Name: _____
Date: _____

Module 5.6: Advanced Topics in LID Design: Hydrologic Modeling

General instructions: You may model facility dimensions to the nearest half foot.

Exercise #1: Modeling Bioretention and Permeable Pavement

Site: WSU Extension in Everett
2000 Tower St. Everett, WA 98201
Site Design Assumptions:

Predominant Soil:	Till
Pre-developed Land Cover:	Forest

Exercise #1a: Bioretention (Water Quality)

Site:

Post-developed Land Cover:	Impervious
Design Standard:	Water Quality Treatment (91% Infiltration)

Project: New construction of 5,000 square foot **moderately sloped parking lot**. Design a **bioretention** system to provide **water quality treatment** for all 5,000 sf of parking area.

Facility Design Assumptions:

Sideslopes:	3:1
Ponding Depth:	6 inches
Freeboard:	6 inches
BSM Thickness:	18 inches
BSM Porosity:	40 % effective porosity ("porosity" – "wilting") (46 % porosity in WWHM)
BSM Infiltration Rate:	6 inches/hour
Native Soil Infiltration Rate:	0.5 inches/hour
Overflow pipe diameter:	12 inches

Assume: No underdrain permitted
Square facility geometry
Neglect facility footprint in post-developed area
15 minute computational timestep

Results: WWHM

Facility Bottom Area:	_____ square feet
Facility Footprint:	_____ square feet
Percent of Development:	_____ (top area)

MGSFlood

Facility Bottom Area:	_____ square feet
Facility Footprint:	_____ square feet
Percent of Development:	_____ (top area)

Module 5.6: Advanced Topics in LID Design: Hydrologic Modeling

Exercise #1b: Bioretention (Flow Control)

Site:	Post-developed Land Cover:	Impervious
	Design Standard:	Flow Control (match predeveloped flows and durations from 50% 2-year to full 50-year recurrence interval flow)

Project: New construction of 5,000 square foot **moderately sloped parking lot**. Design a **bioretention** system to provide **flow control** for all 5,000 sf of parking area. Use same facility assumptions as Exercise 1a.

Use a 15 minute computational timestep.

Results: MGSFlood

Facility Bottom Area:	_____ square feet
Facility Footprint:	_____ square feet
Percent of Development:	_____%

Module 5.6: Advanced Topics in LID Design: Hydrologic Modeling

Exercise #1c: Permeable Pavement

Site:
- Post-developed Land Cover: Impervious/Permeable Pavement
- Design Standard: Flow Control (match predeveloped flows and durations from 50% 2-year to full 50-year recurrence interval flow)

Project: New construction of 5,000 square foot parking lot. Design a **moderately sloped permeable pavement** facility to provide **flow control** for 2,000 square feet of permeable pavement (parking stalls) and **run-on** from 3,000 square feet of adjacent impervious parking area (driving lanes).

Facility Design Assumptions:

Pavement Area:	2,000 square feet
Pavement Slope:	2 % (model as flat without check dams – assume design will incorporate check dams to provide required average ponding depth)
Pavement Infiltration Rate:	50 inches/hour
Gravel Porosity:	30%
Native Soil Infiltration Rate:	0.5 inches/hour

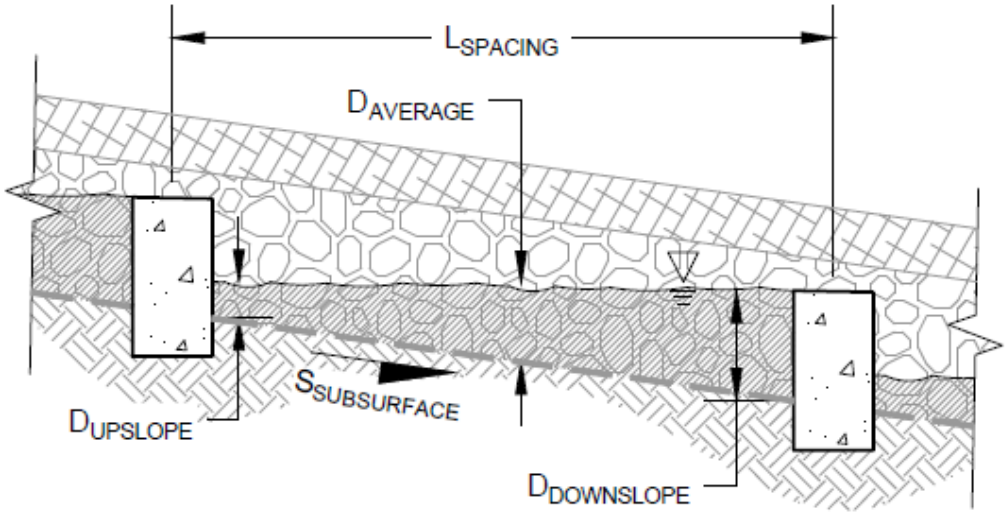
Use a 15 minute computational timestep.

Results: WWHM

Average Ponding Depth: _____ feet

MGSFlood

Average Ponding Depth: _____ feet



Module 5.6: Advanced Topics in LID Design: Hydrologic Modeling

Exercise #2: Modeling Green Roofs and Dispersion

Site: WSU Extension in Everett
2000 Tower St. Everett, WA 98201
Site Design Assumptions:

Predominant Soil:	Till
Pre-developed Land Cover:	Forest

Exercise #2a: Green Roof

Site:

Post-developed Land Cover:	Green Roof
Design Standard:	NA

Project: New construction of 5,000 square foot green roof. Evaluate performance of **Green Roof** in MGS Flood and WWHM. Determine how WWHM Green Roof parameters impact 2-year and 25-year flows from the baseline configuration.

Use a 15-minute computational timestep.

Baseline Green Roof Design Assumptions:

Green Area	0.115 acres
Depth of Material	4 inch
Slope of Rooftop	0.001 (ft/ft)
Vegetative Cover	Ground Cover
Length of Rooftop	50 ft

Results: MGS Flood Recurrence Interval Flows

2-year:	_____ cfs
25-year:	_____ cfs

WWHM Recurrence Interval Flows

2-year:	_____ cfs
25-year:	_____ cfs

WWHM Green Roof Parameter		2-year (cfs)	25-year (cfs)	Δ from Baseline Green Roof in WWHM
Vegetative Cover	Shrubs			
Slope of Roof	0.02 ft/ft			
Depth of Material	8 inch			
Length of Rooftop	100 ft			

Module 5.6: Advanced Topics in LID Design: Hydrologic Modeling

Exercise #2b: Green Roof to Bioretention

Site: Post-developed Land Cover: Green Roof
Design Standard: Flow Control

Project: New construction of 5,000 square foot green roof. Design a **bioretention** system downstream of the green roof to provide flow control for the site.

Bioretention Design Assumptions:

Sideslopes:	3:1
Ponding Depth:	6 inches
Freeboard:	6 inches
BSM Thickness:	18 inches
BSM Porosity:	40 %
BSM Infiltration Rate:	6 inches/hour
Native Soil Infiltration Rate:	0.5 inches/hour
Overflow Diameter:	12 inch

Assume: No underdrain permitted
Square facility geometry
Neglect facility footprint in post-developed area
15 minute computational timestep

Results: MGSFlood

Facility Bottom Area: _____ square feet

How does this facility compare to the facility sized in exercise 1b?

Smaller / Larger By how much? _____%

Module 5.6: Advanced Topics in LID Design: Hydrologic Modeling

Exercise #2c: Dispersion

Site: Post-developed Land Cover: Impervious
Design Standard: NA

Project: New construction of **5,000 square foot moderately sloped parking area**. Determine the performance of sheet flow dispersion in the **adjacent lawn area (5,000 square feet)** next to the parking lot.

Dispersion Design Assumptions:

Option 1: Model parking lot as lateral flow impervious basin routed to a lateral flow soil basin (only available in WWHM).

Option 2: Model impervious area as grass.

Results:

	Option 1		**Option 2**	
WWHM				
Unmanaged Surface(s)				
2-year:	_____	cfs	2-year:	_____ cfs
25-year:	_____	cfs	25-year:	_____ cfs
Dispersed Surface				
2-year:	_____	cfs	2-year:	_____ cfs
25-year:	_____	cfs	25-year:	_____ cfs
Reduction in Recurrence Interval Flows (from unmanaged):				
2-year:	_____	%	2-year:	_____ %
25-year:	_____	%	25-year:	_____ %
MGSFlood Recurrence Interval Flow				
Unmanaged Surface(s)				
			2-year:	_____ cfs
			25-year:	_____ cfs
Dispersed Surface				
			2-year:	_____ cfs
			25-year:	_____ cfs
Reduction in Recurrence Interval Flows (from unmanaged):				
			2-year:	_____ %
			25-year:	_____ %

Which technique (green roof or dispersion) better manages low flows (2-year)?

_____

Which technique (green roof or dispersion) better manages high flows (25-year)?

_____

Why? _____

Module 5.6: Advanced Topics in LID Design: Hydrologic Modeling

Exercise #3: Modeling a Residential Development

Site: Hawks Prairie Gold Course
8383 Vicwood Lane Lacey, WA 98516
Site Design Assumptions:

Predominant Soil:	Till
Pre-developed Land Cover:	Forest

Exercise #3a:

Site:

Post-developed Land Cover:	See Development Plan (attached).
Design Standard:	Flow Control

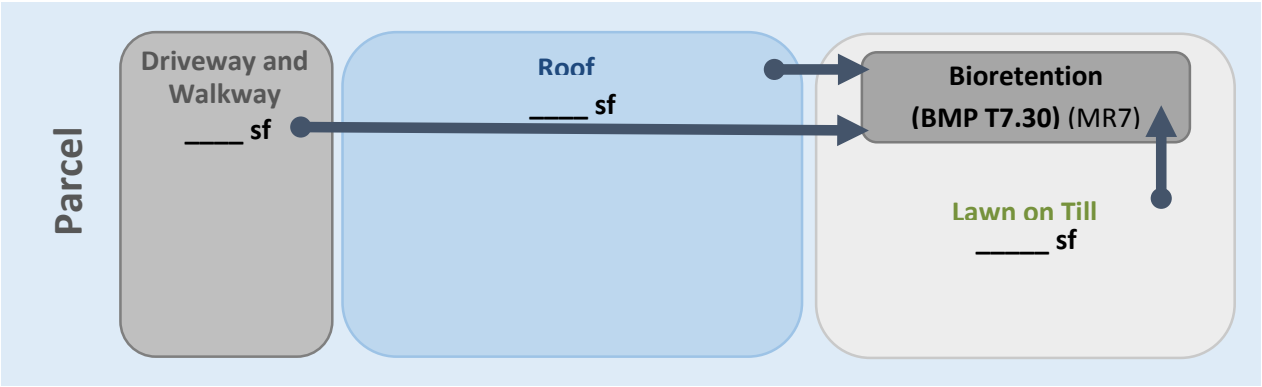
Project: New construction of single residential lot. Design a **bioretention** system at the downstream end of the property to provide flow control for the lot.

Facility Design Assumptions:

Sideslopes:	3:1
Ponding Depth:	6 inches
Freeboard:	6 inches
BSM Thickness:	18 inches
BSM Porosity:	40 %
BSM Infiltration Rate:	6 inches/hour
Native Soil Infiltration Rate:	0.5 inches/hour
Overflow Structure Diameter:	12 inches

Assume: No underdrain permitted
Square facility geometry
Subtract bioretention bottom area from lawn area
5 minute computational timestep

Results: MGSFlood
Facility Bottom Area: _____ square feet



Module 5.6: Advanced Topics in LID Design: Hydrologic Modeling

Exercise #3b:

Site: Post-developed Land Cover: See Development Plan (attached).
Design Standard: NA

Project: Determine performance of List #2 BMPs (see Figure 2) for a single lot. Assume roof area managed by bioretention facility, at-grade impervious managed by permeable pavement, and lawn area flows to the POC unmanaged.

Bioretention Design Assumptions:

Bioretention Facility Sizing Factor:	5%
Sideslopes:	3:1
Ponding Depth:	6 inches
Freeboard:	6 inches
BSM Thickness:	18 inches
BSM Porosity:	40 %
BSM Infiltration Rate:	6 inches/hour
Native Soil Infiltration Rate:	0.5 inches/hour
Overflow Structure Diameter:	12 inches

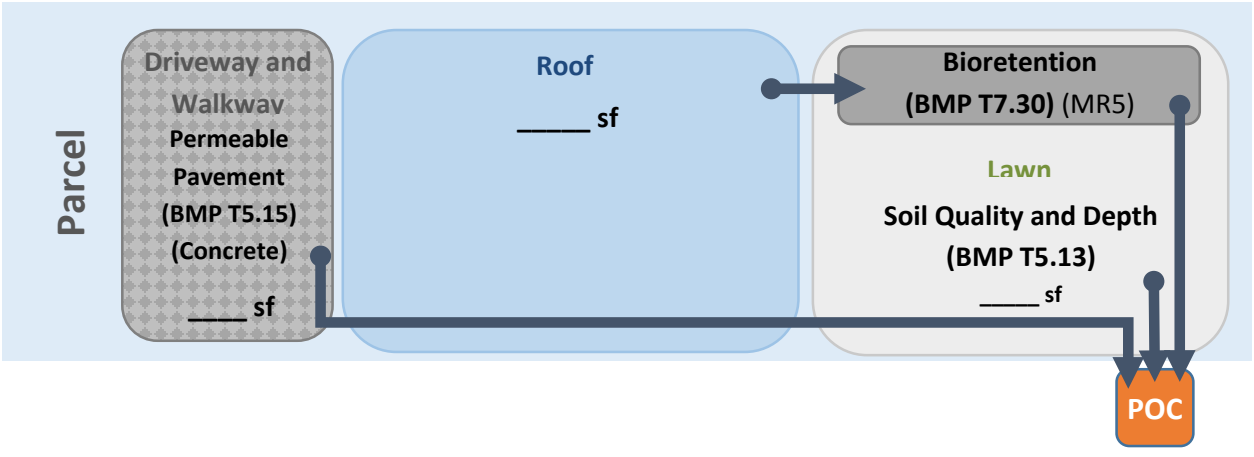
Assume: No underdrain permitted
Square facility geometry
Subtract bioretention bottom area from lawn area
5 minute computational timestep

Permeable Pavement Design Assumptions:

Pavement Slope (ft/ft)	0.05
Trench Slope (ft/ft)	0.0
Pavement Infiltration Rate (in/hr)	20
Native Infiltration (in/hr)	0.5
Gravel Porosity (%)	30
Trench Depth (ft)	0.25

Soil Quality and Depth Assumptions: Modeled as Pasture on Till

Results:
Bioretention Bottom Area: _____ square feet
Lawn Area (less bio bottom area): _____ square feet
2-year peak flow: _____ cfs
25-year peak flow: _____ cfs
LID Standard: Pass / Fail
Flow Control Standard: Pass / Fail



Module 5.6: Advanced Topics in LID Design: Hydrologic Modeling

Exercise #3c:

Site: Post-developed Land Cover: See Development Plan (attached).
Design Standard: NA

Project: Determine performance of List #2 BMPs (see Figure 3) for the right-of-way adjacent to two lots.

Right-of-Way Design Assumptions:

Lot Width (ft)	75
Number of Lots	2
Right-of-way Width (ft)	48
Roadway Width (ft)	28
Sidewalk Width (ft)	10 (5 ft both sides of road)
Planter Strip Width (ft)	10

Permeable Pavement Roadway and Sidewalk Design Assumptions:

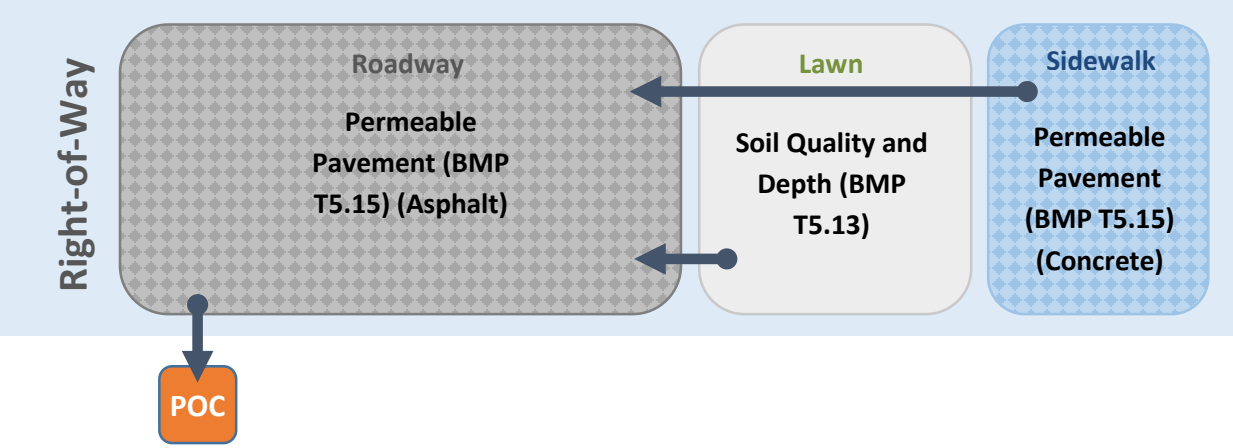
Pavement Slope (ft/ft)	0.01
Trench Slope (ft/ft)	0.0
Pavement Infiltration Rate (in/hr)	20
Native Infiltration (in/hr)	0.5
Gravel Porosity (%)	30
Trench Depth (ft)	0.25

Soil Quality and Depth Assumptions:

Modeled as Pasture on Till (for planter strip area)

Results: MGSFlood

2-year peak flow: _____ cfs LID Standard: Pass / Fail
25-year peak flow: _____ cfs Flow Control Standard: Pass / Fail



Module 5.6: Advanced Topics in LID Design: Hydrologic Modeling

Exercise #3d:

Site: Post-developed Land Cover: See Development Plan (attached).
Design Standard: NA

Project: Size a regional detention pond to meet the flow control standard for two lots and the right-of-way assuming the facilities used in Exercise 3b and 3c.

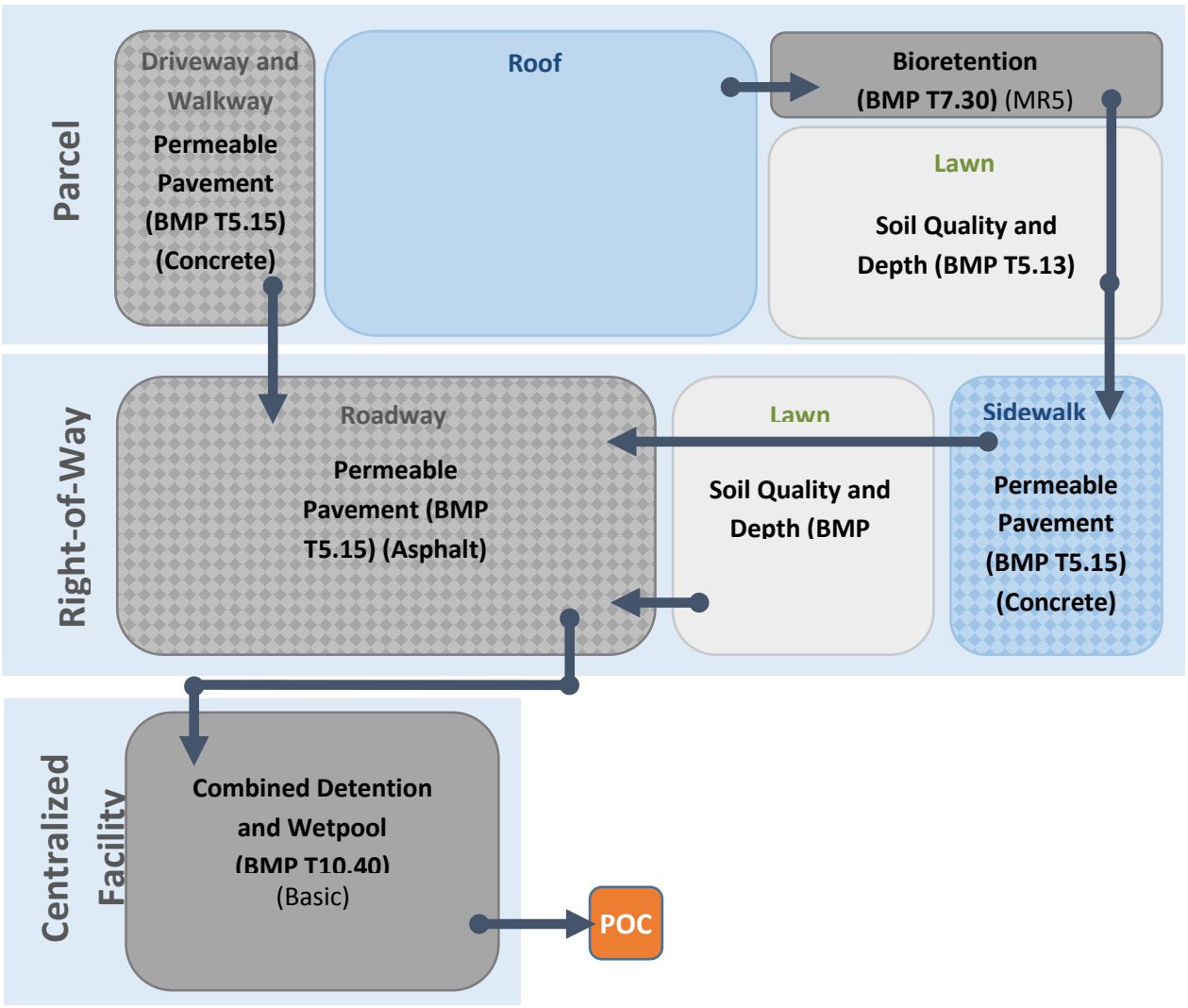
Regional Detention Pond Design Assumptions:

Sideslopes	3:1
Ponding Depth	2 feet
Freeboard	12 inches
Infiltration	none

Assume: Single orifice configuration (0.5 inch min. diameter)

Area Name	Area (sf)	Area (acres)	Modeled Land Cover/BMP
Lot 1			
Driveway			
Roof			
Lawn			
Walkway			
Bioretention			
Lot 2			
Driveway			
Roof			
Lawn			
Walkway			
Bioretention			
Right-of-Way			
Roadway			
Lawn			
Sidewalk			
Total Area			

Results:	MGSFlood	
	Facility Bottom Area:	_____ square feet


Parcel
Driveway and Walkway
Permeable Pavement (BMP T5.15) (Concrete)
Roof
Bioretention (BMP T7.30) (MR5)
Lawn
Soil Quality and Depth (BMP T5.13)
Right-of-Way
Roadway
Permeable Pavement (BMP T5.15) (Asphalt)
Lawn
Soil Quality and Depth (BMP
Sidewalk
Permeable Pavement (BMP T5.15) (Concrete)
Centralized Facility
Combined Detention and Wetpool (BMP T10.40)
(Basic)
POC

Module 5.6: Advanced Topics in LID Design: Hydrologic Modeling

Exercise #4:

Site: Site: WSU Extension
600 128th Street SE
Everett, WA

Instructions: Review example hydrologic modeling memo and attached WWHM model output report. Identify discrepancies between the memo and the output report and errors in model inputs and/or calculations.

Results:	Description of Error/Discrepancy	Location of Error/Discrepancy
1		
2		
3		
4		
5		
6		
7		
8		
9		
10		