Survivor's Guide to the New Era of Stormwater BMPs
March 23-24, 2009
Williamsburg, VA

Site Design Workshop (Day 1) Notes
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Overview

A two-day workshop was held in Williamsburg, VA on March 23 – 24 to help local governments, design consultants, and other stakeholders understand the technical criteria proposed in the new stormwater regulations. Day 1 of the workshop was a design charette, similar in many respects to charettes sponsored by DCR and/or ASCE held around the state. However, this charette included an up-front analysis of selected plans by local consultants (the plans used in the charette were drawn from this pool). Day 2 included presentations of the designs, and a discussion of BMP selection and sizing issues encountered on each site.

Prior to the workshop, the consultants had worked through a committee of the Tidewater Builders Association to analyze how the proposed regulations affect a variety of plans. This process was continued with participation from the Center for Watershed Protection (CWP) and Williamsburg Environmental Group, Inc. (WEG) in order to select a subset of the plans and prepare them for use in the workshop. The primary goals of the exercise were to:

1. Identify consequential issues related to types of BMPs and costs of the proposed technical criteria; and
2. Evaluate the possible influence of coastal plain topography and other constraints on BMP selection and design.

Subsequent to the workshop, some additional analysis was done on several of the plans to get a more accurate portrayal of BMPs sizing and costs.

It is important to note that cost assessments of the regulations are difficult due to variability in the type and location of development projects, the influence of initial site layout and design choices, and the wide range of opportunity costs associated with fitting stormwater practices on a site. DCR has sponsored a study of the economic impact of the proposed technical criteria, which can be found at the following link:
http://www.dcr.virginia.gov/documents/stmFinalVTReport.pdf

The purpose of this report is to summarize the workshop outcomes and subsequent work done to approximate BMP selection, sizing, and cost issues. This report also provides some discussion items related to the draft BMP specifications.

Draft Specifications

The selection and sizing of BMPs during the workshop were derived from a series of Quick Look-up Tables. These tables consist of general selection and design criteria based on the detailed draft BMP specifications provided on the DCR BMP Clearinghouse website (http://www.vwrrc.vt.edu/swc/NonProprietaryBMPs.html) and were established to allow

attendees to quickly select, locate, and size appropriate BMPs during the workshop. These tables do not necessarily represent the design elements critical to the coastal plain, nor do they represent the draft BMP coastal plain adaptations proposed by the Chesapeake Stormwater Network. (CSN Technical Bulletin # 2: http://www.chesapeakestormwater.net/stormwater-research-highlights/ . The coastal plain adaptations consist of design adaptations that are based on BMP performance studies and are intended to account for and accommodate the unique topographic and other features of the coastal plain that influence BMP performance.

The specifications provided on the BMP Clearinghouse website are considered very draft, and as such have not been formally (or informally) reviewed. In some cases these draft specifications reflect a clear departure from the current "Blue Book" specifications. Upon review of the proposed coastal plain adaptations, concerns were raised by Tidewater consultants and developers that the potential impacts of the new technical criteria are greater than had been identified in previous economic assessments and design charrettes. Thus one of the specific goals identified for this Coastal Plain design workshop was to fully test the proposed draft specifications, including the proposed coastal plain adaptations, and develop relative cost estimates for each site design proposal.

Unit Cost Basis

A consistent format for deriving cost estimates for the designs was considered essential in order to establish an "apple to apple" comparison. Therefore a unit costs basis for the different types of BMPs was adopted for use by the attendees. These costs were derived from CWP's Urban Subwatershed Restoration Manual Series – Manual 3: *Urban Stormwater retrofit Practices*, Version 1.0; Appendix E: Derivation of Unit Costs for Stormwater Retrofits and New Stormwater Treatment Construction. Additional unit costs were derived from WEG project cost data, and the Wisconsin Department of Natural Resources.

The unit costs were provided to the attendees on a one-page table: Unit Construction Costs, and were based on either square footage of the practice, cubic foot treatment volume, or the impervious acreage treated. There can be considerable debate over the accuracy of any unit costs, and certainly regional variations can drive costs higher or lower. However, the objective was to simply develop a consistent cost basis for comparison purposes.

Another consideration was how to report the costs. Prior to the workshop it was agreed that a "cost per pound of TP removed" value represents the basic economics of the new BMP specifications and the implementation of a runoff reduction treatment train approach. It was also determined to be useful to identify the total cost reflective of the removal requirement (RR) in order to assess the impact of the proposed criteria.

Pre-Workshop Design Summaries

Prior to the workshop, 5 sites were selected by Tidewater area consultants. Each site was represented by a design that was either under way or had been previously approved under the existing stormwater technical criteria. The consultants were then asked to develop a stormwater design that would meet the requirements of the proposed technical criteria and develop a cost estimate. Since there were no standardized unit costs established at that time, there was no specific comparison provided, other than on a site-by-site basis. However, in preparation for the

workshop, these designs were re-evaluated using the Workshop Unit Construction Costs to establish a baseline for comparison with the workshop designs.

It should be noted that there were instances where compliance with the proposed technical criteria was achieved using manufactured BMPs. It is unclear at this time how manufactured systems will be approved, their relative sizing, and therefore relative costs.

Workshop Design Summaries

A Site Summary that itemizes the hydrologic characteristics (drainage areas, soils, natural features, etc.) and the proposed project details (lot sizes, proposed impervious cover – parking requirements, roads, building footprints, etc.) for each project was provided to the attendees. Even so, it is important to note that the workshop designs may not reflect all of the design constraints associated with each site. Therefore, as would be expected, there are significant differences in the estimated "cost per pound" provided by the consultants and the workshop participants for each site as provided in the Day 2 Design Presentation (powerpoint presentation).

Pollutant Calculation Summaries

The summary of the pollutant load removal requirements fort he existing and proposed criteria for each site are provided in the following tables. It is apparent that the increase in the calculated load likewise results in an increase in the removal requirements.

Table 1 - Commercial Redevelopment
Existing Condition: 1.44 acres (1.23 ac impervious)
Proposed Condition: 1.44 acres (1.27 ac impervious, 0.17 ac turf)

	Current Regulations	Proposed Regulations	% Change
Post-Developed Load (lb)	2.8	2.9	4%
Removal Requirement RR (lb)	0.4	0.6	50%
Removal Requirement RR (%)	10%*	20%*	

* Reduction measured from existing load

Table 2 - Institutional – School Campus Development
Proposed Condition: 95.5 acres (28.1 ac impervious, 35.9 ac turf, 31.5 ac woods/open)

	Current Regulations	Proposed Regulations	% Change
Post-Developed Load (lb)	63.8	77.3	21%
Removal Requirement RR (lb)	21.6	50.5	145%
Removal Requirement RR (%)	34%	65%	

Table 3 - Institutional – Medical Campus Development
Proposed Condition: 45.9 acres (19.8 ac impervious, 18.5 ac turf, 7.6 ac woods/open)

	Current Regulations	Proposed Regulations	% Change
Post-Developed Load (lb)	45.7	52.2	14%
Removal Requirement RR (lb)	25.4	39.3	55%
Removal Requirement RR (%)	56%	75%	

Table 4 – Residential Development
Proposed Condition: 49.5 acres (17.5 ac impervious, 17.7 ac turf, 14.3 ac woods/open)

	Current Regulations	Proposed Regulations	% Change
Post-Developed Load (lb)	41.2	46.8	14%
Removal Requirement RR (lb)	19.3	32.9	71%
Removal Requirement RR (%)	47%	70%	

Table 5 - Mixed Use Development
Proposed Condition: 12.8 acres (8.3 ac impervious, 4.5 acres turf)

	Current Regulations	Proposed Regulations	% Change
Post-Developed Load (lb)	18.5	20.55	11%
Removal Requirement RR (lb)	12.9	17.0	32%
Removal Requirement RR (%)	70%	82%	

Detailed Cost Assessment

WEG selected two of the five sites for a more detailed review in order to further evaluate changes in compliance costs. This detailed review consisted of verifying the compliance of the BMP designs with both the current and proposed regulatory criteria and BMP specifications. The selected sites are the 49.5 acre residential development, and the 12.8 acre mixed use development. These sites were selected since they represent a broad range of BMP selection, design, and cost parameters. It should be noted that the residential site was originally designed to comply with the James City County 10-Point system, and the mixed use site was designed in a watershed that did not require water quality at the time of plan approval. Finally, the BMP sizing and design for compliance under the proposed technical criteria were not formally checked during the design workshop.

Thus, the BMP selection and compliance computations for these two sites were carefully evaluated and modified as necessary. A cost estimate was then developed using the same unit

costs as provided during the charrette. It should be noted that there are numerous design alternatives that could be considered for these projects. The designs chosen were the result of a relatively quick assessment and implementation exercise. A more detailed evaluation could easily identify effective alternatives designed to meet multiple criterion (such as aesthetics, LEED ND Certification, etc.) as identified by the owner/developer. It should also be noted that the cost drivers for some of the RRM practices are based on criteria in the current draft BMP specifications, and as noted above, these are undergoing review and are subject to change. To the extent that the specifications may change, including criteria related to optimizing the selection and design of certain practices, and practices in series, the costs may change as well.

Residential Development: The 49.5 acre residential development includes a wide range of lot sizes and represents a higher density development than the overall imperviousness would indicate. The perimeter of the site consists of wooded buffers, leaving the interior BMP drainage areas at a higher impervious cover: overall site imperviousness = 35%; interior drainage area average imperviousness = 55%.

Compliance under **existing** technical criteria:

Water Quality:

Retention Basin II (4 x WQv*****; 50% TP efficiency)

Approx Costs: $84,000; Load removed: 11.45lb TP;
$7,336/lb TP

***** WQv based on 0.5" x impervious cover.

Bioretention (SA = 2.5% of contributing impervious cover; 50% TP eff.)

Approx Cost: SA = 7,655 ft2; $191,392; Load removed: 7.9 lb TP
$24,226/lb TP

Water Quantity:

Additional Detention Storage

Approx Cost: $ 40,000 (not included in total cost below)

Total Water Quality Costs – **Existing Criteria**: $ 275,392 / 19.35 lb = **$14,232 / lb TP**

Compliance under **proposed** technical criteria:

Water Quality: Treatment trains: Bioretention, Dry Swale II to Wet Pond II; Bioretention to Infiltration; Dry Swale II to Conservation Area.

Wet Pond II*****; (75% TP efficiency)

Approx Costs: $84,000******

***** Pool volume sizing per Draft BMP specs; Unit costs ($ / imp DA) considered equivalent to existing specs. See Wet Pond Discussion below.

Bioretention (Level I, Level II: SA = TV/1 ft2; TV/1.4 ft2)

Approx Cost: Total SA = 19,530 ft2; $488,225

Infiltration (Level I)

Approx Cost: Total TV = 5,000 ft3; $50,000

Dry Swale II

Approx Cost: Total 1,000 linear ft; $ 50,000

Water Quantity:

Additional Detention Storage

Approx Cost: $ 40,000 (not included in total cost below)

Total Water Quality Costs **Prop. Criteria**: $ 672,225/34.51 lb = **$19,480 / lb TP**

****** $/lb unit cost not itemized for individual components of the treatment train.

Mixed Use Development: The 12.8 acre mixed-use project is proposed as a very high density residential/commercial development. The original design was proposed without water quality compliance due to it's location in the watershed. If the site were to be developed under the current VSMP water quality requirements it would not be able to comply with the 70% removal requirement (current maximum credit under the *Performance-Based* approach is 65% - Retention Basin III). However, for purposes of this exercise, a stormwater quality design is proposed under the existing *Technology-Based criteria,* for comparison purposes. A large area at the center of the site was designated for an aesthetic wet pond. This area was evaluated for use as a water quality wet pond under both the existing and proposed criteria.

It should be noted that the site is extremely flat and has a very shallow water table, thus highlighting the issues related to the coastal adaptations related to wet ponds. (Refer to discussion below regarding the permanent pool credit given to ground water wet ponds.)

Compliance under **existing** technical criteria:

Water Quality:

Retention Basin III (4 x WQv* w/ aquatic bench; 65% TP efficiency)

4xWQv ~ 60,000 ft3; assume min 4' depth = 15,000 ft2 SA (approx area provided at center of site ~ 11,000 ft2 – requires redesign of site layout to fit pond.

Approx Costs: $83,200; Load removed: 8.37lb TP; $9,940/lb TP

* WQv based on 0.5" x impervious cover.

Water Quantity:

Additional Detention Storage

Approx Cost: $ 40,000

Total Water Quality Costs – **Existing Criteria**: $ 83,200** / 8.37lb = **$ 9,940** / lb TP**

** Costs do not include opportunity costs for lost developable land

Compliance under **proposed** technical criteria:

Water Quality: Treatment trains: Bioretention, Dry Swale II to Wet Pond II*; Wet Pond II*; (75% TP efficiency)

Approx Costs: $83,200**
***** Pool volume sizing per Draft BMP specs; Unit costs ($ / imp DA) considered equivalent to existing specs. See Wet Pond Discussion below.

Bioretention (Level I, Level II: SA = TV/1 ft2; TV/1.4 ft2)
Approx Cost: Total SA = 20,000 ft2; $500,000

Dry Swale II
Approx Cost: Total 1,000 linear ft; $ 50,000

Water Quantity:
Additional Detention Storage
Approx Cost: $ 31,160

Total Water Quality Costs **Prop. Criteria**: $ 633,200/17.2 lb = **$36,814 / lb TP**

****** $/lb unit cost not itemized for individual components of the treatment train.

As stated previously, there are numerous design alternatives that could be considered for both sites. The use of permeable pavement, more or less dry swales (level 1 or 2), bioretention (level 1 or 2), etc., as well as optimization of any one type of practice upstream of another, can lead to possibly more or less costs. In general, however, the various options considered were in the same general range of the compliance costs cited.

Discussion

1) The increase in the removal requirement (RR) is generally split between the increased load associated with turf, and the decrease in the load limit (from 0.45 to 0.28 lb/ac/yr). The low impervious (high turf) sites yield the greatest increase, while the highly impervious sites (low turf) yield the lowest increase.

2) The relative unit costs of the BMPs are the same for both the existing and proposed technical criteria. However, the sizing criteria, and therefore costs, for some BMPs increases as a function of the primary sizing variable: 0.5" WQv (based on impervious cover); or the proposed Treatment Volume (TV) based on the 90th percentile rainfall depth of 1" (or greater for level II BMPs). The use of the Treatment Volume (based on the contributing drainage area) as the sizing standard for bioretention represents a significant increase in costs. Consider a 1 acre drainage area:

Bioretention Sizing – Surface Area Requirement

1 acre DA	Existing Requirements		Proposed Requirements	
	50% TP eff. (SA = 2.5% Imp Cover)	65% TP eff. (SA = 5% Imp Cover)	Level 1 25% TP eff. (SA = 1.0 x TV)	Level 2 50% TP eff. (SA = 1.25 x TV)
50% Imp./50% Turf	544 ft^2	1089 ft^2	2,087 ft^2	2,609 ft^2
100% Imp.	1,089 ft^2	2,178 ft^2	3,449 ft^2	4,311 ft^2

* Assumes B soils. Also, unit costs for Level 2 could be higher due to deeper system depth (per specifications).

As the specifications undergo further review, there should be a careful analysis of sizing as related to meeting the performance goals stated in the proposed regulations. In some cases, it may be possible to reduce sizing requirements (for instance, by allowing a "credit" for upstream runoff reduction) while still meeting the performance goals.

3) The use of Treatment Volume can further increase the size of practices as a function of hydrologic soil group (A thru D) increasing the volumetric runoff coefficient .

4) BMP Sizing:
   a) Bioretention Basin surface area requirement increases from 2.5% (50% eff) or 5% (65% eff) of the contributing impervious area, to the Treatment Volume (TV) as based on the entire contributing drainage area. This represents a substantial increase in the surface area and the underlying engineered soil matrix. Design questions:
      i) Can the storage volume associated with the underlying soil and gravel matrix be considered as part of the treatment volume, thus reducing the surface area requirement? Or, can the soil volume be considered to more accurately reflect the storage of the Treatment Volume for runoff reduction purposes.
      ii) Can the required surface area be provided with a smaller footprint of the underlying engineered soil matrix? (The soil mix represents a significant cost component.)

   b) The use of Dry Swales, Permeable Pavement, Infiltration, and other storage component practices should be evaluated for a sizing criterion that accounts for the storage volume provided.

   c) An encouraging development presented at this workshop is the allowed reduction in the BMP sizing based on the runoff reduction provided in upstream practices. This is a significant benefit to the larger volume practices such as detention, ED, and wet basins (however, these practices also tend to be less expensive on a per cubic foot basis). This should be identified in the BMP specifications. Possible research needs include the effectiveness of a larger surface storage area footprint and a smaller soil filtration area with mulch and plants (see 4.a.ii. above). This could help on sites where bioretention is sized significantly larger under the proposed criteria due to the addition of turf (the entire contributing drainage area vs. just the impervious cover). Key questions relate to the minimum filter surface area (or media) required for longevity as a function of imperviousness or other limiting factor.

   d) Wet Ponds – the proposed wet pond sizing specification actually reflects a decrease in the required permanent pool volume (depending on the site Rv). As an example – using the mixed use development above - the current standard would require a pool volume of 4x WQv = 4 x [0.5"*12.8 ac.* 0.65(% imp)*3,630] = 60,000 ft3. The new criteria for Wet Pond II (TV = 1.5*Rv*A/12) = 51,575 ft3; and if the drainage area is first conveyed through dry swale I or bioretention I (40% runoff reduction), the volume can be further

reduced to 31,000 ft3. Finally, the detention storage provided above the permanent pool can be counted if it is contained as extended detention, further reducing the pool volume.

The mixed use development referenced above would have required substantial redesign or loss of impervious cover (parking, building footprint, etc.) under the existing requirements, while the new requirements would actually allow compliance without changes to the site design.

The wet pond design specification, in conjunction with the coastal adaptation regarding the lack of credit for pool volume intercepting the water table need to be clarified and in concert with one another to ensure properly sized and functional wet ponds.

e) The differences in the sizing and costs of the level 1 and 2 practices were not clearly represented in the Quick Look-up Tables, and therefore should be carefully specified and reviewed in order to capture the "bells and whistles" that influence performance and costs.

5) As noted previously, turf intensive land uses will now be required to incorporate substantial BMP designs. In some cases, athletic fields, parks, and other actively managed single owner developments should be allowed to consider urban nutrient management as a compliance tool.

6) The use of offset fees or other mechanism to "purchase" more economical water quality should be added to the BMP list. The implementation of small scale practices such as bioretention, dry swales, etc., on high density sites to the "maximum extent practicable" must be identified with consideration given to the associated costs (either on a "per pound" or "per acre" basis) and the long term function of the development site.

Cost per Pound - Ranges of values from the Design Workshop:

The following cost per pound of TP are based on "quick" computations done by the design groups at the one-day charette/workshop on March 23. These are not exhaustive numbers, but rough numbers that the teams generated based on a couple-hour exercise. The ranges in cost per pound are of most interest. The "Pre-Workshop Design" number reflects an analysis done by one of the consultants involved in the Tidewater Builders Association effort prior to the workshop, and provides a point of comparison.

1. Commercial Re-Development
   - Workshop Group 1: $ 19,000/lb TP
   - Workshop Group 2: $ 28,000/lb TP
   - Workshop Group 3: $ 95,000/lb TP
   - Pre-Workshop Design $ 66,700/lb TP
2. Institutional – School Campus
   - Workshop Group 1: $ 15,000/lb TP
   - Pre-Workshop Design: $ 51,422/lb TP

3. Institutional – Medical Campus
   - Workshop Group 1: $ 5,500/lb TP
   - Workshop Group 2: $ 7,000/lb TP
   - Workshop Group 3: $ 120,000/lb TP
   - Pre-Workshop Design: $ 5,091/lb TP
4. Residential Development:
   - Workshop (2 groups; only 1 cost estimate): $ 2,000/lb TP
   - Pre-Workshop Design: $ 13,000/lb TP
5. Mixed Use Development:
   - Workshop Group 1: $ 200,000/lb TP
   - Workshop Group 2: $ 250,000/lb TP
   - Pre-Workshop Design $ 37,500/lb TP