirable plants. For minimum disturbance, remove unwanted plants manually. Mowing will keep weeds in check, more frequent mowing will favor grasses. Meadows can be mown at specific times to favor specific species.

j. Plant Stock and Availability

i. Plants should conform to the standards of the American Standard for Nursery Stock, as approved by the American National Standard Institute (ANSI). Note that these standards establish only the minimum requirements for nursery-grown plants, i.e., relation of size of crown of plant to root ball dimension, or minimum number of stems for shrubs based on size. Higher-quality plants may be preferred by the client and provided by a reputable nursery.

ii. Using smaller plants is often more effective since they are less expensive, easier to handle, experience less transplant shock, require less initial irrigation, and adapt more quickly to the site.

iii. An extensive list of appropriate species typically available from commercial nurseries in and around Tennessee can be found at the end of this Appendix. Where not readily available, plants can be contract grown.

k. Seed Stock and Availability

i. The addition of a companion or "nurse" crop (quick-growing annual or weak perennial added to permanent mixtures) is a good practice on difficult sites, for late seeding, or in situations where the development of permanent cover is likely to be slow. The companion crop germinates and grows rapidly, holding the soil until the perennial species becomes established. The seeding rate of the companion crop must be limited to avoid crowding, especially under optimum growing conditions.

Nurse Crop/Companion Crop Suggestions:

Name	Scientific Name	Planting Dates	Broadcast Pure Live Seed	Notes
Barley	*Horduem vulgare*	August – November	144 lbs. per acre* 3.3 lbs. per 1000 sq. ft.*	14,000 seeds per pound. Winter hardy. Use on productive soils.
Weeping Love	*Eragrostis*	March – June	4 lbs. per acre*	1,500,000 seeds per pound. May last for

Grass	*curvula*		0.1 lbs. per 1000 sq. ft.*	several years. Nice addition to a meadow mixture.
Common Oats	*Avena sativa*	September – November	128 lbs. per acre* 2.9 lbs. per 1000 sq. ft.*	13,000 seeds per pound. Use on productive soils. Not as winter hardy as barley or rye.
Rye	*Secale cereal*	July – November	168 lbs. per acre* 3.9 lbs. per 1000 sq. ft.*	18,000 seeds per pound. Drought tolerant and winter hardy.
Annual Rye	*Lolium multiflorum*	August – April	40 lbs. per acre* 0.9 lbs. per 1000 sq. ft.*	227,000 seeds per pound.
Wheat	*Triticum Aestivum*	September – December	180 lbs. per acre* 4.0 lbs. per 1000 sq. ft.*	15,000 seeds per pound.
Virginia Wild Rye	*Elymus virginicus*	September – December	20 lbs. per acre* 0.5 lbs. per 1000 sq. ft.*	80,000 seeds per pound. Likes moist sites.

*Planting rates shown above are for a single species cover crop. Adjust seeding rates for mixtures of seeds accordingly. Reduce seeding rates by 50 percent for drill seeding applications.

ii. For both turf and meadow, seed mixes with a diversity of species are preferable to a single species mix. Mixtures provide greater adaptability to different growing conditions and better tolerance to disease and pests.

iii. Meadow Grasses: Sources include specialized wildflower seed companies, as well as some traditional turf grass or agricultural seed producers. Selection for meadow seed should be based on local conditions and may include a nurse crop to stabilize the soil ahead of slower germinating grasses and wildflowers as part of erosion and sediment controls. Meadows do best on nutrient-poor soils.

iv. Turf Grasses: USDA certifies and regulates turf grass purity, germination rate, crop content, and weed content. The label should indicate the producer state, the seed distributor, and mix or blend according to the test methods and procedures of the Association of Official Seed Certifying Agencies.

v. Quality seed should be acquired from reliable sources.

l. Disease Risk

Consider Emerging Disease Risk when Choosing Plant Species:
Careful attention to tree health is especially important in places where people will frequently be passing through or visiting. Ultimately, trees should need little help in surviving, but during construction activities, it is possible that undesirable environmental conditions can stress trees and make them more susceptible to pests and diseases. It is suggested to proactively manage an urban forest to protect noteworthy trees from emerging diseases and insects. The following tree species are subject to severe insects/diseases and, at present, may require annual inspections and/or treatments to support their long-term health:

i. American elm – Dutch elm disease. Without annual preventive treatment, American elms have an uncertain lifespan. There are, however, new disease-resistant cultivars such as "Valley Forge", "Princeton" and "New Harmony."
ii. Ash – emerald ash borer. The emerald ash borer has been found in Tennessee. Containment of the emerald ash borer is a difficult task and the long-term outlook for ash species is uncertain. Annual preventive treatments are available for individual trees. Planting new ash trees is not recommended.
iii. Red oak group (e.g., red oak, pin oak, scarlet oak) and to a lesser extent sycamores, maples, elms – bacterial leaf scorch (BLS). This chronic disease causes infected trees to chronically decline and die. While there is neither prevention nor a cure for BLS, watering during drought periods may reduce disease symptoms and help extend the lifespan of infected trees. Prompt removal of infected wood may help slow the progress of the disease; however, this management technique has not been scientifically validated. Trees at risk for BLS, especially the red oak group, should be protected from environmental stresses such as drought, salt, and root damage. Successful tree protection during design and construction can help extend the lifespan of trees susceptible to BLS.
iv. Hemlock - woolly adelgid (HWA). The woolly adelgid is a pest from East Asia that attacks the eastern hemlock (*Tsuga Canadensis*) and the Carolina hemlock (*Tsuga caroliniana*), sucking the sap and injecting a toxin while feeding. Like the ash tree, containment has been difficult and few options are available to control the pest. While advancements are being made in producing a resistant cultivar, planting new hemlocks is not recommended at this time.

3. General Planting Methods

a. Seeding Grasses and Wildflowers
The method employed will depend on the scale of work, budget, terrain, etc.
Seeding methods include:
i. Broadcasting (spreading seed on the surface of the ground)
   - Broadcast seeding is the cheapest and fastest method.
ii. Drill seeding
   - Drill seeding provides the best soil/seed contact.
iii. Hydro-seeding

- Hydro-seeding is used on more difficult terrain and large areas. Seed and mulch can be applied separately in two steps, or in combination. It is a two-step process, which provides better soil/seed contact for higher germination rates.

b. Planting Trees, Shrubs, and Small Plants
Plants should be planted in prepared planting soil of sufficient width and depth to support the long-term growth of the plant.
   i. Balled and Burlapped, and Container-Grown Trees and Shrubs:
      - Excavate soil approximately three times as wide as the root ball diameter and to depth of root ball.
      - Check for evidence of unexpected water seepage or retention in planting pit before planting.
      - Examine root balls and remove stem girdling roots and kinked roots.
      - Remove containers and burlap, rope, and wire baskets from tops and sides of root ball.
      - Set root ball in center of planting pit with plant plumb and with root flare at adjacent grade.
      - REMOVE all plastic wrapping; where wrapped in burlap, cut off the top one-third. If ball has a wire basket, REMOVE the entire basket.
      - Backfill pit with mix of equal parts original excavated soil and planting soil.
      - Apply mycorrhizal inoculants into backfill according to manufacturer's instructions.
      - Backfill around root ball in layers and tamp to settle soil and eliminate air spaces.
      - When pit is half full, water thoroughly. Continue backfilling with planting soil.

c. Bare-Root Stock
Woody plant seedlings lifted from the nursery soil and delivered with their roots bare of soil.
   i. Roots of bare-rooted stock shall be kept moist and protected from freezing during planting operations by placing in a water-soil (mud) slurry, peat moss, sphagnum moss, superabsorbent (e.g., polyacrylamide) slurry or other equivalent material. (Note: Do not soak trees in water for more than 8 hours.)
   ii. The planting trench or hole must be deep and wide enough to permit roots to spread out and down without doubling, J-rooting, or L-rooting.
   iii. If the roots are too long for the planting equipment, minimal pruning of small end roots may be needed. Do not prune back into the main root system or more than 25 percent of the total root length.
   iv. Prune out any diseased root branches. Pack soil around each plant firmly to eliminate air pockets after planting.

d. Ground Cover and Small Plants
   i. Use planting soil for backfill. Dig holes of sufficient size to allow for spreading of roots.
   ii. Cut pot-bound roots and dip in solution of root dip and mycorrhizal inoculants complying with manufacturer's written instructions.

iii. Plant root ball by working soil around roots to eliminate air spaces, and leave a slight saucer indentation around plants.
iv. Plant top of root ball flush with adjacent grades.
v. Water soil thoroughly and apply 2 to 3 inches of mulch on surface.

e. A less conventional, but effective way to preserve soil structure, small plants, microorganisms, seed reservoirs, etc. is to cut and stockpile the upper soil layers as a "sod" *(*see 5.2.4.2, Soil and Plant Salvage, in this manual).

f. Live Staking of Floodplain and Wetland Woody Plants (See Detail)
Live stakes are cuttings taken from living plants capable of rooting quickly when placed in soil.
i. The cut stems develop root systems holding the soil in place.
ii. Native floodplain and wetland species are good candidates for live stake planting. Species include willow, shrub dogwood, box elder, sycamore, and elderberry.
iii. Also used, but with less success, are alder, sycamore, and viburnum. Willow is often used in combination with other species as it seems to stimulate root development in the other species. The ability to establish themselves quickly makes the plants especially suited for bank and slope stabilization. The ease of transport is an added benefit.
iv. Planting timing: February to early March when plants are completely dormant (before bud swelling), and when ground is not frozen. Keep stems moist. Plant the same day if possible.
v. Live stake description: Dormant, healthy green wood with a minimum of two bud scars near the upper part of the stem, 2 to 4 feet long. Cut the top end of the stem square and the bottom end of the stem at a 45-degree angle to identify which end to insert in the ground.
vi. Insert bottom end of cuttings into soil at a 45-degree angle and tamp soil around the stem. To avoid splitting the stake, use a dead blow hammer that has sand or shot in the hammerhead. In hard soil, use an iron bar or steel pipe to create a hole for planting. Discard split stakes and replace with new live stakes.
vii. Additional techniques including whips, fascines, and wattles. See: http://www.fs.fed.us/publications/soil-bio-guide/guide/chapter5.pdf.

D. Mulch and Compost

1. Mulch is defined as a material applied as a layer over the soil. Mulch typically includes organic materials, but also could include stone aggregates.
2. Compost is decomposed organic matter used as a **soil amendment** to improve the tilth of the soil.

E. Mulch for Vegetated Stormwater Systems

As a part of a vegetated BMP system, mulch provides a number of critical functions:
1. Acting as a sponge, soaking up stormwater and allowing water to infiltrate soil slowly and also maintaining soil moisture for plants.

2. Inhibiting evaporation from soil.
3. Discouraging the establishment of weeds.
4. Mitigating wind and water erosion. Where this is a primary function, degree of slope and soil type should help determine effective mulch types.
5. Hardwood mulch can absorb heavy metals from stormwater.
6. Moderating soil temperatures.

F. Mulch Selection

As a general rule, use mulch that complements the types of plantings being established. Use straw (or similar) mulch for meadows, leaf litter (or similar) mulch for woodland plantings, etc. Compost grass clippings and sods separately from the leaves of woody plants. These two types of organic material develop different micro-biota (specific to grass or to woody plants) in the process of decomposing. This recommendation does not necessarily apply to ornamental plantings.

1. Mulch for Seeding
   Mulch used to cover seed is typically fine in texture and lightweight, to protect seeds from drying out. This mulch should generally be straw or fiber with tackifiers.

   a. Straw mulches include salt hay or threshed straw of agricultural crops (wheat, rye, oats, barley, etc.) and must be air-dried, clean, and mildew and weed-seed free. Hay from native, warm-season grasses can also be used and does not need to be seed-free. Straw may be spread by hand or blower to form a uniform layer ¾ inches in loose thickness. It can be anchored by crimping with a disk, or by spraying with a bonding agent/tackifier.

   b. Fiber is a biodegradable, dyed-wood, cellulose-fiber mulch. It is nontoxic and free of germination inhibitors or living plants. It has a pH range of 4.5 to 6.5 (slightly acid to relatively neutral). Fiber mulch is typically applied by hydro-spray according to the manufacturer's written instructions. Seed and fiber mulch can be applied together in a single-step process, or separately for better soil/seed contact.

2. Mulch for Planted Meadows
   Wildflowers and grasses grown in containers should be straw and can include salt hay or threshed straw of agricultural grasses (wheat, rye, oats, barley, etc.) and must be air-dried, clean, and be mildew and weed-seed free. Hay from native, warm-season grasses can also be used. Straw mulch may be spread by hand or blower to form a uniform layer ¾ inches in loose thickness.

3. Mulch for Woody Plants
   Mulch for woody plants can be thicker and denser than mulch for seeding, and is resistant to erosion by wind and water.

a. Materials can include shredded hardwood, ground or shredded bark, salt hay or threshed straw, pine needles, and peanut, pecan, and cocoa-bean shells. Individual particle sizes should range from ½ inch to 3 inches in circumference.
b. Mulch should be no more than 3 inches thick to allow exchange of gases from soil to atmosphere.

4. Mulch for Structural BMPs
   Mulches that float when wet should be avoided in structural BMPs.
   a. Mulch that floats can be lost and will clog stormwater inlets. Non-composted mulches tend to float and should not be used.
   b. Hardwood bark that is double or triple shredded and well-composted will remain in place.

5. Do Not Use:
   a. Shredded pine bark in structural BMPs.
   b. Un-composted bark mulch, fresh clippings, and immature composted materials, which rob soil of oxygen and nitrogen.
   c. Rubber mulch or Crumb Rubber.
   d. Plastic sheeting of any kind, as it disintegrates from exposure.

G. Types of BMPs and Their Specific Issues

In this manual, BMPs are divided into three categories two of which are discussed below:
1. Restorative BMPs
2. Structural BMPs

For these BMP types, there are significant differences in the approach to plant selection and the use of alternate planting methods.

1. Restorative BMPs

Ecological restoration is an intentional activity used to initiate or accelerate the recovery of a degraded, damaged, or destroyed ecosystem (regardless of how minor the interventions). Restoration should be understood as a gradient of different approaches ranging from strict, historical restoration (for instance, returning an ecosystem to a documented historical condition using accurate, scientifically based parameters) to simple repair and enhancement of an existing landscape, where the goal is only a healthier, more functional ecosystem. These practices focus on creating healthier, more functional ecosystems for stormwater management.

a. Protection or Restoration?
First determine if a landscape requires restoration as opposed to protection. If native plant communities with specific dominant species are present (NatureServe provides plant community examples, see link below or xl lists provided), evidence of human disturbance is minima and exotic invasive plants make up less than 25 percent of the total area than the area may be preserved rather than restored.

b. Landscape Selection – Cover type
To determine the landscape category most suited for a restorative BMP on a specific project, identify nearby natural areas with environmental conditions similar to the site. The Chattanooga Arboretum and Nature Center is situated in a very large block of forested area at the edge of Chattanooga to the west of Look Out Mountain. Prentice Cooper State Forest and Wildlife Management area is in proximity to Chattanooga as is Cahutta National Forest. These areas will contain landscape communities that could be used as reference models, depending on the project circumstances. Match growth requirements (soil, light, moisture) to the conditions on the site. A parallel, but less disturbed site can illustrate a range of local landscape types that complement the proposed budget, program, and building footprint. Additionally NatureServe write ups have been provided with specific dominant species for your convenience.

For specific plant community types for the Level III Ecoregion *Ridge and Valley Provence* designated by USEPA, use the NatureServe website:
http://www.tn.gov/environment/na/pdf/tn_eco_systems.pdf
Or the Nature Serve Data Explorer:
http://www.natureserve.org/explorer/servlet/NatureServe?init=Ecol
Or refer to the accompanying plant database for suggestions.

c. Plant Selection for Restorative BMPs
Appropriate species selection depends on the specific requirements of the BMP; on project goals, schedule, and budget; and on the visibility and accessibility of a given stormwater management measure.
   i. Plant selection is focused primarily on functional improvements (i.e., plants whose roots increase soil porosity).
   ii. Plants are chosen for their ability to survive and thrive in difficult, existing conditions, with minimal long-term management.

iii. Species selected for restorative BMPs are typically native. Plants chosen are not usually nursery specimens, cultivars, hybrids, or ornamental species (with the exception of some plants bred to survive particular, difficult conditions or to remove pollutants).
iv. For greater "fidelity" to local ecosystems, plants can be collected or grown from seed harvested from Level IV Ecoregions - *Southern Limestone/Dolomite Valleys and Low Rolling Hills,* designated by USEPA.

d. Planting Methods for Restorative BMPs

Appropriate planting methods also depend on the specific requirements of the BMP; on project goals, schedule, and budget; and on the visibility and accessibility of a given stormwater management measure.

i. Typically, planting strategies for restorative BMPs differ from those chosen for structural BMPs, but this is not an ironclad rule. Restorative BMPs are frequently located within a large site, in underused or less visible areas, where smaller plant sizes and lower-cost strategies can be used.
ii. Canopy trees and understory can be planted in smaller, even very small sizes, as "whips" or "seedlings," or less than 1-inch caliper trees. Shrubs can also be smaller (less than 2 to 3 feet in height) and often grown in containers or flats. Woody groundcovers are in flats or in mats. Herbaceous plants are either seeded in, over extensive areas, or planted as plugs for smaller, difficult areas that require immediate cover.
iii. Density of plants is generally greater to stabilize soil. In restoration landscapes, loss of plants is part of the process, and there is no need to leave space for a plant to develop to maximum size and shape, as in ornamental landscapes.
iv. The typical goal of a restorative BMP is to reproduce the plant-to-plant and plant-to-site relationships found in similar (but less disturbed) local environments, in more or less the same numbers and patterns.
v. Also consider collecting seeds and plants from USDA plant hardiness zone 7b to 8a to accommodate global warming.
vi. A less conventional but effective way to preserve soil structure, small plants, microorganisms, and seed reservoirs, etc. is to cut and stockpile the upper soil layers as "sod." See 5.2.4.2 Soil and Plant Salvage.

e. Mulches for Restorative BMPs

Mulches are often simple native materials such as straw or hay for meadows and leaves for woodlands and forests.

f. Management for Restorative BMPs
    i. Restorative landscapes are generally "managed" rather than "maintained." Plants are allowed to organize themselves by natural mechanisms such as "colonization, competition and reproduction." Individual species are not pampered—those that die are no longer part of the system, and are not replaced.
    ii. Measures to protect plants from an overabundance of grazers (i.e., deer and rabbits) can be critical to the survival of a restorative BMP.
    iii. Non-chemical Management of invasive plant species is critical to BMP success.

2. Structural BMPs

a. Planting Strategies for Structural BMPs
    i. BMPs that are visible are generally required to have "people-pleasing" qualities (showy flowers, dramatic forms, fall color, and winter interest).
    ii. Planting design frequently leaves greater space between plants, to allow each plant to grow and mature, without being crowded by others.
    iii. While these landscape plantings will grow and mature, they are not expected to change into a different landscape (for example, from a meadow to a forest) over time. They are generally understood to be "stage sets," which are relatively static and only grow older and larger.

b. Species Selection for Structural BMPs
    i. Plant species used can be natives, but cultivars are more frequently chosen—since they are often developed for aesthetic qualities.
    ii. Plant species chosen for structural BMPs generally require a higher performance in a more concentrated space.
    iii. Plants are often larger, more mature, "specimens," chosen to create an immediate effect. Tag individual plants at the selected nursery to ensure the stock is healthy and has an appropriate form based on the design requirements.
    iv. Minimum size for canopy must be 2 inches in caliper or greater. Minimum size for understory trees is 6 feet or greater. Where possible, use multiple stem species.
    v. Minimum size shrubs are 3 to 4 feet high or greater.
    vi. Minimum size for herbaceous plugs is 5 inches deep (deep roots ensure a fast start). Shallow rooted herbaceous plants, such as ferns and sedges, can be broader and shallower.

c. Mulches for Structural BMPs
    i. Where possible, all space on the ground should be filled with plants and the use of mulches kept to a minimum.
    ii. Consider imaginative alternatives to traditional mulches, i.e., boulders, river rock, pebbles and crushed glass, choose mulches that complement site textures and colors.

d. Management for Structural BMPs
    i. See specific structural BMP for operations and maintenance guidance.
    ii. Anti-herbivore measures can be important on corporate headquarters, institutional campuses, and other large properties. These measures may include control of Canadian geese on lawn. Replacing vast extents of lawn with other cover types should greatly reduce the Canadian geese problem.

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