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MEMORANDUM

DATE: 23 July 2019  
TO: Eric Christensen, Water Resources Director, City of Olympia  
CC: Bill Taylor, Principal Investigator  
FROM: Doug Beyerlein, P.E., Hydrology Lead and Project Manager  
SUBJECT: Bioretention Hydrologic Performance Study II Deliverable 4.6 Hydrologic Design Report

**For Task 4 of the Bioretention Hydrologic Performance Study II we have completed Deliverable 4.6 – Hydrologic Design Report.**

The hydrologic design report consists of compiling drainage area-related information for use in the WWHM2012 modeling that will be conducted as part of Task 5 (Data Analysis). Where possible, the following drainage area-related information has been compiled from documentation (drainage reports and/or plan drawings) for the project site. In cases where the drainage reports and the WWHM Report files differ in details the WWHM Report information has been used, as this is information directly from the model input.

Where drainage area and bioretention site information were not available we have substituted our field collection information.

In Task 5 we will be comparing the previously documented hydrologic design information with our field collected information and will be noting where there are significant differences. The purpose of this technical memo is to provide a baseline against which field-collected information can be compared.

**Site: Bellingham, Utter & Washington, Bioretention Cell #5, (BUW)**

The hydrologic design information provided for this site is from the “Columbia Neighborhood Storm Water Quality Improvements Design Report” produced by Pacific Surveying & Engineering, dated November 10, 2016.

The original hydrologic design was based on the 2012 Ecology manual and used WWHM2012 to do the runoff calculations.

The hydrologic design is based on a total contributing area of the 0.93 acres. The contributing area consisted of 0.49 acres of landscape (C soil, lawn vegetation, flat slope), 0.26 acres of roofs, and 0.18 acres of roads (flat slope).

The bioretention facility was designed to have a bottom area of 210 square feet. The maximum ponding depth is 0.5 feet with a riser at 0.2 feet. The amended soil was to be 1.75 feet deep with a design amended soil based on the Ecology standard soil mix (SMMWW 12). Below the Ecology soil mix is 0.5 feet of gravel.

The site was designed for no infiltration. A 4-inch diameter underdrain (with no orifice control) is located 1 inch above the bottom of the gravel layer.

#### **Site: Bellingham, Kentucky & Cornwall, Site #2, (BCK)**

This bioretention site was designed and constructed by the City of Bellingham. There is no stormwater or hydrologic design report for this facility, but the City did provide a WWHM project file and a WWHM2012 project report dated 5/16/2016.

The original hydrologic design was based on the 2012/2014 Ecology manual and apparently used WWHM12 to do the runoff calculations. In the model input the Site #2 bioretention facility is designated as "Kentucky South Bioswale".

The hydrologic design is based on a total contributing area of the 0.27 acres. The contributing area consisted of 0.27 acres of impervious surfaces (roads, flat slope).

The bioretention facility was designed to have a bottom area of 169 square feet with 3 to 1 side slopes (H:V). The bottom slope is flat. The maximum ponding depth is 3.827 feet with a riser at 0.167 feet. The amended soil was to be 1.50 feet deep with an amended soil mix of 15 inches per hour soil mix (Amended 15 in/hr). The Ksat safety factor is 1. Below the amended soil mix is 1.83 feet of gravel.

The site was designed for 100% infiltration and actually infiltrated 99.99%. The design infiltration rate is 12.3 inches per hour. The infiltration reduction factor is 1.0 (no reduction). Infiltration through the side walls was allowed.

A 4-inch diameter underdrain (with a 0.26-inch diameter orifice control) is located 17 inches above the bottom of the gravel layer.

#### **Site: Marysville, 3rd & Quinn, NE Corner North Cell, (M3Q)**

The hydrologic design information provided for this site is from the document "1<sup>st</sup> and 3<sup>rd</sup> Street Stormwater Retrofit Project Predesign Report, City of Marysville, Snohomish County, Washington" produced by Gray & Osbourne, Inc., dated January 2014.

The original hydrologic design was based on the 2012 Ecology manual and used WWHM12 to do the runoff calculations. Note that WWHM3 is incorrectly mentioned second page of Appendix B as the stormwater sizing software; the model input screenshots are actually of WWHM2012.

The hydrologic design is based on a total contributing area of the 0.08 acres. The contributing area consisted of 0.08 acres of impervious surfaces (roads, flat slope).

The bioretention facility was designed to have a bottom area of 500 square feet with vertical side slopes (0 to 1 (H:V)). The bottom slope is flat. The maximum ponding depth is 1.5 feet with a riser at 1.0 foot. The amended soil was to be 1.50 feet deep with the Ecology 6 inch per hour soil mix (SMMWW). The Ksat safety factor is 1. Below the Ecology soil mix is native soil.

The site was designed for 100% infiltration. The design infiltration rate is 1.0 inches per hour. The infiltration reduction factor is 1.0 (no reduction). There is no underdrain.

**Site: Marysville, 1st & Cedar, LID Site #S-1, (M1C)**

The hydrologic design information provided for this site is from the document “1<sup>st</sup> and 3<sup>rd</sup> Street Stormwater Retrofit Project Predesign Report, City of Marysville, Snohomish County, Washington” produced by Gray & Osbourne, Inc., dated January 2014.

The original hydrologic design was based on the 2012 Ecology manual and used WWHM12 to do the runoff calculations. Note that WWHM3 is incorrectly mentioned second page of Appendix B as the stormwater sizing software; the model input screenshots are actually of WWHM2012.

The hydrologic design is based on a total contributing area of the 0.03 acres. The contributing area consisted of 0.03 acres of impervious surfaces (roads, flat slope).

The bioretention facility was designed to have a bottom area of 193 square feet with vertical side slopes (0 to 1 (H:V)). The bottom slope is flat. The maximum ponding depth is 1.5 feet with a riser at 1.0 foot. The amended soil was to be 1.50 feet deep with the Ecology 6 inch per hour soil mix (SMMWW). The Ksat safety factor is 1. Below the Ecology soil mix is native soil.

The site was designed for 100% infiltration. The design infiltration rate is 2.0 inches per hour. The infiltration reduction factor is 1.0 (no reduction). There is no underdrain.

**Site: Monroe School District, Park Place Middle School, Cell #6, (MPP)**

The hydrologic design information provided for this site is from the document “Stormwater Site Plan for Park Place Middle School, Monroe, Washington” produced by Harmsen Associates, Inc., dated February 4, 2016.

The original hydrologic design was based on the 2005 Ecology manual as adopted by the City of Monroe and used WWHM3 to do the runoff calculations.

The hydrologic design is based on a total contributing area of the 0.48 acres. The contributing area consisted of 0.19 acres of landscape (C soil, lawn vegetation, flat slope) and 0.29 acres of pavement and walkways (roads, flat slope).

WWHM3 did not have a bioretention element to represent Cell #6. Instead the design engineers used the SSD Table element. Input to the SSD Table element consists of a user-defined table of stage, surface area, storage volume, surface discharge, and infiltration. There is no documentation on how the data in this table was calculated.

The stormwater site plan report states that the Cell #6 bioretention facility was designed to have a bottom area of 684 square feet with 3 to 1 (H:V) side slopes. The bottom slope is assumed to be flat. The maximum ponding depth is 1.5 feet with a riser at 1.0 foot. The amended soil was to be 1.50 feet deep with a bioretention soil mix (soil mix infiltration rate of 2 inches per hour). Below the bioretention soil mix is native soil.

The site was designed for 100% infiltration. The design infiltration rate is 4 inches per hour. The infiltration reduction factor is 1.0 (no reduction). Infiltration through the side walls was allowed. There is no underdrain.

**Site: Monroe School District, Salem Woods Elementary School, Cell #2, (SSW)**

The hydrologic design information provided for this site is from the document “Full Drainage Report for Salem Woods Elementary School, Snohomish County, Washington” produced by Harmsen Associates, Inc., dated January 19, 2017.

The original hydrologic design was based on the 2016 Snohomish County Drainage Manual and used WWHM12 to do the runoff calculations. Note that WWHM3 is incorrectly mentioned on page 2 of the drainage report as the stormwater sizing software; the actual WWHM2012 summary documentation is provided in Appendix B.

The hydrologic design is based on a total contributing area of the 0.71 acres. The contributing area consisted of 0.22 acres of landscape (C soil, lawn vegetation, moderate slope), 0.03 acres of roofs, and 0.46 acres of pavement and walkways (parking, moderate slope).

The bioretention facility was designed to have a bottom area of 1158 square feet with 3 to 1 (H:V) side slopes. The bottom slope is unknown. The maximum ponding depth is 1.5 feet with a riser at 1.0 foot. The amended soil was to be 1.50 feet deep with the Ecology standard soil mix (SMMWW 12). The Ksat safety factor is unknown. Below the Ecology soil mix is native soil.

The site was designed for 100% infiltration. The design infiltration rate is 11.5 inches per hour. The infiltration reduction factor is 1.0 (no reduction). Infiltration through the side walls was allowed. There is no underdrain.

**Site: Renton, Harrington & NE 8th, Cell #E2, (RSH)**

The hydrologic design information provided for this site is from the document “Technical Information Report: Green Connections – Harrington Avenue NE Phase II, NE 8<sup>th</sup> Place to NE 7<sup>th</sup> Street – Stormwater Retrofit Project” produced by CH2M, dated April 2017.

The original hydrologic design was based on the 2012 Ecology manual and used WWHM4 to do the runoff calculations.

The hydrologic design is based on a total contributing area of the 0.17 acres. The contributing area consisted of 0.0283 acres of landscape (A/B soil, lawn vegetation, moderate slope) and 0.1417 acres of impervious (roads, moderate slope).

The bioretention facility was designed to have a bottom area of 64.2 square feet with 3 to 1 (H:V) side slopes. The facility bottom slope is shown as 0.50, but it is assumed that

this is an error and should be 0.005 feet/foot. The maximum ponding depth is 0.70 feet with a riser at 0.45 feet. The amended soil was to be 1.50 feet deep with a design amended soil infiltration rate of 5 inches per hour (Amended 5 in/hr). No Ksat safety factor was included. Below the Ecology soil mix is 0.5 feet of gravel.

The site was designed for infiltration and an underdrain. The long-term native soil infiltration rate was 1.2 inches per hour with an infiltration reduction factor of 1.0 (the long-term infiltration rate included a safety factor of 8).

A 6-inch diameter underdrain (with a 1-inch diameter orifice control) is located at the bottom of the gravel layer. The amended soil layer treated 94.9% of the stormwater flowing into the facility.

**Site: Tacoma School District, Wainwright Intermediate School, Fircrest, Cell #4, (FWI)**

The hydrologic design information provided for this site is from the document "Stormwater Site Plan" produced by AHBL, dated March 2015, revised May 2015.

The original hydrologic design was based on the 2012 Ecology manual and used WWHM2012 to do the runoff calculations.

The hydrologic design is based on a total contributing area of the 0.33 acres. The contributing area consisted of 0.23 acres of landscape (C soil, lawn vegetation, flat slope) and 0.10 acres of parking (roads, flat slope).

The bioretention facility was designed to have a bottom area of 159 square feet with 3 to 1 (H:V) side slopes. The facility bottom slope is zero. The maximum ponding depth is 1.5 feet with a riser at 1.0 feet. The amended soil was to be 1.50 feet deep with a design amended soil based on the Ecology standard soil mix 6-inch infiltration rate (SMMWW). A Ksat safety factor of 4 was included. Below the Ecology soil mix is 1.0 foot of gravel.

The site was designed for no infiltration. A 6-inch diameter underdrain (with no orifice control) is located at the bottom of the gravel layer. The amended soil layer treated 96.25% of the stormwater flowing into the facility.

**Site: Tacoma School District, Wilson High School, Rain Garden, (TWH)**

The hydrologic design information provided for this site is from the document "Wilson High School Phase 2 Stormwater Site Plan" produced by Sitts & Hill Engineers, dated October 2014.

The original hydrologic design was based on the 2012 City of Tacoma manual and used WWHM2012 to do the runoff calculations. However, the bioretention site (labeled "Rain Garden" in the report) was modeled using the WWHM2012 gravel trench element instead of the bioretention element.

The hydrologic design is based on a total contributing area of the 1.62 acres. The contributing area consisted of 0.19 acres of landscape (C soil, lawn vegetation, flat slope) and 1.43 acres of parking (flat slope).

The bioretention facility was designed to have a bottom area of 992 square feet with 3 to 1 (H:V) side slopes. The bottom slope is 0.00001. The maximum ponding depth is 1.0 foot with a riser at the surface of the soil. The amended soil was to be 1.5 feet deep. The gravel trench element input used a porosity of 0.4 for the top layer. This implies a soil with the consistency of gravel (no specific soil mix was stated). A second soil layer of 1.0 foot was included; it had a porosity of 1.0 (implying no soil), which appears to be an error.

The site was designed for 91% infiltration. The design infiltration rate is 1.5 inches per hour. The infiltration reduction factor is 1.0 (no reduction). Infiltration through the side walls was allowed. There is no underdrain.

**Site: Tumwater School District, Bush Middle School, Bioretention Area, (TBM)**

The hydrologic design information provided for this site is from the document "Drainage Report: Tumwater Middle School Renovations and Additions" produced by BCRA, dated May 27, 2016.

The original hydrologic design was based on the 2005 Ecology manual and used WWHM2012 to do the runoff calculations.

The hydrologic design is based on a total contributing area of the 0.18 acres. The contributing area consisted of 0.05 acres of landscape (A/B soil, lawn vegetation, flat slope) and 0.13 acres of roads (flat slope).

The bioretention facility was designed to have a bottom area of 280 square feet with 3 to 1 (H:V) side slopes. The bottom slope is zero. The maximum ponding depth is 1.5 feet with a riser at 1.0 foot. The amended soil was to be 1.75 feet deep with a design amended soil based on the Ecology standard soil mix (SMMWW 6). The Ksat safety factor is 4. Below the Ecology soil mix is native soil.

The site was designed for 100% infiltration. The design infiltration rate is 0.9 inches per hour. The infiltration reduction factor is 1.0 (no reduction). Infiltration through the side walls was allowed. There is no underdrain.