Performance Enhancing Devices for Stormwater BMPs

Enhanced Vegetation

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Enhanced Vegetation

1. Definition & Applications

Vegetation is commonplace and expected in many stormwater BMPs. However, the strategic importance of vegetation for runoff reduction and pollutant removal has not been fully acknowledged, and there is no unified guidance for planting design and long-term maintenance to support volume and pollutant removal objectives.

Research indicates that the presence of plants enhances other nutrient removal mechanisms. The below ground microbial community associated with plant roots plays a key role in immobilizing dissolved nutrients during the wet and dry cycles encountered in stormwater practices. As plants mature, their root systems maintain or even increase the hydraulic conductivity of the media and the practice as a whole. Researchers suggest that plants with a deep, thick, and dense root system enhance dissolved nutrient removal. Deep-rooted prairie plant species such as big bluestem, Joe Pye weed, and switchgrass performed well in several experiments (Hirschman et al., 2017).

Since vegetation is a major component of the living system of a stormwater BMP, there should be flexibility in the original plant palette as well as how the plant community is managed through the life of the practice. Historically, planting designs for stormwater practices have either been ignored, mismanaged, or treated as static over time. Enhanced planting design and management as a performance enhancing device (PED) can be incorporated with initial installations or as retrofits of practices where the existing vegetation is not healthy, is difficult to maintain, is leading to nuisance conditions, or other factors.

That said, there are many design professionals and planting strategies across the Bay Watershed. This fact sheet will introduce one approach that can be considered an integrated planting design and adaptive management framework to fulfill PEDs objectives for stormwater as well as providing ecosystem services.

The approach includes:

- Initial planting with densely-planted layers modelled on local natural plant communities (mostly eastern grassland types with the above and below-ground biomass as described above).
- Intensive management during the first several growing seasons.
- Adaptive management addressing successional adaptation of plant communities over time and, as a general rule, annual cutting in late February.

This fact sheet is not a how-to guide on this approach, and actual implementation will require a team approach with qualified professionals (see Section 7, “Finding Help”). However, this fact sheet does outline a conceptual framework and resources for those interested in learning more. The approach is derived largely from the work of Floyd (2018a, 2018b), Rainer and West (2015), Nassauer (1995), and Weaner and Christopher (2016), as well as the curriculum of the Chesapeake Bay Landscape Professional certification program and Virginia Department of Game & Inland Fisheries Habitat Partners© Program (see Section 8, “Resources”).

The approach can be adapted or scaled to a particular application, and the design team should discuss how the approach, or some of its components, can be used to enhance the planting plan and its management over time. See **Section 9** for a list of qualifying conditions in order for enhanced vegetation design and management to qualify for increased nutrient removal credit as a PED.

2. Initial Planting Design

Existing Bay jurisdiction stormwater manuals and specifications are not prescriptive about planting design and offer a range of options and very generic plant lists. Some of the planting "templates" in existing standards include:

- Turf cover (with or without trees)
- Perennial garden (with or without shrubs)
- Tree, shrub, herbaceous
- Meadow

Depending on the initial design and how it is managed, each option can lead to expected and unexpected outcomes. In some cases, the resulting stormwater landscape can be difficult to maintain or even create nuisance conditions. For many BMPs in the Bay Watershed, there is no cohesive long-term or adaptive management strategy.

A more unified design/adaptive management approach could focus on a natural plant community prairie system. These systems are adapted to undergo periodic disturbance and alternate periods of dry and wet, conditions that are apt for the stormwater context. The strategy involves identifying and observing local plant communities that can serve as references for the stormwater landscape being created. The general principles for establishing and managing this type of plant community are outlined below:

- Use local natural plant communities as reference landscapes.
- Provide dense cover of the BMP surface with layers of vegetation.
- Intensely manage the plantings for the first 3 growing seasons.
- Use an adaptive management approach for long-term O&M.

<u>Reference Landscapes for Stormwater</u>

As near as possible, the local reference landscapes should replicate a variety of site conditions at the location of the stormwater landscape.

Several site factors to note include:

- Soil chemistry (especially cations and exchange capacity, for which there are indicator species)
- Soil moisture, drainage, texture
- Elevation
- Aspect
- Topography, Slopes
- Quality and duration of light

It is critical to note here that many stormwater landscapes (e.g., bioretention) will be using an engineered soil media based on state specifications, and this soil media is dissimilar in many ways from the existing and/or native, soil on a site. In essence, the existing soil will be excavated, removed, and

replaced with several feet of an "exotic" mix that will influence the type and long-term health of any vegetation that is planted. In many places in the Bay Watershed, the imported soil mix will be very well-drained (high sand content), outfitted with an underdrain (promoting even more rapid drainage), and may have less organic content than any existing site soils. With regard to the plant community, the imported, well-drained soil media as well as the existing site soils at the margins of the practice both play a role in selecting a reference landscape in order to maximize ecosystem services. Both will exercise a powerful affect on the plant community that will flourish within the stormwater landscape.

The stormwater landscape must tolerate short periods of inundation, but also longer periods of dry or even drought conditions. Therefore, for stormwater landscape applications, the reference natural plant community should be from places where these conditions exist. The best examples are low areas and swales and ditches in the upland prairies observed in powerline rights-of-way. Others may include plant communities on well-drained floodplains and small fragments of natural plant communities along roadsides, in areas with groundwater discharge, in ditches and low meadows, and other similar sites.

The reference plant community may or may not have a deep layer of relatively sandy soil; the important thing is that the vegetation has a diverse array of species that associate with each other in the given environment. The reference site will likely not be free of invasive or non-native species, so the task is to find the plant associations that do exist at the site. This will likely require the assistance of a trained professional (see Section 7).

Plant Communities, Not Individual Species

The focus here is on the natural plant community, and not just individual native plant species. Many designs incorporate an assemblage of native plants, but the selected plants may not ever associate with each other as part of a natural plant community. This means that the ecosystem benefit is diminished, as many ecosystem services derive from the co-evolution of micro-organisms, insects, birds, other wildlife, and associations found in the plant community. Underground, root systems from the various members of a community occupy different depths and niches, creating a more functional hydrologic regime. The natural plant community modelling concept is designed to help replicate, at least to a greater degree, these ecosystem services (Floyd, 2018a, 2018b; see also Rainer & West, 2015 for a design concept based on plant communities).

Over time, a designer may identify a range of reference natural plant communities, some large and some mere fragments of a previous landscape. Once a good species list is developed from these communities, the stormwater landscape can be developed using some (but clearly not all) of the reference community species. Design elements to consider are the inclusion of a dense ground cover layer consisting of sedges, rushes, low grasses, creeping forbs, or other ground covers that will fill the spaces between other plants and may have diverse root morphologies. Other layers can include plants that add seasonal interest or structure (Rainer & West, 2015). Shrubs and trees can provide structure, as guided by the reference landscapes. Some species may be dominant while other occupy margins, low wet spots, drier berms, or small patches.

There is no hard-and-fast rule for the number of species to include, and the scale of the practice, desired aesthetics, and maintenance capabilities may guide this decision. Methodologies for ecosystem modeling suggest that stormwater landscapes can strive to include at least 30 species for many applications. However, this decision will also be influenced by the skill of maintenance crews and

public acceptance. In some cases, the initial design can start with a simpler approach consisting of several species of locally well-recognized native plants. Diversity and complexity can be added over time as the stormwater landscape is managed and crews increase their skill levels with this type of native landscape. Also, some native (and some non-native) species will colonize the stormwater landscape over time, so diversity and complexity may be part of an adaptive management approach (see Section 5).

The number of plants used per species may vary widely by species, with the dominant species comprising a majority of the selected plants. Other species may be represented by fewer plants, but the important thing is to introduce them into the system. Over time, the dominance or rarity of species will sort itself out if there is adequate diversity in the initial palette.

Cover the BMP Surface Area with Vegetation – Green Mulch

Another important point is the initial planting density. If using plugs, they should be planted as densely as possible (e.g., 6 inches on-center, 4 per square foot) to provide a good jump start and reduce the "open" space between plantings that are attractive areas for invasives to encroach. If using other herbaceous plant stock, plant as densely as reasonable. It is also recommended to use an appropriate seed mix to supplement the plantings. Note that this type of planting scheme may only need an initial thin layer of mulch, if any, or a suitable matting (e.g., jute or coir). The design can even dispense with initial mulching if a seed mix is used to supplement planted stock. The strategy is intended to eliminate the need for typical, annual re-mulching, as the ground will covered by "green" mulch in the form of densely growing and layered plants. Note that mulch is carbon heavy, may change the chemistry of the soil in unfavorable ways, and can recruit for non-native or invasive species.

Certainly, not all of the selected plants will survive or thrive, but the concept is to provide a jump start for a plant community to develop and evolve. This dense planting scheme can increase initial costs, but, if properly managed, will reduce subsequent maintenance needs and costs and result in a successful well-managed stormwater landscape.

3. Source Selection & Procurement

There is an increasing number of nurseries that offer native plants. The link below has a partial list by state.

https://www.fws.gov/chesapeakebay/BayScapes/bsresources/bs-nurseries.html

Aside from the nurseries on this list, there may be other local or regional sources of native plants. Consulting your state's native plant society, or a local chapter, may be beneficial. Consider the following when looking for a source of high quality native plants:

- Purchase "sets" that are, in effect, natural communities of plants
- Comprised of species that co-evolved in the region.
- Produced to capture the range of appropriate, adaptive genetic diversity.
- Locally produced and sourced.
- Consist of straight natives and not necessarily native cultivars (cultivars of native plants bred for color, shape, bloom time, height, or other characteristics deemed desirable in the landscape trade).

- Grown without neonicotinoids.

Also keep in mind that availability for some species may be limited, and sourcing native plants may require a longer lead time compared to most landscape products. Larger projects have found it advantageous to contract with a native plant nursery to grow the desired species and quantities. This type of arrangement may take a year or more lead time prior to actual planting.

4. Management During First Several Growing Seasons

The first three years of maintenance and management are the most critical for this type of planting scheme and require maintenance crews trained to recognize PED planting strategies and native plants versus invasive plants. The following is general guidance for this three year period, based on Floyd (2018b).

Year 1

- Assuming a late winter planting start, leave no ground unplanted. Use vegetation as a substitute for mulch, plant as densely as the budget will allow, and infill with a carpet of seeds (of appropriate species for the project)
- Spot weeding: remove non-natives/invasives once/month through the growing season. Maintenance crews should be trained to recognize which plants should stay and those that should be removed.
- Cut to 4 to 6 inches through the growing season (every 4 to 6 weeks or so). As a PED strategy, it is important to evaluate carefully how many of the cuttings to remove from the BMP (e.g., for off-site composting). On one hand, the vegetation will have sequestered nutrients that can be removed from the system. On the other hand, leaving some cuttings will aid in the fuller development of a healthy plant and soil ecosystem. It is advised to consult a qualified professional to gain insight on the right balance.
- Keep volunteer native species based on successional management plan.
- Overseed in the Fall.

Year 2

- Spot weeding: remove non-native/invasives periodically, as needed.
- Overseed in the Spring, as needed based on a gap-fill assessment. In some cases, seeds can be collected from site itself to fill gaps.
- Cut to 4 to 6 inches through July (again, evaluate the efficacy of removing at least some of the cut vegetation from the system).
- Fill in gaps: continue to add plants and make adjustments.
- Keep volunteer native species based on successional management plan.
- Overseed in the Fall, as needed based on gap-fill assessment.

Year 3

- Spot weeding: remove non-native/invasives periodically, as needed.
- Allow full growth (don't cut through the entire year, and only in late February thereafter).
- Assess need to fill any additional gaps.

- After the growing season, intensive management can be relaxed, letting the plant community evolve, while maintaining the edge.

5. Long-Term/Adaptive Management

In theory, if the three-year intensive management outlined above is followed, the natural plant community will evolve and will result in a dense planting that covers the surface area of the practice and provides complex structure, allowing fewer opportunities for invasives to colonize. The natural or managed succession within the plant community is an adaptive rather than static management approach that can reduce long term maintenance when compared to managing the planting plan as a static condition.

There are several tasks that should be conducted as part of a long-term adaptive management strategy:

- As desired, keep succession at bay by cutting back every 1 to 3 years in late February, and removing some of the cut vegetation if it cannot be mulched and left on site. Cut back woody growth every 3 to 5 years; woody plants add diversity and cover for the plant community, and should be maintained in a lower growing condition than is typical of many existing BMPs.
- Monitor invasives and non-native species, keeping in mind that complete eradication may be very difficult; 3 to 5% surface cover is normal for these situations.
- Make sure to keep a discernable edge so that it is clear that even the "wildest" native landscape is deliberate and is being cared for. Edges can be demarcated by a mowed strip, low fence or wall, or similar boundary that shows the intentional hand of humans in the landscape (Nassauer, 1995) .
- Keep a check on winter salt and sand inputs and remove accumulated slag, as necessary, at the end of the winter season. The O&M may have to include ongoing outreach and education of the road and transportation crews.

Also, importantly, monitor the landscape regularly and be willing to adapt the maintenance plan to changing conditions in plant growth, aesthetics, and property management objectives. For instance, some tree canopy may be desired, but complete canopy will shade out the herbaceous layer that thrived with more sunlight. It may be necessary to adapt the original planting design by planting more shade-tolerant native species under the canopy. Also, keep in mind that some species will become dominant in the community (maybe 5 or 6 species). Others will occur in patches or even become rare, but this reflects the evolution of a natural plant community. If the community is tending towards only a few dominant species, it may be necessary to re-evaluate the community and do some selective removal and replanting/reseeding with additional species that are good matches for the plant community (this does not mean continuing to replant species that are <u>not</u> doing well at the site).

The key is that the plant community is monitored on an annual basis and deliberate adaptations made based on design objectives.

Also, BMPs in the Bay Watershed must undergo a verification process to ensure the BMP is still present and performing as designed (CSN, 2014). This verification is intended to take place every two permit cycles for MS4s, or every 9-10 years. For vegetated practices, this would be an ideal time to revisit the original planting design, evaluate performance and issues encountered, and conduct any recommended redesign or replanting as part of an adaptive management scheme.

6. Risks

Vegetation may be an inherently low risk aspect of BMPs. However, if ones considers poor public perception and possible nuisance conditions to be risk factors, then vegetation is the most important component of a BMP. Public perception can be improved through informed design decisions and techniques, such as "Cues to Care" (Nassauer, 1995) or the systematic approach of Rainer and West (2015). Community education and outreach can be key components of public acceptance and of a long-term O&M plan for these sites. Misinformed or poorly-trained maintenance crews can also result in improper vegetation management and failure of this technique. Also, a poorly-performing vegetative community will affect runoff reduction and pollutant removal capabilities.

An additional risk to the vegetative community may be inputs of salt and sand in the winter. Monitoring this should be part of the long-term O&M plan.

7. Finding Help

This fact sheet outlines a fairly sophisticated approach for BMP planting design and management, and one that will require not only professional knowledge but also resources and a skilled workforce. While this may be intimidating to some, the point is to build broader collaborations between stormwater and landscape professionals and incorporate aspects of the approach into projects as opportunities arise.

The Chesapeake Bay Landscape Professional (CBLP) certification is a program of the Chesapeake Conservation Landscape Council (CCLC): https://cblpro.org/. The website also has a directory of professionals who have become certified in basic conservation and BMP landscaping with a focus on maintenance (Level 1) or the more advanced certification in design and/or installation (Level 2). The CBLP program may be a good place to start to find qualified professionals or build collaborations. This is not the only stormwater or green infrastructure certification program, but is one focused on the Chesapeake Bay and landscaping issues for stormwater BMPs.

The "Resources" section below provides additional links and organizations for native plants and plant communities.

8. Resources

Maryland Natural Communities
www.dnr2.maryland.gov/wildlife/Pages/plants_wildlife/nhpnatcomm.aspx

Natural Communities of Virginia
http://www.dcr.virginia.gov/natural-heritage/natural-communities/nctoc

Terrestrial and Palustrine Plant Communities of Pennsylvania
http://www.naturalheritage.state.pa.us/fikebook.aspx

Wild Vegetation of West Virginia
http://www.wvdnr.gov/Wildlife/Factsheets/default.shtm

Guide to Delaware Vegetation Communities
http://www.wrc.udel.edu/wp-content/heritage/NVCS/Guide-to-Delaware-Vegetation-Communities-Winter-2013.3.pdf

Ecological Communities of New York State
https://www.dec.ny.gov/docs/wildlife_pdf/ecocomm2014.pdf

Native Plant Center, Chesapeake Bay Region. Alliance for the Chesapeake Bay
www.nativeplantcenter.net

Virginia Department of Game & Inland Fisheries, Habitat Partners Program
https://www.dgif.virginia.gov/wildlife/habitat/

Definitions of native and exotic in Federal Register Executive Order 11987
www.archives.gov/federal-register/codification/executive-order/11987.html

USDA-NRCS definitions of native, non-native, invasive, naturalized, etc.
www.nrcs.usda.gov/wps/portal/nrcs/detail/ct/technical/ecoscience/invasive/?cid=nrcs142p2_011124

USDA NRCS PLANTS database
www.plants.usda.gov/java/

Maryland Native Plant Society
www.mdflora.org

Digital Atlas of the Virginia Flora
http://www.vaplantatlas.org/

Flora of Virginia
www.floraofvirginia.org

Virginia Natural Heritage Database
www.vanhde.org/species-search

Flora of Pennsylvania
www.paflora.org

The Flora of Delaware Online
http://www.dnrec.delaware.gov/fw/NHESP/information/Pages/PlantCommunities.aspx

Center for Urban Habitats
https://centerforurbanhabitats.com/

Chesapeake Riverwise Manual
www.stormwater.allianceforthebay.org/riverwise-communities-manual

Kennan K, and Kirkwood N. (2015). PHYTO: Principles and Resources for Site Remediation and Landscape Design. Routledge. New York.

9. Qualifying Conditions for Vegetation as a PED

The following conditions summarize the use of vegetation to qualify for the PEDs pollutant removal credit:

- As a general concept, model planting design on local natural plant communities. Provide diversity, layers of plants, and diversity of root morphologies.
- Initial plantings should aim to provide quick cover of the BMP surface area using densely-planted plugs, other plant stock, and overseeding with an appropriate seed mix (based in general terms on the reference natural plant communities).
- The O&M plan should include detailed management for the first three growing seasons; see Section 4 for guidance.
- The O&M plan should also address longer-term adaptive management of the plant community and periodic evaluation of plant health and shifts in the community (see Section 5). Engage qualified professionals in developing and implementing the O&M plan.

References

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Floyd, D. (2018b). Stormwater Landscapes: Using Natural Plant Communities for Design. Center for Urban Habitats. https://centerforurbanhabitats.com/. Continuing Education Workshop sponsored by: Virginia Department of Game & Inland Fisheries, Virginia Habitat Partners, Chesapeake Bay Landscape Professional. Powerpoint presentations by D. Floyd and D. Hirschman.

Hirschman, D.J., Seipp, B., Schueler, T. (2017). Performance Enhancing Devices for Stormwater Best Management Practices. Urban Stormwater Work Group. Center for Watershed Protection.

Nassauer, JI. (1995). Messy Ecosystems, Orderly Frames. Landscape Journal. 14(2): pp. 161-170

Rainer, T. and West, C. (2015). *Planting in a Post-Wild World: Designing Plant Communities for Resilient Landscapes.* Timber Press. Portland, OR. ISBN 978-60469-553-3.

Weaner L, and Christopher, T. (2016). *Garden Revolution: How Our Landscapes Can Be a Source of Environmental Change.* Timber Press. Portland, OR. ISBN 9781604696165.

Photos

Figure VEG-1. Example of Bioretention plant community modeled on local natural plant community.