**REPORT for OBJ2.TASK 10:**

**SPECIFIC STORM WATER CREDIT SYSTEMS**

**To: MPCA**

From: The Kestrel Design Group Team:

Date: June 21, 2013

Re: Contract CR5332 Objective 2 Task 10

**SCOPE**

1. **Issues Informing MIDS Calculator: Phosphorus – discuss whether P reductions in calculator should vary with media and design**

**MIDS CALCULATOR ANNUAL P REMOVAL: CURRENT AND PROPOSED**

**Percent P Removed Via Volume Reduction And Other Treatment**

Current: 100%

Proposed: 100%

**Percent P Removed Via Non-Volume Reduction Treatment**

|  |  |  |
| --- | --- | --- |
|  | **Particulate P** | **Dissolved P** |
|  | **Current** | **Proposed** | **Current** | **Proposed** |
| No underdrain | 0% | 0% | 0% | 0% |
| Elevated underdrain | 45% | Is soil P content tested to be < 36 mg/kg per Mehlich III test? If yes, 40 %If no, 0% | 0% | Is soil P content tested to be < 36 mg/kg per Mehlich III test? If no, 0%If yes, is there at least 2 feet of soil **above** the elevated underdrain? If yes, 20% credit, If no, credit = 0.2\*xWhere x = (soil depth above elevated underdrain) /2’Credit for approved P-sorbing soil amendments\*?For iron enhanced soils, Imbrium or WTRs, additional 40% credit |
| Underdrain at the bottom | 91% | Is soil P content tested to be < 36 mg/kg per Mehlich III test? If yes, 40 %If no, 0% | 0% | Is soil P content tested to be < 36 mg/kg per Mehlich III test? If yes, 20 %If no, 0%Does the system include approved P-sorbing soil amendments\*?For iron enhanced soils, Imbrium or WTRs, additional 40% credit |
| Internal Water Storage (IWS) |  | Is soil P content tested to be < 36 mg/kg per Mehlich III test? If yes, 40 %If no, 0% |  | Is soil P content tested to be < 36 mg/kg per Mehlich III test? If yes, 20 %If no, 0%Does the system include approved P-sorbing soil amendments\*?For iron enhanced soils, Imbrium or WTRs, additional 40% credit |

Approved P sorption amendments:

* 5% by volume elemental iron filings above IWS or elevated underdrain
* Minimum 5% by volume sorptive media above IWS or elevated underdrain
* Minimum 5% by weight water treatment residuals (WTR) to a depth of at least 10 cm (1/3 foot)
* Other P sorptive amendments with supporting third party research results showing P reduction for at least 20 year lifespan, P credit commensurate with research results (see Task 7 for examples of other P sorptive amendments currently being studied)

Note: the above P reduction credits proposed for P sorbing amendments are very conservative, and could potentially be increased as more data becomes available, especially for planted systems. While some of the existing data is for unplanted columns, planted systems are expected to have higher P removal than unplanted systems based on Lucas and Greenway (2011) and, Henderson et al (2007) and Henderson (2008).

**SUPPORTING RESEARCH**

**Soils with low P-Index**

While many bioretention practices have been found to leach phosphorus, research shows that with a P index below 36 mg/kg, bioretention systems can reduce rather than increase phosphorus in the effluent.

|  |  |  |  |
| --- | --- | --- | --- |
| **Study** | **ID** | **Concetration Reduction (%)** | Notes: |
| **OP** | **TP** | **Particulate P** |  |
| Hunt et al., 2006 | G1 | -940 | -409 | No data | Old style media - medium p index (20-26) |
| G2 | -3829 | -2900 | -2487 | Old style media - high p index (86-100) |
| Passeport et al., 2009 | North Cell | 78 | 63 | 53 | media 80% stalite, 15% sand, 5% OM (p index=8) |
| South Cell | 74 | 58 | 46 | media 80% stalite, 15% sand, 5% OM (p index=5) |
| Line and Hunt, 2009 | DOT Cell | 62 | 44 | No data | Standard media - p index (22-36) |
| Brown and Hunt 2011 | 0.6 m media | -10 | -4 | -2 | Pre-Repair |
| 0.9 m media | -6 | 18 | 36 | Pre-Repair |
| Brown and Hunt, 2012 | 0.6 m media | -367 | 32 | 8 | Post-Repair (irreducible concentrations) |
| 0.9 m media | -570 | -25 | 32 | Post-Repair (irreducible concentrations) |
| Hunt et al., 2008 | HMBC | NM | 31 | NM |  |
| Luell et al. 2011 | Small Cell | NM | -10 | NM |  |
| Large Cell | NM | 7 | NM |  |
| Brown and Hunt 2011 | SCL Cell | 35 | 69 | 67 |  |
| **Mean** | **39** | **41** | **40** |  |
| **Median** | **48.5** | **51** | **46** |  |

Negative sign “-“ implies pollutant export

NM = not measured

**Soils Amendments**

See task 7 for research summary

Barr proposed 60% dissolved P removal credit for iron **enhanced sand filters**, based on studies by Erickson et al. Based on the same studies, as well as agricultural research, total **bioretention** dissolved P credit for low P index soil enhanced with iron proposed here by Kestrel team is also 60% (see Task 7 for research summary).

**PRECEDENTS**

**North Carolina**

The North Carolina Department of Environment and Natural Resources gives P removal credit for bioretention as follows for bioretention with P-Index between 10 and 30 (N.C. Department of Environment and Natural Resources, 2009):

Pollutant Removal – No IWS

45% Total Phosphorus

Pollutant Removal – with IWS

Coastal Plain & Sand Hills

60%Total Phosphorus

Pollutant Removal – with IWS

Piedmont & Mountains Counties (clay soils)

45%Total Phosphorus

**Virginia**

***Table 9.1. Summary of Stormwater Functions Provided by Bioretention Basins***

|  |  |  |
| --- | --- | --- |
| **Stormwater Function** | **Level 1 Design** | **Level 2 Design** |
| **Total Phosphorus (TP) Removal 1** | 25% | 50% |

|  |  |
| --- | --- |
| **Level 1 Design (RR 40 TP: 25 )** | **Level 2 Design (RR: 80 TP: 50)** |
| Sizing (**Section 6.1**): Surface Area (sq. ft.) = (Tv - the volume reduced by an upstream BMP) / Storage Depth 1 | Sizing (**Section 6.1**): Surface Area (sq. ft.) = [(1.25)(Tv) - the volume reduced by an upstream BMP] /Storage Depth 1 |
| Recommended maximum contributing drainage area = 2.5 acres |
| Maximum Ponding Depth = 6 to 12 inches 2 | Maximum Ponding Depth = 6 to 12 inches 2 |
| Filter Media Depth minimum = 24 inches; recommended maximum = 6 feet | Filter Media Depth minimum = 36 inches; recommended maximum = 6 feet |
| Media & Surface Cover (**Section 6.6**) = supplied by vendor; tested for acceptable phosphorus index(P-Index) of between 10 and 30, ***OR***Between 7 and 21 mg/kg of P in the soil media |
| Sub-soil Testing (**Section 6.2**): not needed if an underdrain used; Min infiltration rate > 1/2 inch/hour in order to remove the underdrain requirement. | Sub-soil Testing (**Section 6.2**): one per 1,000 sq. ft. of filter surface; Min infiltration rate > 1/2 inch/hour in order to remove the underdrain requirement. |
| Underdrain (**Section 6.7**) = Schedule 40 PVC with clean-outs  | Underdrain & Underground Storage Layer (**Section 6.7**) = Schedule 40 PVC with clean outs, and a minimum 12-inch stone sump below the invert; ***OR***, none, if soil infiltration requirements are met (**Section 6.2**) |
| Inflow: sheetflow, curb cuts, trench drains, concentrated flow, or the equivalent |
| Geometry (**Section 6.3**):Length of shortest flow path/Overall length = 0.3; ***OR***, other design methods used to prevent short-circuiting; a one-cell design (not including the pre-treatment cell). | Geometry (**Section 6.3**):Length of shortest flow path/Overall length = 0.8; ***OR***, other design methods used to prevent short-circuiting; a two-cell design (not including the pretreatment cell). |
| Pre-treatment (**Section 6.4**): a pretreatment cell, grass filter strip, gravel diaphragm, gravel flow spreader, or another approved (manufactured) pre-treatment structure. | Pre-treatment (**Section 6.4**): a pretreatment cell *plus* one of the following: a grass filter strip, gravel diaphragm, gravel flow spreader, or another approved (manufactured) pre-treatment structure. |
| Conveyance & Overflow (**Section 6.5**) | Conveyance & Overflow (**Section 6.5**) |
| Planting Plan (**Section 6.8**): a planting template to include turf, herbaceous vegetation, shrubs, and/or trees to achieve surface area coverage of at least 75% within 2 years. | Planting Plan (**Section 6.8**): a planting template to include turf, herbaceous vegetation, shrubs, and/or trees to achieve surface area coverage of at least 90% within 2 years. If using turf, must combine with other types of vegetation 1. |
| Building Setbacks 3 (**Section 5**): 0 to 0.5 acre CDA = 10 feet if down-gradient from building or level (coastal plain); 50 feet if up-gradient.0.5 to 2.5 acre CDA = 25 feet if down-gradient from building or level (coastal plain); 100 feet if up-gradient. (Refer to additional setback criteria in **Section 5**) |
| Deeded Maintenance O&M Plan (**Section 8**) |
| 1 Storage depth is the sum of the Void Ratio (Vr) of the soil media and gravel layers multiplied by their respective depths, plus the surface ponding depth. Refer to **Section 6.1**.2 A ponding depth of 6 inches is preferred. Ponding depths greater than 6 inches will require a specific planting plan to ensure appropriate plant selection (**Section 6.8**).3 These are recommendations for simple building foundations. If an in-ground basement or other special conditions exist, the design should be reviewed by a licensed engineer. Also, a special footing or drainage design may be used to justify a reduction of the setbacks noted above.  |

**References**

Balch, G.C., H. Broadbent, B. C. Wootton and S. L. Collins in association with Fleming College. 2013. “Phosphorus Removal Performance of Bioretention Soil Mix Amended with Imbrium®Systems Sorbtive®Media.”

Barr Engineering. 2013. MIDS Credits: Iron-Enhanced Sand Filters. Presentation to

MIDS Work Group March 15, 2013.

Barr Engineering. 2013. Presentation to MIDS Workgroup January 18, 2013.

Brown, R. A. and W. F. Hunt. 2012. “Improving bioretention/biofiltration performance with

restorative maintenance”. [*Water*](http://www.ncbi.nlm.nih.gov/pubmed/22233916) *Science and Technology* 65(2):361-7.

Brown, R.A. and W.F. Hunt III. 2011. ‘Impacts of Media Depth on Effluent Water Quality and Hydrologic Performance of Undersized Bioretention Cells”. *Journal of Irrigation and Drainage Engineering* 137(3): 132-143.

Henderson, C.; Greenway, M.; Phillips, I. 2007. “Removal of Dissolved Nitrogen, Phosphorus and Carbon From Stormwater Biofiltration Mesocosms.” [*Water*](http://www.ncbi.nlm.nih.gov/pubmed/22233916) *Science and Technology* 55(4), 183-191.

Henderson, C. F. K. 2008. ‘The Chemical and Biological Mechanisms of Nutrient Removal from Stormwater in Bioretention Systems.” Thesis. Griffith School of Engineering, Griffith University.

Hunt, W. F., Smith, J. T., Jadlocki, S. J., Hathaway, J. M., and Eubanks, P. R. 2008. “Pollutant removal and peak flow mitigation by a bioretention cell in urban charlotte, N.C.” *Journal of Environmental Engineering*, 134(5), 403–408.

Hunt, W. F., Jarrett, A. R., Smith, J. T., and Sharkey, L. J. (2006). “Evaluating bioretention hydrology and nutrient removal at three field sites in North Carolina.” *Journal of Irrigation and Drainage Engineering* 132(6), 600–608.

Line, D. E. and Hunt, W. F. 2009. “Performance of a Bioretention Area and a Level Spreader-Grass Filter Strip at Two Highway Sites in North Carolina.” *Journal of Irrigation and Drainage Engineering*, 135(2): 217–224.

[Lucas, W. C. and M. Greenway. 2011](http://www.ncbi.nlm.nih.gov/pubmed/21905407). “Phosphorus Retention by Bioretention Mecocosms Using MediaFormulated for Phosphorus Sorption: Response to Accelerated Loads.” *Journal of Irrigation and Drainage Engineering* 137(3): 144-152.

Luell, S. K., W. F. Hunt and R. J. Winston. 2011. “Evaluation of undersized bioretention stormwater control

measures for treatment of highway bridge deck runoff.” *Water Science & Technology* 64(4):974-9.

N.C. Department of Environment and Natural Resources. 2009. Stormwater BMP Manual Chapter 12: Bioretention. Revised 07-24-09. <http://portal.ncdenr.org/c/document_library/get_file?uuid=199a62d4-3066-4e24-a3f1-088c6932483a&groupId=38364>

Passeport, E., Hunt, W. F., Line, D. E., Smith, R. A., and Brown, R. A. 2009. “Field study of the ability of two grassed bioretention cells to reduce stormwater runoff pollution.” *Journal of Irrigation and Drainage Engineering*, 135(4): 505–510.

Virginia DCR. 2010. Stormwater Design Specification No. 9. Bioretention. Version 1.7.