Statewide LID Training Program
• 2012: Public and private partners engage state legislature to fund program
• June 2012: LID Training Steering Committee convened
• 2012-2013: Washington State LID Training Plan developed: [www.wastormwatercenter.org/statewide-lid-training-program-plan](http://www.wastormwatercenter.org/statewide-lid-training-program-plan)
• 2014: Training program built from state LID Training Plan
Statewide LID Training Program

OVERVIEW OF PROGRAM

PROJECT LEAD

HERRERA

CORE TEAM

CASCADIA

Veda

Environmental

ADDITIONAL TRAINING SUPPORT

CH2MHILL

Kindred

Hydro

LEAPING FROG FILMS

SvR

DESIGN COMPANY

ASSOCIATED EARTH SCIENCES INCORPORATED

WASHINGTON STORMWATER

ABBOTSFORD CONCRETE PRODUCTS

STORMWATER ONE

Online Training & Credentials
Statewide LID Training Program

PROGRAM OVERVIEW

• Implement first phase of trainings (September 2014 through May 2015)
• 64 trainings offered in first phase
• Three levels: Introductory, Intermediate, and Advanced
# Statewide LID Training Program

## Overview of Program

<table>
<thead>
<tr>
<th>INTRODUCTORY</th>
<th>INTERMEDIATE</th>
<th>ADVANCED</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>1.0</strong></td>
<td><strong>3.1</strong></td>
<td><strong>5.1</strong></td>
</tr>
<tr>
<td>Introduction to LID for Eastern Washington</td>
<td>Intermediate LID Topics: NPDES Phase I &amp; II Requirements</td>
<td>Advanced Topics in LID Design: Bioretention</td>
</tr>
<tr>
<td><strong>2.1</strong></td>
<td><strong>3.2</strong></td>
<td><strong>5.2</strong></td>
</tr>
<tr>
<td>Introduction to LID for Inspection &amp; Maintenance Staff</td>
<td>Intermediate LID Design: Bioretention</td>
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</tr>
<tr>
<td><strong>2.2</strong></td>
<td><strong>3.3</strong></td>
<td><strong>5.3</strong></td>
</tr>
<tr>
<td>Introduction to LID for Developers &amp; Contractors: Make Money be Green</td>
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</tr>
<tr>
<td><strong>3.1</strong></td>
<td><strong>3.4</strong></td>
<td><strong>5.4</strong></td>
</tr>
<tr>
<td><strong>4.1</strong></td>
<td><strong>5.5</strong></td>
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<td><strong>4.2</strong></td>
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<td><strong>5.1</strong></td>
<td><strong>5.7</strong></td>
<td><strong>8.1</strong></td>
</tr>
<tr>
<td><strong>5.2</strong></td>
<td><strong>5.8</strong></td>
<td><strong>8.2</strong></td>
</tr>
<tr>
<td>Intermediate LID Design: Site Assessment, Planning &amp; Layout</td>
<td>Advanced Topics for LID Operations: Permeable Pavement</td>
<td>Advanced Topics in LID Design: Bioretention Media</td>
</tr>
</tbody>
</table>

## Train the Trainers

| **9.1** | **9.2** |
| Service Providers | LID Topic Experts |
# Statewide LID Training Program

## TODAY’S TRAINING

<table>
<thead>
<tr>
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<td>8.1</td>
</tr>
<tr>
<td>3.4</td>
<td>Intermediate LID Design: Site Assessment, Planning &amp; Layout</td>
<td>5.4</td>
</tr>
<tr>
<td>4.1</td>
<td>Intermediate LID Design: Rainwater Collection Systems &amp; Vegetated Roofs</td>
<td>8.2</td>
</tr>
<tr>
<td>4.2</td>
<td>Intermediate LID Design: Hydrologic Modeling</td>
<td>9.1</td>
</tr>
<tr>
<td></td>
<td></td>
<td>9.2</td>
</tr>
</tbody>
</table>

**TRAIN THE TRAINERS**
REBECCA DUGOPOLSKI, PE
Senior Engineer
Key project experience: Stormwater monitoring, design, and NPDES Permit compliance

MEGHAN FELLER, PE
Project Engineer
Key project experience: Stormwater planning, design, and NPDES Permit compliance
introduction

hydrologic modeling basics

performance standards

BMP modeling specifics

wrap up
introduction

hydrologic modeling basics

performance standards

BMP modeling specifics

wrap up
LEARNING OBJECTIVES

1. Gain a basic level of knowledge using WWHM and MGSFlood to predict pre- and post-development flow volumes and durations.

2. Learn basic, entry level skills to size bioretention, permeable pavement, rainwater collection systems, and vegetated roofs in residential and commercial settings using WWHM and MGSFlood.

3. Understand the advantages and limitations of WWHM and MGSFlood and gain an awareness of additional modeling tools for specific predictions.
LOGISTICS

SCHEDULE
• 4-hour classroom training with one break

OTHER LOGISTICS
• Restroom location
• Food
• Turn off cell phones
• Sign in and sign out
LID PRINCIPLES: Pre-developed forest

2012 LID Technical Guidance Manual for Puget Sound
LID PRINCIPLES: Developed condition
INTRODUCTION

LID PRINCIPLES: Stormwater Impacts

HOW DO WE GET THERE?

• Quantify the effects of development
• Size and evaluate the performance of stormwater management practices
TRADITIONALLY...

- Primarily detention and large scale infiltration
- Detention pond/vault/pipe or infiltration pond/gallery
• Detention hydrograph (single event)

- Match peak flows, increased duration:
  - OK for piped system with direct discharge to a lake or ocean?
  - OK for discharge to a creek?
  - OK for discharge to a wetland?
May limit erosive flows in stream but we have not mimicked hydrologic cycle (no evaporation, no groundwater recharge, different hydrograph)
INTRODUCTION

FLOW DURATIONS

- Detention (continuous simulation)
- Match peaks and durations
  - Durations $\rightarrow$ percent of time a particular flow occurs

![Graph showing flow durations for predeveloped and postdeveloped areas.](image)

Flow (cfs) vs. Exceedance Probability

Predeveloped

Postdeveloped

Statewide LID Training Program

4.2 HYDROLOGIC MODELING

INTERMEDIATE TOPICS IN LID DESIGN
INTRODUCTION

FLOW DURATIONS

INFILTRATION VS DETENTION

Infiltrating Facilities

Detention Facilities

Flow Duration Plot

Flow Control Performance
- Excursion at 50% Q2: -100.0% PASS
- Excursion 50% Q2 to Q2: -99.9% PASS
- Excursion Q2 to Q50: 0.0% PASS
- % Pos Excursion Q2 to Q50: 0.0% PASS

LID Performance
- Excursion at 50% Q2: -100.0% PASS
- Excursion 50% Q2 to 50% Q2: -100.0% PASS

Flow Control Performance
- Excursion at 50% Q2: -9.1% PASS
- Excursion 50% Q2 to Q2: -9.1% PASS
- Excursion Q2 to Q50: 4.6% PASS
- % Pos Excursion Q2 to Q50: 15.9% PASS

LID Performance
- Excursion at 50% Q2: -47.4% FAIL
- Excursion 50% Q2 to 50% Q2: 72.4% FAIL

Exceedance Probability

Predeveloped

Postdeveloped

If not detention, then what?

Statewide LID Training Program

4.2 HYDROLOGIC MODELING

INTERMEDIATE TOPICS IN LID DESIGN
LOW IMPACT DEVELOPMENT (LID): Stormwater Management Strategy

INTRODUCTION

• **Site design & planning techniques** emphasizing conservation

• **Use of small-scale & distributed** engineered controls to closely mimic pre-development hydrologic processes

• Minimizing the concentration of stormwater

• **Careful assessment of site soils and strategic site planning to best use those soils for stormwater management**
INTRODUCTION

LID Principles: Site Design And Planning

- Minimize disturbance
- Reduce impervious surface
- Protect and restore native soils and vegetation
- Manage stormwater close to the source in a system of distributed practices
- Disconnect impervious surfaces

Traditional

LID
INTRODUCTION
LID BMPs: Small-Scale Engineering Controls

- Infiltration
- Filtration
- Storage
- Evaporation
- Transpiration

Conserve or regain pre-developed hydrologic functions

Synonyms for LID BMPs:

Green Stormwater Infrastructure (GSI), Integrated Management Practices (IMPs), and On-Site Stormwater Management BMPs
1. Introduction
2. Hydrologic modeling basics
3. Performance standards
4. BMP modeling specifics
5. Wrap up
HYDROLOGIC MODELING BASICS

LID PRINCIPLES: Stormwater Impacts

HOW DO WE GET THERE?

• Quantify the effects of development
• Size and evaluate the performance of stormwater management practices

HYDROLOGIC MODELING
HYDROLOGIC MODELING BASICS
PURPOSE OF HYDROLOGIC MODELING

• Q: What is hydrologic modeling?

• A: Use of mathematical equations to estimate hydrologic cycle components and facility performance based on:
  • Weather patterns
  • Land use
  • Soil
  • Topography

Source: http://www.und.nodak.edu/
• Q: Why do we use hydrologic models?

• A: Characterize hydrologic conditions:
  - Predeveloped
  - Current
  - Post-project
  - Design mitigation
PURPOSE OF HYDROLOGIC MODELING

• Q: When does hydrologic modeling enter into your project?

• A: Start to finish
  • Preliminary design (sizing)
  • Final design (optimization)
  • Demonstrate requirements met (permit submittals)
HYDROLOGIC MODELING BASICS

MODELING TOOLS

• Single-event models
  • Appropriate for conveyance sizing

• Continuous models
  • Required for sizing BMPs to meet the LID performance standard (MR#5), treatment (MR#6), or flow control (MR #7)

• Simplified sizing tools
  • Allow sizing without hydrologic modeling
MODELING TOOLS: Single-Event Models

- Input single storm event, typically synthetic
- Output peak flow rates
- Typical methods and models
  - SCS
  - SBUH
  - Rational Method
  - StormShed
  - HydroCAD
  - SWMM
  - HEC-HMS
  - SUSTAIN
MODELING TOOLS: Continuous Models

- Input long-term rain and evaporation
- Output continuous runoff, peak flow, & duration
- Accounts for antecedent conditions
  - Is the soil already saturated?
  - Is your bioretention facility already full of water?
- Common models:
  - HSPF
  - WWHM
  - MGS Flood
  - KCRTS
  - SUSTAIN
  - SWMM
  - InfoWorks
MODELING TOOLS: WWHM/MGFSFlood Input

- **Meteorological Data**
  - Rainfall (5-min, 15-min, hourly)
  - Evaporation (daily)

- **Land Cover Types**
  - Regional calibrated parameters (Dinicola 1990)
  - Impervious areas
    - Timing: slope, length of flow path, surface roughness
    - Volume: depression storage
  - Pervious areas
    - Timing: slope, length of flow path, surface roughness
    - Volume: depression storage, vegetative cover, soil type

- **BMP Configurations**
HYDROLOGIC MODELING BASICS

MODELING TOOLS: WWHM/MGSFlood Input

- Meteorological Data
  - Select precipitation region
  - Select mean annual precipitation depth

[Image of climate selection interface and map showing precipitation regions]

MGS Flood
HYDROLOGIC MODELING BASICS

MODELING TOOLS: WWHM/MGSFlood Input

- Meteorological Data
  - Select precipitation region
  - Select mean annual precipitation depth
HYDROLOGIC MODELING BASICS

MODELING TOOLS: WWHM/MGSFlood Input

- Meteorological Data
  - Select precipitation region
  - Select mean annual precipitation depth

Legend
Mean annual precipitation (inches)
- 15 to 20
- 20 to 30
- 30 to 40
- 40 to 50
- 50 to 60
- 60 to 70
- 70 to 80
- 80 to 100
- 100 to 120
- 120 to 140
- 140 to 160
- > 160

Region break line
Precipitation constraint
Elevation > 1500 feet
County boundary
10-inch precipitation contour
2-inch precipitation contour

Statewide LID Training Program
DEPARTMENT OF ECOLOGY
State of Washington

4.2 HYDROLOGIC MODELING
INTERMEDIATE TOPICS IN LID DESIGN
HYDROLOGIC MODELING BASICS

MODELING TOOLS: WWHM/MGSFlood Input

- Land Cover

By comparison...

**Subbasin Land Use - Subbasin 1**

<table>
<thead>
<tr>
<th>Cover</th>
<th>Area (ac)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Till Forest</td>
<td>0.000</td>
</tr>
<tr>
<td>Till Pasture</td>
<td>0.000</td>
</tr>
<tr>
<td>Till Grass</td>
<td>1.000</td>
</tr>
<tr>
<td>Outwash Forest</td>
<td>0.000</td>
</tr>
<tr>
<td>Outwash Pasture</td>
<td>0.000</td>
</tr>
<tr>
<td>Outwash Grass</td>
<td>0.000</td>
</tr>
<tr>
<td>Saturated Soil</td>
<td>0.000</td>
</tr>
<tr>
<td>Green Roof</td>
<td>0.000</td>
</tr>
<tr>
<td>User</td>
<td>0.000</td>
</tr>
<tr>
<td>Impervious</td>
<td>1.000</td>
</tr>
</tbody>
</table>

**Subcatchment 1**

<table>
<thead>
<tr>
<th>Property</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Name</td>
<td>1</td>
</tr>
<tr>
<td>X-Coordinate</td>
<td>455.044</td>
</tr>
<tr>
<td>Y-Coordinate</td>
<td>5997.807</td>
</tr>
<tr>
<td>Description</td>
<td></td>
</tr>
<tr>
<td>Tag</td>
<td></td>
</tr>
<tr>
<td>Rain Gage</td>
<td>X</td>
</tr>
<tr>
<td>Outlet</td>
<td>X</td>
</tr>
<tr>
<td>Area</td>
<td>5</td>
</tr>
<tr>
<td>Width</td>
<td>500</td>
</tr>
<tr>
<td>% Slope</td>
<td>0.5</td>
</tr>
<tr>
<td>% Imperv</td>
<td>25</td>
</tr>
<tr>
<td>N-Imperv</td>
<td>0.01</td>
</tr>
<tr>
<td>N-Perv</td>
<td>0.1</td>
</tr>
<tr>
<td>Dstore-Imperv</td>
<td>0.05</td>
</tr>
<tr>
<td>Dstore-Perv</td>
<td>0.05</td>
</tr>
<tr>
<td>%Zero-Imperv</td>
<td>25</td>
</tr>
</tbody>
</table>

**MGS Flood**

**SWMM**
### Kitsap County: Pavement sized as function of contributing impervious area and precipitation

<table>
<thead>
<tr>
<th>BMP</th>
<th>Design Infilt. Rate (in/hr)</th>
<th>Flow Control Standard (MR #7)</th>
<th>Sizing Equation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Permeable Pavement Facility</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>6 inch ponding depth</td>
<td>0.25</td>
<td>0.1100</td>
<td>-1.0536</td>
</tr>
<tr>
<td></td>
<td>0.5</td>
<td>0.0187</td>
<td>+0.4945</td>
</tr>
<tr>
<td></td>
<td>1.0</td>
<td>0.0048</td>
<td>+0.3531</td>
</tr>
<tr>
<td>Permeable Pavement Surface</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Slope &lt;= 2%</td>
<td>0.13 – 0.249</td>
<td>0.005</td>
<td>0</td>
</tr>
<tr>
<td>≥ 0.25</td>
<td>0.01</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Area (sf) = Impervious Area (sf) x [M x Precip. (in) + B]

Aggregate Depth (in) = M x Precip. (in)
# HYDROLOGIC MODELING BASICS

## MODELING TOOLS: Simplified Sizing Tools

### Kitsap County Pre-Sized Calculator

<table>
<thead>
<tr>
<th>Facility Size</th>
<th>Credit</th>
<th>Area MB</th>
</tr>
</thead>
<tbody>
<tr>
<td>Site Mean Annual Precipitation</td>
<td></td>
<td></td>
</tr>
<tr>
<td>New and Improved Impervious Area</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Flow Control Standard Allowance</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### GSI-Calc

**Permeable Pavement (2 to 5% Slopes with Berms)**

- **Design Infiltration Rate (mm/hr):** [Input] 300
- **Soil 1:** [Input] 50
- **Soil 2:** [Input] 50
- **Soil 3:** [Input] 50
- **Average Subsurface Pervious Depth:** 100

**Notes:**
- The average subsurface pervious depth (100 + 50)/2 = 75 cm is required for stormwater management. The minimum aggregate design depth shall be the greater of the depth required to achieve this subsurface permeability and the minimum aggregate required for design loading.
- Permeable pavement achieves the water quality treatment standard if neither soil meets 50% treatment soil requirements. Alternatively, a treatment layer may be included.

---

**Statewide LID Training Program**
1. introduction

2. hydrologic modeling basics

3. performance standards

4. BMP modeling specifics

5. wrap up
PERFORMANCE STANDARDS

NPDES MUNICIPAL STORMWATER PERMIT: Minimum Requirements (MRs)

1. Preparation of Stormwater Site Plans
2. Construction Stormwater Pollution Prevention Plan (SWPPP)
3. Source Control of Pollution
4. Preservation of Natural Drainage Systems and Outfalls
5. On-Site Stormwater Management
6. Run-off Treatment
7. Flow Control
8. Wetlands Protection
9. Operations and Maintenance
MINIMUM REQUIREMENT #5

Implementation options:

• List #1
• List #2
• LID Performance Standard
MINIMUM REQUIREMENT #5

MR #5 applies to:

- Projects triggering MR #1-#5 only
  - List #1 or LID Performance Standard Applies

- Projects triggering MR #1-#9
  - List #2 or LID Performance Standard Applies
## MINIMUM REQUIREMENT #5: Projects Triggering MR #1-#9

<table>
<thead>
<tr>
<th>Project Type &amp; Location</th>
<th>Requirement</th>
</tr>
</thead>
<tbody>
<tr>
<td>Development (new or redevelopment) on any parcel inside the UGA, or development outside the UGA on a parcel less than 5 acres</td>
<td>LID Performance Standard and BMP T5.13 OR List #2 (applicant option)</td>
</tr>
<tr>
<td>Development (new or redevelopment) outside the UGA on a parcel of 5 acres or larger</td>
<td>LID Performance Standard and BMP T5.13</td>
</tr>
</tbody>
</table>
Consider all the BMPs in the order listed and use the first BMP that is considered feasible.
PERFORMANCE STANDARDS

MINIMUM REQUIREMENT #5: List #1

**Lawn and Landscaped Areas**

1. Soil Quality and Depth (BMP T5.13)

**Roofs**

1. Full Dispersion or Downspout Full Infiltration (T5.30 or T5.10A)
2. Rain Gardens or Bioretention (T5.14A or B) > 5% of drainage area
3. Downspout Dispersion Systems (T5.10B)
4. Perforated Stub-out Connections (T5.10C)

**Other Hard Surfaces**

1. Full Dispersion (T5.30)
2. Permeable Pavement, Rain Gardens, or Bioretention
   • (T5.15, T5.14A, T5.14B)
   • Rain Garden or Bioretention area > 5% of drainage area
3. Sheet Flow Dispersion, or Concentrated Flow Dispersion (T5.12 or T5.11)
## PERFORMANCE STANDARDS
### MINIMUM REQUIREMENT #5: LIST #2

<table>
<thead>
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<th>Lawn and Landscaped Areas</th>
<th>Roofs</th>
<th>Other Hard Surfaces</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Soil Quality and Depth (BMP T5.13)</td>
<td>1. Full Dispersion or Downspout Full Infiltration (T5.30 or T5.10A)</td>
<td>1. Full Dispersion (T5.30)</td>
</tr>
<tr>
<td></td>
<td>2. Bioretention (T5.14B) &gt; 5% of drainage area</td>
<td>2. Permeable Pavement (T5.15)</td>
</tr>
<tr>
<td></td>
<td>3. Downspout Dispersion Systems (T5.10B)</td>
<td>3. Bioretention (T5.14B) &gt; 5% of drainage area</td>
</tr>
<tr>
<td></td>
<td>4. Perforated Stub-out Connections (T5.10C)</td>
<td>4. Sheet Flow Dispersion, or Concentrated Flow Dispersion (T5.12 or T5.11)</td>
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</table>
MINIMUM REQUIREMENT #5: LID PERFORMANCE STANDARD

Match pre-developed durations from 8% of the 2-year peak flow to 50% of the 2-year peak flow

Flow Control Standard addresses higher, less frequent stormwater flows

LID Performance Standard addresses lower, more frequent stormwater flows

Source: Ecology SWMMWW Presentation
MINIMUM REQUIREMENT #6 and #7:

• Runoff treatment (MR #6)
  • Infiltrate 91 percent of the total runoff volume through soil meeting Ecology treatment criteria (for infiltration BMPs)

• Flow Control (MR# 7)
  • Match pre-developed discharge rates from 50% of the 2-year peak flow up to the full 50-year peak flow

• Other flow control standards
  • Combined sewer or capacity constrained basins (peak-based standards): apply only in specific cities with flow control exempt areas with limited conveyance capacity
  • Wetland protection
FLOW DURATION STANDARDS

- LID performance standard (MR #5)
- Flow control (MR #7)
**PERFORMANCE STANDARDS**

**SIZING COMPARISON EXAMPLE: Bioretention**

- Precipitation: 38 inches annually (Seattle)
- Predeveloped condition: Forest on till
- Design Infiltration Rate: 0.25 inch/hour
- Configuration: Vertical walls
- Ponding depth: 6 inches

<table>
<thead>
<tr>
<th>LID Standard</th>
<th>Flow Duration Standard</th>
<th>Treatment Standard</th>
</tr>
</thead>
<tbody>
<tr>
<td>5,000 sf</td>
<td>5,000 sf</td>
<td>5,000 sf</td>
</tr>
<tr>
<td>240 sf</td>
<td>1090 sf</td>
<td>345 sf</td>
</tr>
<tr>
<td>5.1%</td>
<td>27.8%</td>
<td>6.2%</td>
</tr>
</tbody>
</table>
PERFORMANCE STANDARDS

LID COST ANALYSIS: Small Commercial

Lot 1 Acre
Total Impervious 35,500 sf

Roof Area 5,000 sf

Scenario 7 to 10
Statewide LID Training Program
PERFORMANCE STANDARDS

LID COST ANALYSIS: Results Scenario 8

Scenario 8 – Small Commercial – 2005 – Till

Soil Quality and Depth

Stormwater Treatment Planter Vault

Detention Tank

HMA Parking
PERFORMANCE STANDARDS

LID COST ANALYSIS: Results Scenario 10

Soil Quality and Depth

HMA Parking

Detention Tank

Bioretention

Scenario 10 – Small Commercial – 2012 – Till
LID COST ANALYSIS: 2012 manual (with LID)
1. BIORETENTION
2. PERMEABLE PAVEMENT
3. VEGETATED ROOFS
4. CISTERNS
5. DISPERSION
6. MINIMAL EXCAVATION FOUNDATIONS
7. REVERSE SLOPE SIDEWALKS
1. BIORETENTION
2. PERMEABLE PAVEMENT
3. VEGETATED ROOFS
4. CISTERNS
5. DISPERSION
6. MINIMAL EXCAVATION FOUNDATIONS
7. REVERSE SLOPE SIDEWALKS
BIORETENTION: Definition and Types

- Shallow landscaped depressions that receive stormwater from small contributing areas
- Small scale, dispersed facilities
- Types:
  - With underdrain
  - Without underdrain
  - With underdrain and liner
BIORETENTION: Without Underdrain

- Relies on infiltration to native soil
- Can meet on-site list requirement
- Can provide effective WQ treatment for some pollutants
- Can meet the flow control standard (MR #7) for many soil conditions

Notes:
1. Bottom width shall be a minimum of 2 feet and bottom area shall be flat (0% slope).
2. Imported bioretention soil shall meet specifications.
**BIORETENTION: With Underdrain**

- Some infiltration to native soil
- Can meet on-site list requirement (List #2 requires the underdrain to be elevated at least 6 inches)
- Can provide effective WQ treatment for some pollutants
- May not be able to meet flow control standard (MR #7) alone, but can help to achieve flow control goals (raised underdrain and orifice improve performance)

**BMP MODELING SPECIFICS**

1. Bottom width shall be a minimum of 2 feet and bottom area shall be flat (0% slope).
2. Imported bioretention soil shall meet Ecology specifications.
BIORETENTION: With Underdrain and Liner

- No infiltration to native soil
- Can provide effective WQ treatment for some pollutants

Cannot meet flow control standard (MR #7) alone, but can help to achieve flow control goals (orifice improves performance)
BIORETENTION: Current Modeling Guidelines

• Implicit Method (2012 LID Manual)
  • Lump surface ponding and storage in bioretention soil if
    • Subgrade infiltration rate < long-term bioretention soil infiltration rate
    • Slope ≤ 1 %
  • Effective depth = ponding depth + bioretention soil depth x void ratio (%)
  • MGS Flood and WWHM3
  • Neglects movement of water through layers
**BIORETENTION: Current Modeling Guidelines**

**Implicit Method**

- Inflow
- "Swale" bottom area and slope
- Side slope
- Bioretention soil
- Native soil infiltration rate
- Effective depth
- Freeboard
- Riser height
- Overflow
- Riser diameter
- Bioretention soil thickness and porosity
- Effective subsurface storage modeled as effective storage depth (soil depth x porosity)

**Key:**
- Effective subsurface storage
- Piping
- Native Soil

Statewide LID Training Program

**4.2 HYDROLOGIC MODELING**
BIORETENTION: Current Modeling Guidelines

• Explicit Method
  • Explicitly represents:
    • Surface ponding
    • Infiltration into bioretention soil and native soil
    • Storage in bioretention soil
    • Overflow
    • Underdrain flow
  • MGSFlood4, WWHM4, WWHM2012
BMP MODELING SPECIFICS

BIORETENTION: Current Modeling Guidelines

Explicit Method

Inflow

“Swale” bottom area and slope

Side slope

Bioretention soil infiltration rate

Native soil infiltration rate

Effective depth

Freeboard

Riser height

Riser diameter

Bioretention soil thickness and porosity

Diameter and elevation of underdrain (if any)

Key:

- Aggregate
- Underdrain
- Subbase
- Piping
- Bioretention Soil

* Showing “riser outlet structure” (alternative: “vertical orifice and overflow”)
**BMP MODELING SPECIFICS**

**BIORETENTION: Model Representation**

Contributing area

Precipitation

Evaporation

Runoff/Interflow

To GW

Bioretention Module

Infiltration to soil

Surface storage

Subsurface storage (voids)

Infiltration to native

Underdrain flow

Overflow

Point of Compliance

Where flow control standard must be met *

Key:

- Bioretention Soil
- Underdrain
- Piping
- Aggregate
- Native Soil

* Can be met with a combination of bioretention and downgradient retention/detention facilities

**Statewide LID Training Program**

**4.2 HYDROLOGIC MODELING**

**INTERMEDIATE TOPICS IN LID DESIGN**
### Surface SSD Table

<table>
<thead>
<tr>
<th>Stage (ft)</th>
<th>Area (ac)</th>
<th>Storage (ac-ft)</th>
<th>Discharge (cfs)</th>
<th>Infilt. (cfs)</th>
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</table>
BIORETENTION: Sizing for LID Performance Standard

- WWHM2012 Example- Explicit Method
  - Site in Seattle
  - Size bioretention cell to meet LID Performance Standard
  - Predeveloped condition = forest on till
  - Native soil is till (0.3 inch/hour design infiltration rate)
  - Bioretention cell (18” ponding depth, no underdrain)
  - Receiving runoff from 2,000 sf of impervious area (0.046 acres)
  - Using bioretention module in WWHM2012
  - 15 minute time-step
BIORETENTION: Sizing for LID Performance

- Precipitation/Evap. Data → Select county and location on map
- Computational Time Step → 15 minutes
BMP MODELING SPECIFICS

BIORETENTION: Sizing for LID Performance Standard

Predeveloped Basin → Select area, soil type, land cover and slope
BIORETENTION: Sizing for LID Performance Standard

Predeveloped Basin → Point of Compliance
Developed Mitigated Basin → Impervious with same area and slope....
Developed Mitigated Basin (continued): Route to Bioretention Module
BIORETENTION: Sizing for LID Performance Standard

Developed Mitigated Basin (continued): Characterize Bioretention

BSM

Infiltration to Native Soil

Outlet & Ponding Depth

Name

Dimensions

BMP MODELING SPECIFICS

Statewide LID Training Program

4.2 HYDROLOGIC MODELING

INTERMEDIATE TOPICS IN LID DESIGN
BIORETENTION: Sizing for LID Performance Standard

Soil Inputs

* 15.24 cm/hr = 6 in/hr (this value will need to be manually updated to 30.48 cm/hr in order to use the 12 in/hr BSM infiltration rate allowed in the 2014 SWMMWW)
### Stage Storage Discharge Table

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<thead>
<tr>
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<th>Area (acres)</th>
<th>Storage (acre-ft)</th>
<th>Discharge (cfs)</th>
<th>Infiltration (cfs)</th>
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</table>

**Source:** EPA (2016) Bioretention Design - BMP Model
Flow Duration Curve - Developed Unmitigated (Impervious)

GOAL

50-yr

½ 2-yr

The Facility PASSED
BIORETENTION: Sizing for LID Performance Standard

LID Report

<table>
<thead>
<tr>
<th>LID Technique</th>
<th>Used for Treatment?</th>
<th>Total Volume Needs Treatment (ac-ft)</th>
<th>Volume Through Facility (ac-ft)</th>
<th>Infiltration Volume (ac-ft)</th>
<th>Cumulative Volume Infiltration Credit</th>
<th>Percent Volume Infiltrated</th>
<th>Water Quality</th>
<th>Percent Water Quality Treated</th>
<th>Comment</th>
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<tbody>
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<td>Retention 1 POC</td>
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<td>100.00</td>
<td></td>
<td></td>
<td>0%</td>
<td>No Credit</td>
</tr>
</tbody>
</table>

Compliance with LID Standard: 8% of 2-yr to 50-yr

Duration Analysis Result: Passed
BIORETENTION: Sizing for LID Performance Standard

Iteratively Sized Bioretention Area to Meet Duration Standard

Bioretention bottom area = 20 sf (1% of contributing impervious area)
Footprint area = 50 sf (2.5% of contributing impervious area)
(given 12” ponding, 6” freeboard, 3:1 side slopes)

Infiltrates almost 90% runoff
BIORETENTION: Sizing for Flow Control

Flow Frequency Results

Can't compute flow frequency analysis. There are too many zero flows.
BIORETENTION: Sizing for Flow Control

Flow Frequency Results

Use Gringorten or Weibull Method for low annual flows
BIORETENTION: Sizing for Flow Control

Iteratively Sized Bioretention Area to Meet Duration Standard

Bioretention bottom area = 370 sf (18.5% of contributing impervious area)
Footprint area = 490 sf (24.5% of contributing impervious area)
(given 12” ponding, 6” freeboard, 3:1 side slopes)

Infiltrates almost 100% runoff
BIORETENTION: Water Quality Treatment

Iteratively Size to Infiltrate 91% Runoff File

Bioretention bottom area = 66 sf (3.3% of contributing impervious area)
Footprint area = 300 sf (15% of contributing impervious area)
given 12” ponding, 6” freeboard, 3:1 side slopes

Infiltrates 91%
Check Drawdown Criterion- WQ volume infiltrated through facility in 48 hours

Volume infiltrated in 48 hrs = ponding area at mid-depth x infiltration rate x 48 hrs
= 162 sf x 0.25 in/hr x 48 hours = 162 cf = 0.0037 acre-ft < 0.0100 acre-ft

Does not meet Ecology recommendation
BIORETENTION: MGSFlood

BMP MODELING SPECIFICS

Statewide LID Training Program

4.2 HYDROLOGIC MODELING
GSI-Calc Overview
GSI-Calc Overview

• Sizing tool for LID BMPs as a function of:
  • Site precipitation region & mean annual precip
  • Contributing impervious area
  • Predominant site soil type (till or outwash)
  • Native soil design infiltration rate

• Assist developers & reviewers to size/ design LID without continuous modeling

• Reduce barriers to LID implementation
GSI-Calc Applicability

- Lowland areas of Western WA
  - Up to 1,500 feet above sea level
  - Higher elevations impacted by snow accumulation/melt

- Projects subject to selected standards:
  - Ecology flow control standard in MR #7*
    (match 50% of 2-year to 50-year to forest condition)
  - Ecology treatment standard for infiltration BMPs
    (infiltration 91% through soil meeting requirements)
  - Kitsap County predeveloped recharge standard*
    (Kitsap County only)

*Predeveloped forest on till and outwash soil evaluated
GSI-Calc Applicability

• Native Soil Infiltration Rates:
  • Predominantly underlain by till: 0.125 to >0.5 in/hr
  • Predominantly underlain by outwash: 0.5 to >3 in/hr

• Contributing Area = Impervious Surface
  • If a drainage area is mix of impervious and pervious (and the pervious area requires mitigation), could use total area for conservative facility size
  • Hope to add pervious surface runoff into future version
LID BMPs

- Bioretention (3H:1V side slopes)
  - with and without underdrain
- Linear Bioretention (3H:1V side slopes)
  - without underdrain
- Bioretention Planter (vertical walls)
  - with underdrain
- Permeable Pavement Surface
  - low slope and higher slope
- Newly Planted and Retained Trees

Area Sizing Equations
Aggregate Sizing Equations
Flow Control Credits
Precipitation Modeled

**Western Coastline Region:** 70 & 90 in/yr

**Vancouver Castle Rock Corridor:** 40, 56, & 80 in/yr

**Western Puget Sound:** 32, 40, 48, 56, & 80 in/yr

**Eastern Puget Sound:** 24, 40, 48, 56, & 80 in/yr

**Selected prec/evap timeseries will be modeled for each region**
BMP MODELING SPECIFICS

GSI-Calc Tour

Site Precipitation Zone

Mean annual precipitation (in)

Enter manually or use Google Earth
BMP MODELING SPECIFICS

GSI-Calc Tour

Google Earth option
BMP MODELING SPECIFICS

GSI-Calc Tour

Site Information:
- Precipitation Zone: Puget East
- Mean Annual Precipitation (in): 40.43
- Soil Type: Till (Type C)
- New/Replaced Impervious Area (sq ft): 2200
- Pollution-Generating Impervious Surface Area (sq ft): 2200
- Applicable Standard: Ecology

Calculators:
- Forest Duration Standard
- Forest Groundwater Recharge Standard
- Water Quality Standard

Site predominant soil types
Area requiring mitigation
Applicable design standard
BMP MODELING SPECIFICS

GSI-Calc Tour

- Ponding depth
- Square or linear facility
- Design infiltration rate
- Bioretention bottom area

Statewide LID Training Program

4.2 HYDROLOGIC MODELING

INTERMEDIATE TOPICS IN LID DESIGN
EXERCISE
Break
1. BIORETENTION
2. PERMEABLE PAVEMENT
3. VEGETATED ROOFS
4. CISTERNS
5. DISPERSION
6. MINIMAL EXCAVATION FOUNDATIONS
7. REVERSE SLOPE SIDEWALKS
PERMEABLE PAVEMENT: Definition and Types

- Paved surfaces that allow infiltration, treatment, and storage of stormwater
- Can be designed to accommodate pedestrian, bicycle, and auto traffic
- Types
  - Porous asphalt or warm-mix asphalt pavement (*porous asphalt*)
  - Pervious Portland cement concrete (*pervious concrete*)
  - Permeable interlocking concrete pavers (*PICPs*)
  - Grid systems made of concrete or plastic (*reinforced grass and gravel*)
PERMEABLE PAVEMENT: 0-2% subgrade slope

- Can neglect lateral flow
- Subsurface storage depth modeled = aggregate thickness
PERMEABLE PAVEMENT: > 2 to 5% subgrade slope without berms

• Cannot neglect lateral flow
• Subsurface storage depth modeled = average subsurface ponding depth (when no berms, may be estimated as = 1/2”)

BMP MODELING SPECIFICS
PERMEABLE PAVEMENT: > 2 to 5% subgrade slope with berms

• Cannot neglect lateral flow
PERMEABLE PAVEMENT: > 2 to 5% subgrade slope with berms

- Subsurface storage depth modeled = average subsurface ponding depth
  - = water depth before berm overtopping* or overflow
  - Function of slope, check dam height, and check dam spacing
PERMEABLE PAVEMENT: Run-on

• **Run-on?:**
  • Always designed to manage rain falling on the permeable pavement area
  • May also be designed to mitigate run-on (flow from other areas)
## BMP MODELING SPECIFICS

### PERMEABLE PAVEMENT: Current Modeling Guidelines

<table>
<thead>
<tr>
<th>Base Material</th>
<th>Underdrain</th>
<th>Subgrade Slope</th>
<th>Model Surface as:</th>
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</thead>
<tbody>
<tr>
<td>Above Surrounding Grade</td>
<td>Yes – not elevated</td>
<td>Any</td>
<td>Impervious surface</td>
</tr>
<tr>
<td></td>
<td>Yes – elevated</td>
<td>Any</td>
<td>Impervious surface</td>
</tr>
<tr>
<td></td>
<td>No</td>
<td>Any</td>
<td>Grass over underlying soil type (till or outwash)</td>
</tr>
<tr>
<td>Partially or Below Surrounding Grade</td>
<td>Yes – not elevated</td>
<td>Any</td>
<td>Impervious surface</td>
</tr>
<tr>
<td></td>
<td>Yes – elevated</td>
<td>Any</td>
<td>Impervious surface routed to gravel infiltration trench (same size as the pavement area). Trench depth = aggregate depth below surrounding grade</td>
</tr>
<tr>
<td></td>
<td>No</td>
<td>0-2%</td>
<td>Same as “Yes – elevated”</td>
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<tr>
<td></td>
<td></td>
<td>&gt;2%</td>
<td>Impervious surface routed to gravel infiltration trench (same size as the pavement area). Trench depth = subsurface storage depth if berms (nominal 1/2-inch if no berms)</td>
</tr>
</tbody>
</table>
PERMEABLE PAVEMENT: Model Representation

- Meteorological Data
  - Rainfall (5-min, 15-min, hourly)
  - Evaporation (daily)
- BMP Configurations
PERMEABLE PAVEMENT: Model Representation

• Land Cover Types
  • Impervious areas
    • Slope
  • Pervious areas
    • Vegetation
    • Soil type (A, B, C/D)
    • Slope
  • Regional calibrated parameters (Dinicola 1990)
PERMEABLE PAVEMENT: Gravel Trench Model Representation

Gravel Trench Parameters

- Pavement area*
- Raised overflow pipe
- Subsurface ponding depth in storage reservoir controlled by overflow or berms in subbase
- Aggregate layer thickness and porosity
- Subbase infiltration rate

* May include additional contributing area

Key:
- Wearing Course
- Aggregate
- Overflow
- Subbase

Statewide LID Training Program

4.2 HYDROLOGIC MODELING

INTERMEDIATE TOPICS IN LID DESIGN
PERMEABLE PAVEMENT: Gravel Trench Model Representation

Model Configuration
- Infiltration to native
- Infiltration Neglected
- Only aggregate available for storage is modeled
- Theoretical riser
- Point of Compliance
- Overflow
- Porosity
- Where flow control standard must be met

Key:
- Wearing Course
- Aggregate
- Overflow
- Subbase

Note: Only aggregate under overflow invert modeled
PERMEABLE PAVEMENT: Gravel Trench Model Representation

Gravel Trench Routing

Ex. Cross Sections

- Storage
- Exfiltration

Ex. SSD Table

<table>
<thead>
<tr>
<th>Stage (ft)</th>
<th>Area (ac)</th>
<th>Storage (ac-ft)</th>
<th>Discharge (cfs)</th>
<th>Infilt. (cfs)</th>
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Overflow Elevation = top of pavement or invert of overflow pipe

Key:
- Wearing Course
- Aggregate
- Overflow
- Subbase

Statewide LID Training Program
PERMEABLE PAVEMENT: Sizing for Flow Control

• WWHM2012 Example – Explicit Method
  • Site in King County
  • Soil is till (0.25 inch/hour design infiltration rate)
  • Permeable pavement parking lot is 10,000 sf
  • Receiving run-on from 5,000 sf of additional area
  • Design goal = Ecology Flow Control standard (assuming a predeveloped forest condition)
  • Size aggregate depth (av. subsurface ponding depth)

• SIZING FOR FLOW CONTROL GOAL → MAY NEED TO BE THICKER TO SATISFY OTHER DESIGN GOALS (EX. LOADING)
PERMEABLE PAVEMENT: Sizing for Flow Control

- Precipitation/Evap. Data → Select county and location on map
- Computational Time Step → 15 minutes

Option Menu
PERMEABLE PAVEMENT: Sizing for Flow Control

Predeveloped Basin → Select area, soil type, land cover and slope

15,000 sf
PERMEABLE PAVEMENT: Sizing for Flow Control

Predeveloped Basin → Select area, soil type, land cover and slope

Statewide LID Training Program

4.2 HYDROLOGIC MODELING

INTERMEDIATE TOPICS IN LID DESIGN
PERMEABLE PAVEMENT: Sizing for Flow Control

Developed Mitigated Basin $\rightarrow$ Area contributing runon to permeable pavement.

Lateral Impervious Basin

5,000 sf
Impervious land surface over gravel trench with infiltration
PERMEABLE PAVEMENT: Sizing for Flow Control

Developed Mitigated Basin (continued): Characterize Permeable Pavement

Pavement depth + freeboard above surface

POC

Pavement Section

Infiltration to Native Soil

Depression storage before runoff (weir flow over edge)

Name

Area

SSD Table

POC
### Stage Storage Discharge Table

<table>
<thead>
<tr>
<th>Stage (ft)</th>
<th>Area (acres)</th>
<th>Storage (acre-ft)</th>
<th>Dischrg (cfs)</th>
<th>Infiltration (cfs)</th>
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Overflow
PERMEABLE PAVEMENT: Sizing for Flow Control

Flow Duration Curve- Developed Unmitigated (Impervious)

50-yr

½ 2-yr

GOAL
PERMEABLE PAVEMENT: Sizing for Flow Control

Flow Duration Curve - Developed Mitigated (with Permeable Pavement)

Statewide LID Training Program
Iteratively Sized Storage Aggregate Depth to Meet Duration Standard

- Infiltrates almost 100% runoff
- 5.5" required to meet goal

BMP MODELING SPECIFICS
PERMEABLE PAVEMENT: Sizing for Flow Control
Flow Frequency Results

Can't compute flow frequency analysis. There are too many zero flows.

Use Gringorten or Weibull Method for zero annual flows.
Example: Permeable Pavement in King County designed to achieve Creek Protection Duration Standard (Forest on Till)

Example Aggregate Storage Reservoir Depth by Infiltration Rate

- Permeable Pavement Facility (100% Runon)
- Permeable Pavement Facility (50% Runon)
- Permeable Pavement Surface (no Runon)
PERMEABLE PAVEMENT: Sizing for Treatment

Percent Infiltration- at least 91% of entire runoff file

Infiltration through soils meeting Ecology treatment soil requirements

Facility sized for flow control infiltrates much more than 91 percent
PERMEABLE PAVEMENT: LID Performance

LID Performance Standard

Infiltration BMP sized for stream duration standard overachieves LID duration standard
VEGETATED ROOFS: Definition and Types

- Thin layers of engineered soil and vegetation constructed on top of conventional flat or sloped roofs

Types
- Green roofs
- Living roofs
- Eco-roofs
- Roof gardens
VEGETATED ROOFS: Current Modeling Guidelines*: implicit method

- 3-8” growing media →
  - Model as 50% till landscaped / 50% impervious area

- > 8” growing media →
  - Model as 50% till pasture / 50% impervious area

*2012 SWMMWW (amended in 2014)
### BMP MODELING SPECIFICS

#### VEGETATED ROOFS: Current Modeling Guidelines: explicit method

Modified PERLND

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* Value for till soil, lawn, flat slope

** Values dependent on depth of material (values shown for Portland east and west roofs: 3 inches and 5 inches of material, respectively)

Source: WWHM3 Eco-Roof Documentation, Memorandum prepared by Clear Creek Solutions to Seattle Public Utilities, December 7, 2005.
VEGETATED ROOFS: Sizing for Flow Control

- 1 acre vegetated roof
- Location: Seattle
- Performance relative to Ecology Flow Control Standard
- Predeveloped condition is till forest
VEGETATED ROOFS: Sizing for Flow Control

Select Precipitation

Project Information
- Project Name: Green Roof Example
- Analysis Title: 
- Comments: 

Precipitation Data for Analysis
- Select Precipitation Data Set Type to Use in Analysis:
  - Extended Timeseries (Produces Most Accurate Results)
  - Station Data: Uses Ecology Scaling Method
  - User Precipitation Database (MGSUserData.mdb)
- Mean Annual Precip Calculator
  - Project Latitude (Decimal Degrees): 47.4500
  - Project Longitude (Decimal Degrees): 122.3000
  - Compute MAP (inches): 37.7

Select Climate Region
- Seattle 38 in MAP
  - (No Scaling Factor Rec'd)

Project Location
- Precipitation Station:
  - Seattle 38 in 5min
  - Evaporation Station:
    - Seattle 38 in MAP
- Period of Record:
  - 10/01/1939-10/01/2007

6:19 PM
VEGETATED ROOFS: Sizing for Flow Control

Define Predeveloped Condition

[Diagram of a software interface with options for defining scenarios and objects, such as Subbasin, Copy, Structure, Open Channel, Infiltr Trench, User Rating, Splitter, CAVFS, Filter Strip, Bioretention, Porous Pavement.]
Define Predeveloped Condition
Define Developed Mitigated Condition

VEGETATED ROOFS: Sizing for Flow Control
Define Developed Mitigated Condition

BMP MODELING SPECIFICS
VEGETATED ROOFS: Sizing for Flow Control

Statewide LID Training Program

INTERMEDIATE TOPICS IN LID DESIGN 136
Define Developed Mitigated Condition

**Vegetated Roofs: Sizing for Flow Control**

*Statewide LID Training Program*

**Hydrologic Modeling**

*Intermediate Topics in LID Design* 137
VEGETATED ROOFS: Sizing for Flow Control

Run Model

BMP MODELING SPECIFICS

[Image of a software interface for running a model with details on precipitation, evaporation, simulation time span, computational timestep, and runoff routed through network.]

Statewide LID Training Program
4.2 HYDROLOGIC MODELING
INTERMEDIATE TOPICS IN LID DESIGN 138
BMP MODELING SPECIFICS

VEGETATED ROOFS: Sizing for Flow Control

MGSFlood Module

BMP Performance in Seattle

Vegetated roof reduces downstream BMP size
CISTERNS: Definition and Types

- Typical in environments where rainfall or other conditions limit water supply
- Collects and stores runoff from roofs, or other surfaces
- Above or below ground cisterns
- Various materials:
  - Fiberglass
  - Polyethylene
  - Concrete
  - Metal
  - Wood
CISTERNs: Types

• Detention
  • Typically below ground
  • Slows runoff entering the stormwater system

• Harvesting
  • Typically above ground
  • Water is reused for irrigation or plumbing
CISTERNS: Current Modeling Guidelines: detention cisterns

- Explicitly Modeled
  - Vault/tank with low flow orifice and overflow

- Orifice Limitations
  - Minimum orifice size typically will not achieve creek protection flow duration standards

- Uses
  - Useful tool for CSO control
  - Upstream of bioretention

Note: No recommendations in 2005 or 2012 LID Manual
CISTERNS: Current Modeling Guidelines: harvesting cisterns

• Explicitly Model
  • Estimate average annual runoff volume (V) using continuous model
  • Size cisterns to provide storage, V
  • For interior reuse, perform monthly water balance
  • Subtract roof area from site-wide model if sizing flow control or water quality treatment

Fremont, Seattle
DISPERSION: Definition and Types

- Vegetated areas that collect runoff from impervious surfaces
- Restores the natural drainage patterns of sheet flow and infiltration

Types:
- Full dispersion
- Downspout dispersion
- Concentrated flow dispersion
- Sheet flow dispersion
BMP MODELING SPECIFICS

DISPERSION: Current Modeling Guidelines

- Full Dispersion
  - Residential developments that implement full dispersion are assumed to fully meet the treatment and flow control requirements and do not have to use approved runoff models to demonstrate compliance
• Downspout Dispersion
  • Used to disperse runoff onto an undisturbed native landscape area or area that meets BMP T5.13
  • Vegetated flow path must be at least 50 feet
  • WWHM2012: model connected roof area as a lateral flow impervious area (connect the dispersed impervious area to the lawn/landscape lateral flow soil basin element)
  • For multiple downspouts, Ecology may allow the roof area to be modeled as a landscaped area
Concentrated Flow Dispersion

- Used to disperse runoff onto an undisturbed native landscape area or area that meets BMP T5.13
- Vegetated flow path must be at least 50 feet
- WWHM2012: model impervious area as a lateral flow impervious area (connect the dispersed impervious area to the lawn/landscape lateral flow soil basin element)
- For multiple concentrated flow dispersion areas, Ecology may allow the impervious area to be modeled as a landscaped area
BMP MODELING SPECIFICS

DISPERSION: Current Modeling Guidelines

- Sheet Flow Dispersion
  - Used to disperse runoff onto an undisturbed native landscape area or area that meets BMP T5.13
  - WWHM2012: model impervious area as a lateral flow impervious area (connect the dispersed impervious area to the lawn/landscape lateral flow soil basin element)
  - For multiple sheet flow dispersion areas, Ecology may allow the impervious area to be modeled as a landscaped area
1. Bioretention
2. Permeable Pavement
3. Vegetated Roofs
4. Cisterns
5. Dispersion
6. Minimal Excavation Foundations
7. Reverse Slope Sidewalks
MINIMAL EXCAVATION FOUNDATIONS:

Definition

• Limit soil disturbance

• Allow storm flows to more closely approximate natural shallow subsurface interflow paths
MINIMAL EXCAVATION FOUNDATIONS: Current Modeling Guidelines

- Roof runoff dispersed on up gradient side of structure
  - Dispersion per BMP T5.10 (downspout dispersion)
  - Model roof as pasture on native soil
  - Highest credit available
- Note: Area receiving credit reduced when step-forming is used on a slope
MINIMAL EXCAVATION FOUNDATIONS: Current Modeling Guidelines

• Roof runoff dispersed on down gradient side of structure
  • Dispersion per BMP T5.10 (downspout dispersion) AND at least 50 ft of vegetated flow path that meets BMP T5.13
  • Model roof as the connected roof area as a lateral flow impervious area (connect the dispersed impervious area to the lawn/landscape lateral flow soil basin element)
 Sidewalks sloped to drain away from the road and onto adjacent vegetated areas

Design Criteria

• Greater than 10 feet of vegetated surface downslope that is not directly connected into the storm drainage system
• Vegetated area receiving flow from sidewalk must be native soil or meet guidelines in BMP T5.13
REVERSE SLOPE SIDEWALKS: Current Modeling Guidelines

- In WWHM3, enter sidewalk as lawn/landscape on native soil
- In WWHM2012, use the lateral flow elements to send the impervious area runoff onto the lawn/landscape that will be used for dispersion
introduction
hydrologic modeling basics
performance standards
BMP modeling specifics
wrap up
Statewide Low Impact Development Training Program

2014-2015 COURSE CATALOG

http://www.wastormwatercenter.org/lidswtrainingprogram/
## Statewide LID Training Program

### Other Course Offerings

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### Train the Trainers

| 9.1 Service Providers | 9.2 LID Topic Experts |
• An on-line evaluation will be sent to you within 5 days following this training
Two certificates:

- Stay tuned for decisions on certificate
- LID Design certificate
- Long-term LID Operations certificate
Further questions?

training@cascadiaconsulting.com

(206) 449-1163
For information on training and other resources, visit the Washington Stormwater Center website:

http://www.wastormwatercenter.org

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