Western Washington Hydrology Model 2012

User Manual

November 2012

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User Manual

Prepared by Clear Creek Solutions, Inc.

November 2012

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If you require this document in an alternative format, please call the secretary at (360) 407-6401. The TTY number is 711 or 1-800-833-6388.

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INTRODUCTION

The WWHM2012 is the updated edition of the Western Washington Hydrology Model, replacing WWHM3. It was designed by the Washington State Department of Ecology, AQUA TERRA Consultants, and Clear Creek Solutions, Inc. (the successor to the Washington offices of AQUA TERRA Consultants). This version has more options than WWHM3. The user can model almost any hydrologic condition related to stormwater control and design.

This user manual and development of WWHM2012 was funded by the Washington State Department of Ecology Contract No. C1200124 with Clear Creek Solutions, Inc. Clear Creek Solutions staff responsible for the WWHM2012 and this user manual are Joe Brascher, Gary Maxfield, and Doug Beyerlein.

Purpose

The purpose of the WWHM2012 is to size stormwater control facilities to mitigate the effects of increased runoff (peak discharge, duration, and volume) from proposed land use changes that impact natural streams, wetlands, and other water courses.

The WWHM2012 provides:

- A uniform methodology for the 19 counties of Western Washington
- A more accurate methodology than single event design storms
- An easy-to-use software package

The WWHM2012 is based on:

- Continuous simulation hydrology (HSPF)
- Actual long-term recorded precipitation data
- Measured pan evaporation data
- Historic vegetation (for Predeveloped conditions)
- Regional HSPF parameters

Parameter values can be modified for local conditions.

What's New in WWHM2012

WWHM2012 gives the user greater modeling flexibility, options, and accuracy. Version 3 included some simplified approaches to modeling stormwater LID (low impact development) facilities. WWHM2012 includes modeling elements that more accurately represent these stormwater facilities.

Specific changes and additions in Version 2012 include:

- Ability to run on Microsoft Windows 7 operating systems either on a workstation (single computer) or network.
- Updated precipitation data through water year 2009 (September 2009).
- Model simulations using a 15-minute time step in place of an hourly time step.

- 15-minute precipitation data in place of hourly data.
- Updated water quality design flow calculations.
- Improved AutoPond capabilities to optimize sizing of stormwater ponds and vaults.
- New bioretention swale element that accurately represents bioretention and rain gardens with or without underdrains and/or infiltration to the native soil.
- New CAVFS (compost amended vegetated filter strips) element to accurately represent roadside bioretention-based water quality facilities.
- New green roof element to accurately model storage, evapotranspiration, and runoff from vegetated roofs.
- New porous pavement element to accurately model the movement of water through the pavement and subgrade.
- Added SSD Table element options.
- Automated sizing options for infiltration facilities.
- Revised flow duration analysis with two duration standards: (1) Stream Protection Duration, and (2) LID Duration.
- Revised wetland hydroperiod criteria calculations.
- New LID reporting features.

Computer Requirements

- Windows 2000/XP/Vista/7 with 200 MB uncompressed hard drive space
- Internet access (only required for downloading WWHM2012, not required for executing WWHM2012)
- Pentium 3 or faster processor (desirable)
- Color monitor (desirable)

Before Starting the Program

- Knowledge of the site location and/or street address.
- Knowledge of the actual distribution of existing site soil by category (A/B, C, or saturated).
- Knowledge of the planned distribution of the proposed development (buildings, streets, sidewalks, parking, lawn areas) overlying the soil categories.
- An idea of a first approximation of the top surface area for a trapezoidal or irregular-shape pond (if used).

QUICK START

Below is a brief set of steps that show how to use the WWHM2012 to quickly size a stormwater detention pond.



1. Select the county in which the project site is located.

Click the down arrow in the box in the upper left corner. A list of all 19 Western Washington counties is shown. Scroll down to find the county you want. Left click on the county name. The county map will then show on the map screen.

Locate the project site on the map. Use the map controls to magnify a portion of the map, if needed. Select the project site by left clicking on the map location. A red square will be placed on the map identifying the project site.



The WWHM2012 selects the appropriate rain gage record and precipitation multiplication factor. In this example the rain gage record is Everett and the Everett precipitation data are multiplied by a precip factor of 1.20.

2. Use the tool bar (immediately above the map) to move to the Scenario Editor. Click on the General Project Information button.



The General Project Information button will bring up the Schematic Editor.

The schematic editor screen contains two scenarios: Predeveloped and Mitigated.

Set up first the Predeveloped scenario and then the Mitigated scenario.

Check the Predeveloped scenario box.

Left click on the Basin element under the Elements heading. The Basin element is the upper left element.

Select any grid cell (preferably near the top of the grid) and left click on that grid. The basin will appear in that grid cell.

The entire grid can be moved up, down, left, or right using the Move Elements arrow buttons.

The gird coordinates from one project can be saved (Save x,y) and used for new projects (Load x,y).

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To the right of the grid is the land use information associated with the basin. Select the appropriate soil, vegetation, and land slope for the Predeveloped scenario. For this example we will assume that the Predeveloped land use is 10 acres of C soil (till) with forest vegetation, on a flat (0-5%) slope.

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	A/B, Forest, Steep 0	ROADS/STEEP 0
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The outlet from this land use drainage basin will be selected as our point of compliance for the Predeveloped scenario. Right click on the basin element and highlight Connect to Point of Compliance.

The Point of Compliance screen will be shown for Predeveloped Basin 1. The POC (Point of Compliance) outlet has been checked for both surface runoff and interflow. These are the two flow components of stormwater runoff. Do not check the groundwater box unless there is observed and documented base flow (spring flow) on the project site.



Click the Connect button in the low right corner to connect this point of compliance to the Predeveloped basin.



After the point of compliance has been added to the basin, the basin element will change. A small box with a bar chart graphic will be shown in the lower right corner of the basin element. This small POC box identifies this basin as a point of compliance.

To compute the runoff at the POC for the Predeveloped scenario click on the "Run Scenario" button. When "Run Scenario" is clicked WWHM2012 creates an HSPF UCI (User Control Input) file and runs HSPF at a 15-minute time step for the entire length of the precipitation record. Time series output (runoff data) at the POC is saved to the HSPF WDM file for later analysis.



3. Set up the Mitigated scenario.

First, check the Mitigated scenario box and place a basin element on the grid.

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For our 10-acre project site Mitigated land use we have:

5 acres of C soil, lawn, flat 2 acres of roads, flat 1 acre of roof tops 1 acre of driveways, flat 0.5 acre of sidewalks, flat 0.5 acre pond

The pond 0.5 acres is an estimate, as we don't really know the size of the surface area of the pond until we size it. But for the purposes of computing the Mitigated scenario runoff we will assume that the pond surface area acts like an impervious surface.

We will add a trapezoidal pond downstream of the basin.

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Schematic	🗆 🗙 🗟 Basin 1 Mitigated
SCENARIOS	Subbasin Name Basin 1 Designate as Bypass for POC:
Predeveloped	Surface Interflow Groundwater
Mitigated	Area in Basin Show Only Selected
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Basic Elements Basin 1	A/B, Forest, Mod 0 ROADS/MOD 0
	A/B, Forest, Steep 0 ROADS/STEEP 0
Element Option List	BOOF TOPS/FLAT
Connect To Element	B, Pasture, Mod 0 I RIVEWAYS/FLAT 1
	Compliance A/B, Pasture, Steep 0 DRIVEWAYS/MOD 0
Disconnect Element	A/B, Lawn, Flat 0 DRIVEWAYS/STEEP 0
Disconnect POC	A/B, Lawn, Mod 0 SIDEWALKS/FLAT 0.5
Pro Elements Compute Recharge	A/B, Lawn, Steep 0 SIDEWALKS/MOD 0
Find Element	C, Forest, Flat 0 SIDEWALKS/STEEP 0
Cut Element	C, Forest, Mod 0 PARKING/FLAT 0
Copy Element	C, Forest, Steep 0 PARKING/MOD 0
LID Toolbox Paste Element	C, Pasture, Flat 0 PARKING/STEEP 0
Delete Element	C. Pasture, Mod 0 POND 0.5
Duplicate Predeveloped	ed C, Pasture, Steep 0 Porous Pavement 0
Save Element	C, Lawn, Flat 5
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The trapezoidal pond element is placed below the basin element on the grid. All water flows down the grid.

Right click on the basin and select Connect To Element. A green line will appear with

one end connected to the basin and the other end connected to a green box. With the mouse pointer pull the other end of the line down so that the green box is on top of the trapezoidal pond and click on the pond. This will bring up the From Basin to Conveyance screen. As with the Predeveloped scenario we want to only connect the surface flow and the interflow from the basin to the pond. Click OK.

🖻 From Basin to Conv	eyence 🔲 🗖 🔯
Flow From:	
Surface Flow	
🔽 Interflow	-
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A line will connect the land use basin to the trapezoidal pond.



Right click on the trapezoidal pond element to connect the pond's outlet to the point of compliance. Highlight Connect to Point Of Compliance and click.



The Point of Compliance screen will be shown for the pond. The pond has one outlet (by default). The outflow from the pond will be compared with the Predeveloped runoff at the same point of compliance. The point of compliance is designated as POC 1 (WWHM2012 allows for multiple points of compliance). Click on the Connect button.



The point of compliance is shown on the pond element as a small box with the letter "A" and a bar chart symbol in the lower right corner.

4. Sizing the pond.



A trapezoidal stormwater pond can be sized either manually or automatically (using AutoPond). AutoPond will be used for this example.

Click on the AutoPond button and the AutoPond screen will appear. The user can set the pond depth (default: 7 feet), pond length to width ratio (default: 1 to 1), pond side slopes (default: 3 to 1), and the outlet structure configuration (default: 1 orifice and riser with rectangular notch weir).

To optimize the pond design and create the smallest pond possible, move the Automatic Pond Adjuster pointer from the left to the right.

🛿 🖉 trapezoidal Pond 1	
Automatic Pond Adjuster	
0-1 min <2-10 min> 10 min+	
Fast Thorough	
Pond Depth (Incl. 1 It treeboard) 7.0 It.	
Pond length to width ratio: 1 to 1	
Pond Side Slopes: 3 to 1	
Bottom Length:ft	
Botton With:	
Volume at riser head: acro ff	
Choose Outlet Structure	
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Progress:	
Create Pond Optimize Pond	
Accept pond Close	

The pond does not yet have any dimensions. Click the "Create Pond" button to create initial pond dimensions and optimize the pond size and outlet structure.



When "Create Pond" is clicked the WWHM2012 first computes the Predeveloped runoff then the flow frequency for the Predeveloped runoff. From the flow frequency results

half of the 2-year and the 50-year flows are identified. This is the range selected for the stream protection flow duration analysis. The Predeveloped flow duration values between half of the 2-year and the 50-year are plotted on the screen in blue.

The WWHM2012 computes Mitigated runoff. AutoPond selects initial pond and outlet structure dimensions and the Mitigated flow is routed through the pond. The outflow from the pond is analyzed and the Mitigated flow duration is plotted on the screen in red.

AutoPond compares the Mitigated flow duration results with the Predeveloped flow duration values. If the Mitigated flow duration values are greater than the Predeveloped values AutoPond increases the size of the pond or alters the outlet structure based on predefined rules and automatically reruns the Mitigated runoff through the revised pond. If the Mitigated flow duration values are less than the Predeveloped values AutoPond decreases the size of the pond or alters the outlet structure and automatically reruns the Mitigated runoff through the revised pond. Either way, AutoPond continues this exercise until the smallest possible pond is designed. At that point AutoPond announces that it is finished. Click OK. The pond is now sized.

The user may continue to manually optimize the pond by manually changing pond dimensions and/or the outlet structure configuration. After making these changes the user should click on the "Optimize Pond" button to check the results and see if AutoPond can make further improvements.



The final pond dimensions (bottom length, bottom width, effective pond depth, and side slopes) and outlet structure information (riser height, riser diameter, riser weir type, weir notch height and width, and orifice diameter and height) are shown on the trapezoidal pond screen to the right of the Schematic grid.

5. Review analysis.



The Analysis tool bar button (third from the left) brings up the Analysis screen where the user can look at the results. Each time series dataset is listed in the Analyze Datasets box in the lower left corner. To review the stream protection flow duration analysis (50% of the 2-year flow to the 50-year flow) at the point of compliance click on the POC 1 tab at the bottom. This will run the stream protection flow duration analysis for both the 501 POC 1 Predeveloped flow and 801 POC 1 Developed flow.



The stream protection flow duration plot for both Predeveloped and Mitigated flows are shown along with the specific flow values and number of times Predeveloped and Mitigated flows exceeded those flow values. The Pass/Fail on the right indicates whether or not at that flow level the Ecology flow control standard criteria were met and the pond passes at that flow level (from half of the 2-year flow to the 50-year). If not, a Fail is shown; one Fail fails the pond design.

6. Produce report.

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			6994	64	Pass			
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0.17 Formatted report with charts in pdf format. Report opens in pdf v	iewer.		2796	59	Pass			
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✓ Draft Report			1691	53	Pass			
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Advised Forestal			1294	52	Pass			
Landuse Report			1148	53	Pass			
Analyze datasets			1033	54	Pass			
501 PDC 1 Predeveloped flow			943	56	Pass			
801 PDC 1 Mitigated flow Original text based report.			878	58	Pass			
			837	60	Pass		1.1	
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			698	65	Pass			
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			646	67	Pass			
All Datasets Flow Stage			636	71	Pass			
	Close		627	76	Pass			
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Click on the Reports tool bar button (fourth from the left) to generate a project report. You have the option of producing the report that contains all of the project information and results in a number of different formats. Click on "Text Report" button to generate output file in WordPad format. Scroll down the Report screen to see all of the results.

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WHH2012	
PROJECT REPORT	
Project Name: Snohomish 1	
Site Name:	
Site Address:	
City :	
Report Date: 10/10/2012	
Gage : Everett	
Data Start : 1948/10/01	
Data End : 2009/09/00	
Version : 2012/10/09	
Low Flow Threshold for POC 1 : 50 Fercent of the 2 Year High Flow Threshold for POC 1: 50 year	
PREDEVELOPED LAND USE	
Name : Basin 1	
Bypass: No	
GroundWater: No	
Pervious Land Use Acres C, Forest, Flat 10	
Pervious Total 10	
Impervious Land Use Acres	
Impervious Total 0	
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7. Save project.



To save the project click on File in the upper left corner and select Save As.

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My Network Places	Save as <u>t</u> ype:	WWHM2012 Project Files		•	Cancel

Select a file name and save the WWHM2012 project file. The WWHM2012 project file will have a file extension name of whm. The user can exit WWHM2012 and later reload the project file with all of its information by going to File, Open.

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MAIN SCREENS



WWHM2012 has six main screens. These main screens can be accessed through the buttons shown on the tool bar above or via the View menu.

The six main screens are:

- Map Information
- General Project Information
- Analysis
- Reports
- Tools
- LID (Low Impact Development) Analysis

Each is discussed in more detail in the following sections.

MAP INFORMATION SCREEN



The Map Screen contains county information. The map is directly linked to the meteorological database that contains precipitation and evaporation data. The precipitation gage and precip factor are shown to the right of the map. They change depending on the project site location.

The user can elect to use Washington State Department of Transportation (DOT) precipitation data developed by MGS Consulting by checking the "Use DOT data" box to the right of the map. When the DOT data box is checked the map screen changes to show a map of the entire 19 counties of Western Washington with the area for which the DOT precipitation data are available outlined (the data are not available everywhere).

The county selection can be changed by clicking on the pulldown menu above the map and selecting one of the 19 Western Washington counties.

The user can provide site information (optional).

The user locates the project site on the map screen by using the mouse and left clicking at the project site location. Right clicking on the map re-centers the view. The + and - buttons zoom in and out, respectively. The cross hair button zooms out to the full county view. The arrow keys scroll the map view.


GENERAL PROJECT INFORMATION SCREEN

The project screen contains all of the information about the project site for the two land use scenarios: Predeveloped land use conditions and the Mitigated (developed) land use conditions. To change from one scenario to another check the box in front of the scenario name in the upper left corner of the screen.

Predeveloped is defined as the existing conditions prior to land use development. Runoff from the Predeveloped scenario is used as the target for the Mitigated scenario compliance. Unless there are special circumstances, the Department of Ecology requires that Predeveloped land use be Forest. However, the model will accept any land use for this scenario.

Mitigated is defined as the developed land use with mitigation measures (as selected by the user). Mitigated is used for sizing stormwater control and water quality facilities. The runoff from the Mitigated scenario is compared with the Predeveloped scenario runoff to determine compliance with Ecology standards.

Below the scenario boxes are the Elements. Each element represents a specific stormwater feature (basin, pond, etc.) and is described in more detail in the following section.

SCHEMATIC EDITOR



The project screen also contains the Schematic Editor. The Schematic Editor is the grid to the right of the elements. This grid is where each element is placed and linked together. The grid, using the scroll bars on the left and bottom, expands as large as needed to contain all of the elements for the project.

All water movement on the grid must be from the top of the grid down.

The space to the right of the grid will contain the appropriate element information.

To select and place an element on the grid, first left click on the specific element in the Elements menu and then left click on the selected grid square. The selected element will appear in the grid square.

The entire grid can be moved up, down, left, or right using the Move Elements arrow buttons.

The grid coordinates from one project can be saved (Save x,y) and used for new projects (Load x,y).

LAND USE BASIN



The Basin element represents a drainage area that can have multiple combinations of soils, vegetation, land slopes, and land uses. A basin produces three types of runoff: (1) surface runoff, (2) interflow, and (3) groundwater. Surface runoff is water flow on the surface of the soil. Interflow is shallow, subsurface runoff. Groundwater is deeper movement of water in the soil and may drain into the stream channel downstream of the project site.

The user can specify where each of these three types of runoff should be directed. The default setting is for the surface runoff and interflow to go to the stormwater facility; groundwater should not be connected unless there is observed base flow or spring flow occurring in the project drainage basin.

The user can change the default name "Basin 1" to another more appropriate name, if desired.

The user inputs the number of acres of appropriate basin land use information. Pervious land use information is in the form of soil, vegetation, and land slope. For example, "C, Forest, Flat" means SCS soil type C (till), forest vegetation, and flat (0-5%) land slope.

There are three basic soil types: A/B (outwash soils), C (till), and SAT (saturated/ wetland/hydric soils).

There are three basic vegetation categories: forest (second growth Douglas Fir), pasture (non-forested natural areas/scrub/shrub rural vegetation), and lawn (sod lawn/grass/landscaped urban vegetation).

There are also three land slope categories: flat (0-5%), moderate (5-15%), and steep (>15%).

Impervious areas are divided into five types with three different slopes. The four types are: roads, roofs, driveways, sidewalks, and parking. The slope categories are the same as for the pervious land use (flat, moderate, steep). Pond area is also listed as an impervious area.

Runoff credits are included in the ten pervious land categories at the bottom of the Available Pervious list (see below).



These ten land uses are:

- (1) C/IMP DISP/FLAT = Dispersal of impervious area runoff on C soil with flat slope.
- (2) C/IMP DISP/MOD = Dispersal of impervious area runoff on C soil with moderate slope.
- (3) C/IMP DISP/STEEP = Dispersal of impervious area runoff on C soil with steep slope.

- (4) A/B/IMP INF/FLAT = Infiltration of impervious area runoff on A/B soil with flat slope.
- (5) A/B/IMP INF/MOD = Infiltration of impervious area runoff on A/B soil with moderate slope.
- (6) A/B/IMP INF/STEEP = Infiltration of impervious area runoff on A/B soil with steep slope.
- (7) SAT/IMP DISP/FLAT = Dispersal of impervious area runoff on saturated soil with flat slope.
- (8) SAT/IMP DISP/MOD = Dispersal of impervious area runoff on saturated soil with moderate slope.
- (9) SAT/IMP DISP/STEEP = Dispersal of impervious area runoff on saturated soil with steep slope.
- (10) GREEN/ECO-ROOF = Half impervious; half C soil, lawn, with flat slope.

These runoff credits have been included in WWHM2012, but have been superseded with new elements and are not the recommended approach to use to model these conditions.

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Schematic	🗙 🖻 Lateral Basin 1 Predeveloped 🛛 🔀
SCENARIOS	Element Name Lateral Basin 1
Predeveloped	Runoff Type Surface Interflow Groundwater Downstream Connection 0 0 0 0
mitigated	Element Type Lateral Pervious Flow Basin
Run Scenario	Lateral Area (ac)
Basic Elements	
	Tools
	Available Soil Types (PERLNDs)
	A/B, Forest, Flat
	A/B, Forest, Steep
	A/B, Pasture, Flat
	A/B, Pasture, Steep
	A/B, Lawn, Flat
	A/B, Lawn, Steep
Commercial Loolbox	Accept Cancel
Move Elements	
Save x,y Load x,y	
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PERVIOUS LATERAL BASIN

The pervious lateral basin is similar to the standard basin except that the runoff from the lateral basin goes to another adjacent lateral basin (impervious or pervious) rather than directly to a conveyance system or stormwater facility. By definition, the pervious lateral basin contains only a single pervious land type. Impervious area is handled separately with the impervious lateral basin (Lateral I Basin).

The user selects the pervious lateral basin land type by checking the appropriate box on the Available Soil Types Tools screen. This information is automatically placed in the Soil (PERLND) Type box above. Once entered, the land type can be changed by clicking on the Change button on the right.

The user can change the default name "Lateral Basin 1" to another more appropriate name, if desired.

The user enters the number of acres represented by the lateral basin land type.

If the lateral basin contains two or more pervious land use types then the user should create a separate lateral basin for each.

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Schematic	🚺 Lateral I Basin 1 Predeveloped
SCENARIOS	Element Name Lateral I Basin 1
Predeveloped	Runom Type Surface Internow Groundwater
	Element Type Lateral Impervious Flow Basin
Mitigated	Impervious (IMPLND) Type change
Run Scenario	Lateral Area (ac)
Basic Elements	
	Lateral Flow IMPLND
	Ávailable Impervious coverages
	(IMPLNDs)
	Check only one
Pro Elements	
	BOADS/STEEP
	ROOF TOPS/FLAT
	DRIVEWAYS/FLAT
LID Toolbox	T DRIVEWAYS/MOD
Commercial Toolbox	Accept
Move Elements	
Save x,y Load x,y	
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IMPERVIOUS LATERAL BASIN

The impervious lateral basin is similar to the standard basin except that the surface runoff from the lateral impervious basin goes to another adjacent lateral basin (impervious or pervious) rather than directly to a conveyance system or stormwater facility. By definition, the impervious lateral basin contains only impervious land types. Pervious area is handled separately with the pervious lateral basin (Lateral Basin).

The user selects the impervious lateral basin land type by checking the appropriate box on the Available Impervious Coverages screen. This information is automatically placed in the Impervious (IMPLND) Type box above. Once entered, the land type can be changed by clicking on the Change button on the right.

The user can change the default name "Lateral I Basin 1" to another more appropriate name, if desired.

The user enters the number of acres represented by the lateral impervious basin land type.

If the lateral impervious basin contains two or more impervious land use types then the user should create a separate lateral I basin for each.

TRAPEZOIDAL POND



In WWHM2012 there is an individual pond element for each type of pond and stormwater control facility. The pond element shown above is for a trapezoidal pond. This is the most common type of stormwater pond.

A trapezoidal pond has dimensions (bottom length and width, depth, and side slopes) and an outlet structure consisting of a riser and one or more orifices to control the release of stormwater from the pond. A trapezoidal pond includes the option to infiltrate runoff, if the soils are appropriate and there is sufficient depth to the underlying groundwater table.

The user has the option to specify that different outlets be directed to different downstream destinations, although usually all of the outlets go to a single downstream location.

AutoPond will automatically size a trapezoidal pond to meet Ecology flow control standards. QuickPond will instantly create a pond without checking it for compliancy with Ecology standards.

AutoPond is only available in the Mitigated scenario.

The user can change the default name "Trapezoidal Pond 1" to another more appropriate name, if desired.

Precipitation and evaporation can be applied to the pond. The default standard setting is not to apply precipitation and evaporation, but to treat the pond surface area as an impervious surface.

The pond bottom elevation can be set to an elevation other than zero if the user wants to actual elevations. All pond stage values are relative to the bottom elevation. Negative bottom elevations are not allowed.

The pond effective depth is the pond height (including freeboard) above the pond bottom. It is not the actual elevation of the top of the pond.

Pond side slopes are in terms of horizontal distance over vertical. A standard 3:1 (H/V) side slope would be given a value of 3. A vertical side slope has a value of 0.

The pond bottom is assumed to be flat.

The pond outlet structure consists of a riser and zero to three orifices. The riser has a height (typically one foot less than the effective depth) and a diameter. The riser can have either a flat top or a weir notch cut into the side of the top of the riser. The notch can be either rectangular, V-shaped, or a Sutro weir. More information on the riser weir shapes and orifices is provided later in this manual.

After the pond is given dimensions and outlet information the user can view the resulting stage-storage-discharge table by clicking on the "Open Table" arrow in the lower right corner of the pond information screen. This table defines the pond's hydraulic characteristics.

VAULT

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Schematic	🕯 Vault 1 Mitigated		^
SCENARIOS	Facility Name	Vault 1	
		Outlet 1 Outlet 2 Outlet 3	
	Downstream Connection	U U U U U U U U U U U U U U U U U U U	
Mitigated	Frecipitation Applied to Facility	Fixed Width For Auto Vault	
Run Scenario	Eacility Dimensions	Facility Dimension Diagram	
Basic Elements	Length (ft)	Outlet Structure Data	
	Width (ft)	Riser Height (ft)	
	Effective Depth (ft)	Riser Tune Tune	
		Notch Type	
Pro Elemente	Infilmenting Infi		
		Orifice Diameter Height Number (in) (ff)	11
		2 0 + 0 +	
LID Toolbox		3 0 🕂 0 🕂	
		March Maharana M Direct Hand (an 9)	
		Vault Volume at Hiser Head (ac-rt) .000	
		Show Vault Table Open Table	
Commercial Toolbox		Initial Stage (ft)	
	Tide Gate Time Series Dema	and	
Move Elements	- Determine Outlet With Tide Gate		
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	Tide Gate Elevation (ft)	Downstream Connection	
Save xy Load xy	Overflow Elevation (ft)	Iterations 0	
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The storage vault has all of the same characteristics of the trapezoidal pond, except that the user does not specify the side slopes (by definition they are zero).

AutoVault and QuickVault work the same way as AutoPond and QuickPond.

AutoVault is only available in the Mitigated scenario.

The user can change the default name "Vault 1" to another more appropriate name, if desired.

TANK

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Schematic	Tank 1 Mitigated
SCENARIOS	Facility Name Tank 1 Facility Type Tank
	Outlet 1 Outlet 2 Outlet 3
Mitigated	Precipitation Applied to Facility Auto Tank Quick Tank
Bun Second	Evaporation Applied to Facility Facility Dimension Diagram
Basic Elements	Facility Dimensions Outlet Structure Data
Tank 1	Facility Bottom Elevation (ft)
	Diameter (it)
	Length (ft) D Riser Type Flat
	Notif Type
Pro Elements	
	Orifice Diameter Height Number (in) (ft)
	2 0 🕂 0 🕂
	3 0 + 0 +
	Tank Volume at Riser Head (ac-ft) 0
	Show Tank Table Open Table
Commercial Toolbox	Intitial Stage (ft)
	Determine Outlet With Tide Gate
	Use Tide Gate
Move Elements	Tide Gate Elevation 0 Downstream Connection
	Overflow Elevation (ft) 0 Iterations 0
Save x.y Load x.y	
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A storage tank is a cylinder placed on its side. The user specifies the tank's diameter and length.

AutoTank and QuickTank work the same way as AutoPond and QuickPond.

AutoTank is only available in the Mitigated scenario.

The user can change the default name "Tank 1" to another more appropriate name, if desired.

IRREGULAR POND

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Schematic 🔤 🗖 🛛 🗙	🗟 Irregular Pond 1 Mitigated 🛛 🛛 🗠
SCENARIOS	Facility Name Irregular Pond 1 Facility Type Irregular Pond
	Outlet 1 Outlet 2 Outlet 3
Mitigated	Evaporation Applied to Facility
Run Scenario	Facility Dimensions
Basic Elements	Facility Bottom Elevation (it) Outlet Structure
	Effective Depth (it) 6 Riser Diameter (in) 0
	Riser Type Flat
	Notch Type
	Open PondPed
	Infiltration ND +
Pro Elements	Orifice Diameter Height
	Number (in) (ft)
	- 10 10 1
	Pond Volume at Riser Head (ac-ft) 0
Commercial Toolbox	Initial Stage (ft)
	Use Tide Gate? NO 🔶
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An irregular pond is any pond with a shape that differs from the rectangular top of a trapezoidal pond. An irregular pond has all of the same characteristics of a trapezoidal pond, but its shape must be defined by the user.

There is no AutoPond option for an irregular pond. It is recommended that the user first use the trapezoidal pond element with AutoPond to determine the general dimensions and outlet structure configuration of the pond. With that information a similar-size irregular pond with the same outlet structure configuration as the trapezoidal pond will either meet Ecology flow control standards or require only minor changes in surface area and volume to meet the standards.

The user can change the default name "Irregular Pond 1" to another more appropriate name, if desired.

To create the shape of an irregular pond the user clicks on the "Open PondPad" button. This allows the user to access the PondPad interface (see below).

PondPad Interface



The PondPad interface is a grid on which the user can specify the outline of the top of the pond and the pond's side slopes.

The user selects the line button (second from the top on the upper left corner of the PondPad screen). Once the line button is turned on the user moves the mouse over the grid to locate the pond's corner points. The user does this in a clockwise direction to outline the pond's top perimeter. The user can select individual points by clicking on the point button immediately below the line button. Once selected, any individual point can be moved or repositioned.





The default side slope value is 3 (3:1). The side slopes can be individually changed by right clicking on the specific side (which changes the line color from black to red) and then entering the individual side slope value in the slope text box.

The grid scale can be changed by entering a new value in the grid scale box. The default value is 200 feet.

PondPad Controls and Numbers

Clear: Line: Point:	The Clear button clears all of the lines on the grid. The Line button allows the user to draw new lines with the mouse. The Point button allows the user to move individual points to alter the pond shape and size.
Sq Ft:	Converts the computed pond area from square feet to acres and back.
Grid Scale:	Changes the length of a grid line. Default grid scale is 200 feet.
Grid X:	Horizontal location of the mouse pointer on the grid
	(0 is the upper left corner).
Grid Y:	Vertical location of the mouse pointer on the grid
	(0 is the upper left corner)
Area:	Top area of the pond (either in square feet or acres).
Slope:	Side slope of the selected line (side of the pond).

GRAVEL TRENCH BED

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Schematic		🖥 Gravel Trench Bed 1 Mitigate	d 🛛 🔀	^
SCENARIOS		Facility Name	Gravel Trench Bed 1	
Predeveloped		Downstream Connection	Outlet 1 Outlet 2 Outlet 3 0 0 0	
🔂 🗹 Mitigated		Facility Type	Gravel Trench/Bed	
Run Scenario		Precipitation Applied to Facility	Quick Trench	
Basic Elements	Cravel Trench Pert 4	Evaporation Applied to hacility		
	Gravel French Bed 1	Facility Dimensions Trench Length (R) 0 Trench Bottom Width (R) 0 Effective Total Depth (R) 0 Bottom slope (H/Y) 0 Left Side Slope (H/Y) 0	Outlet Structure Data Riser Height (It) 0 Riser Diameter (in) 0 Riser Type Flat Notch Type	
LID Toolbox		Material Layers for Trench/Be Layer 1 Thickness (t) 0 Layer 1 porosity (0-1) 0 Layer 2 priorsity (0-1) 0 Layer 3 Thickness (t) 0 Layer 3 porosity (0-1) 0 Infiltration N0	Ad Orifice Diameter Height Number (in) (t) 1 0 7 0 7 2 0 7 0 7 3 0 7 0 7 Trench Volume at Riser Head (ac-ft) .000	
Lommercial Loolbox			Show Trench Open Table	
			Initial Stage (ft)	
Move Elements Save x.y Load x.y				
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The gravel trench bed is a trench or bed filled with gravel that is used to spread and infiltrate runoff. It can also have one or more surface outlets represented by an outlet structure with a riser and multiple orifices.

The user can change the default name "Gravel Trench Bed 1" to another more appropriate name, if desired.

The user specifies the trench length, bottom width, total depth, bottom slope, and left and right side slopes.

The material layers represent the amended soils and their design characteristics (thickness and porosity). These are the soil layers added to the gravel trench bed to filter the runoff prior to dispersal.

QuickTrench will create a gravel trench bed with default values without checking it for compliancy with Ecology standards.

SAND FILTER



The sand filter is a water quality facility. It does not infiltrate runoff, but is used to filter runoff through a medium and sent it downstream. It can also have one or more surface outlets represented by an outlet structure with a riser and multiple orifices.

The user can change the default name "Sand Filter 1" to another more appropriate name, if desired.

The user must specify the facility dimensions (bottom length and width, effective depth, and side slopes. The hydraulic conductivity of the sand filter and the filter material depth are also needed to size the sand filter (default values are 1.5 and 2.0, respectively). The goal of the sand filter is meet the Ecology treatment standard of filtering at least 91% of the total runoff volume.

The filter discharge is calculated using the equation Q = K*I*A, where Q is the discharge in cubic feet per second (cfs). K equals the hydraulic conductivity (inches per hour). For sand filters K = 1.5 in/hr. Sand is the default medium. If another filtration material is used then the design engineer should enter the appropriate K value supported by documentation and approval by the reviewing authority.

Design of a sand filter requires input of facility dimensions and outlet structure characteristics, running the sand filter scenario, and then checking the volume

calculations to see if the Percent Filtered equals or exceeds 91.0%. If the value is less than 91% then the user should increase the size of the sand filter dimensions and/or change the outlet structure.

Similar to AutoPond in the trapezoidal pond element, the sand filter element has an option to automatically size the sand filter. The user can set the target percentage for being filtered (91% of the total runoff volume to meet the Ecology water quality treatment standard).

BIORETENTION



The bioretention element (also called a rain garden) is a depression filled with one to three layers of amended soil that is used to filter runoff. It is a new WWHM2012 element, not previously available in WWHM3. It can also have one or more surface outlets represented by an outlet structure with a riser and multiple orifices or a vertical orifice and weir overflow structure.

The user can change the default name "Bioretention 1" to another more appropriate name, if desired.

The user specifies the bioretention length, bottom width, total depth, bottom slope, and left and right side slopes.

The material layers represent the amended soils and their design characteristics (thickness and vertical water movement). These are the engineered soil layers added to the bioretention facility to filter the runoff prior to dispersal.

Each amended soil type has appropriate drainage characteristics assigned based on literature values. When a soil type is selected by the user then WWHM2012 automatically assigns the appropriate values for:

1. Wilting: wilting point (0-1)

Western Washington Hydrology Model 2012 User Manual

- 2. K min: minimum hydraulic conductivity (cm/hr)
- 3. K Sat: maximum saturated hydraulic conductivity (cm/hr)
- 4. VG n: Van Genuchten number (from literature)
- 5. A: alpha (constant)
- 6. L: lambda (constant)
- 7. BPH: bubbling pressure head (cm)

The user can see the values for any of the soil types by selecting the soil type from the pulldown menu:



If none of the available soil types represents the amended soil planned for use on the site then the user can select a new soil type and input the appropriate values into the above input table.

Note that SMMWW is the required soil mix specified by the Department of Ecology for the top soil layer in bioretention facilities.

The second amended soil layer should be an intermediate material that is intended to prevent loss of fine material out of the engineered top layer soil mix into the gravel underlayer (layer 3).

The third (bottom) amended soil layer should be gravel.

A full list of Ecology-approved soil mixtures is shown in Table 1.

Soil Type	Wilting	Kmin	Ksat	VGn	٨		RDLI
	TOIL			VOII	~	L	ып
SMMWW							
(Ecology standard)	0.0650	0.85	3.00	15 24	6 50	1 40	7 50
GRAVEI	0.0050	0.00	10.00	1260.00	0.50	1.10	0.20
Sand	0.0200	0.42	3.00	23 56	6.00	0.69	7.26
ASTM 1	0.0900	0.41	1.50	2.54	7.50	0.75	8.50
ASTM 2	0.0825	0.42	1.55	5.08	7.30	0.88	8.30
ASTM 3	0.0750	0.43	1.60	7.62	7.10	1.00	8.10
ASTM 4	0.0725	0.44	1.65	10.16	7.00	1.15	8.00
ASTM 5	0.0700	0.45	1.70	12.70	6.90	1.30	7.90
ASTM 6	0.0675	0.46	1.85	15.24	6.50	1.40	7.50
ASTM 7	0.0667	0.47	2.00	17.78	6.45	1.50	7.45
ASTM 8	0.0659	0.48	2.15	20.32	6.43	1.58	7.43
ASTM 9	0.0651	0.49	2.30	22.86	6.41	1.66	7.41
ASTM 10	0.0643	0.50	2.45	25.40	6.39	1.74	7.39
ASTM 11	0.0635	0.51	2.60	27.94	6.37	1.82	7.37
ASTM 12	0.0627	0.52	2.75	30.48	6.35	1.90	7.35
ASTM 13	0.0619	0.53	2.90	33.02	6.33	1.98	7.33
ASTM 14	0.0611	0.54	3.05	35.56	6.31	2.06	7.31
ASTM 15	0.0603	0.55	3.20	39.00	6.30	2.14	7.30
ASTM 24.32	0.0590	0.55	3.20	39.00	6.25	2.25	7.20
ASTM 35.46	0.0550	0.55	3.25	90.10	6.20	2.30	7.00
ASTM 50	0.0500	0.55	3.30	127.00	6.15	2.35	6.80
ASTM 60	0.0490	0.55	3.35	152.40	6.10	2.40	6.40
ASTM 100	0.0450	0.55	3.40	254.00	6.05	2.45	6.00

Table 1. WWHM2012 Soil Mixtures

Wilting: wilting point (0-1)

K min: minimum hydraulic conductivity (cm/hr)

K sat: maximum saturated hydraulic conductivity (cm/hr)

VG n: Van Genuchten number (from literature)

A: alpha (constant)

L: lambda (constant)

BPH: bubbling pressure head (cm)

Table 1 values are from Schaap and Leij, 1998 soil parameter estimations using Rosetta.

As new soil mixtures are approved by Ecology they will be added to WWHM2012.

Check Ecology's 2012 *Stormwater Management Manual for Western Washington* to determine the appropriate Ksat (maximum saturated hydraulic conductivity) safety factor to use.

The user has the option of including an underdrain and/or infiltration into the native soil underneath the bottom amended soil layer (soil layer 3).

The bioretention surface area automatically receives rainfall and produces evapotranspiration. Due to this model input the bioretention surface area should be excluded from the basin element's total surface area.

Default Swale will create a bioretention facility with default values without checking it for compliancy with Ecology standards.

The water movement through the soil column calculations are based on the methodology described in Appendix A: Bioretention Modeling Methodology.

GREEN ROOF

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Schematic	Green-Roof 1 Mitigated			X
SCENARIOS	Element Name	Green-Roof 1]	
	Runoff Type	Surface Interflow	Groundwater	
	Element Type	Green-Roof		
	Soil (PERLND) Type	Green/ECO/ROOF		
Run Scenario	Green Area (ac)	0		
Basic Elements Green-Roof 1	Depth of Material (in) Slope of Bootton (ff/ff)	4		
	Vegetative Cover	Ground Cover 👻		
	Length of Rooftop (ft)	50		
Pro Elements				
LID Toolbox				
Commercial Toolbox				
Maya Elamanta				
MOVE LICIENS				
Save x,y Load x,y				
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The green roof element or vegetated roof (also called an eco-roof) is soil and vegetation placed on top of an impervious roof. It is a new WWHM2012 element, not previously available in WWHM3.

The user can change the default name "Green Roof 1" to another more appropriate name, if desired.

The user specifies the green roof surface area, soil depth, roof slope, type of vegetative cover (ground cover, shrubs, or trees), and length of the longest runoff path to reach a roof drain (length of rooftop). Default input values are automatically included with the element. They should be changed to reflect actual roof conditions.

The green roof surface area automatically receives rainfall and produces evapotranspiration. Due to this model input the green roof surface area should be excluded from the basin element's total surface area.

If the green roof is connected to a downstream element or is selected as a point of compliance the user should make sure that the groundwater runoff is included. Unlike the other drainage area elements (basin element, etc.), the green roof groundwater always contributes to the total runoff. The groundwater has nowhere else to go.

POROUS PAVEMENT

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Schematic	🗟 Porous Pavement 1 Mitigated 🛛 🔍
SCENARIOS	Facility Name Porous Pavement 1
Predeveloped	Outlet 1 Outlet 2 Outlet 3
	Facility Type Porous Pavement
	Quick Pavement
Rasic Elemente	Facility Dimension Diagram
Porous Pavement 1	Facility Dimensions
	Pavement Length (ft) 0 Overflow Data
	Pavement Bottom Width (it)
	Effective Total Depth (it)
Pro Elements	
	Layers for Porous Pavement
	Pavement Thickness (ft) 0 Diameter Height
	Pavement porosity (0-1) 0 (in) (ft)
	Sublayer 1 norosity (0-1)
	Sublayer 2 Thickness (it)
	Sublayer 2 porosity (0-1)
Commercial Toolbox	Infiltration NO
	Show Pavement Table Open Table
	Initial Stage (ft)
Move Elements	
Save x,y Load x,y	
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The porous pavement element (also called permeable pavement) is an impervious basin element that drains directly to storage layer similar to a gravel trench bed. The porous pavement element is a new WWHM2012 element, not previously available in WWHM3.

The user can change the default name "Porous Pavement 1" to another more appropriate name, if desired.

The user specifies the pavement length, bottom width, total depth, and bottom slope.

The porous pavement layers represent the pavement layer and two subgrade layers and their design characteristics (thickness and porosity). The subgrade layers (Sublayer 1 and Sublayer 2) are available to provide storage prior to discharge through infiltration to the native soil or discharge via an underdrain.

QuickPavement will create a porous pavement feature with default values without checking it for compliancy with Ecology standards.

The porous pavement surface area automatically receives rainfall and produces evapotranspiration. Due to this model input the porous pavement surface area should be excluded from the basin element's total surface area.

CAVFS



CAVFS stands for Compost Amended Vegetated Filter Strip. The CAVFS element is similar to the bioretention element, but is typically used to provide water quality treatment (filtering of stormwater) on roadway shoulders. Runoff from impervious road surfaces drains to the roadway's shoulder CAVFS area.

The CAVFS element is a new WWHM2012 element, not previously available in WWHM3. CAVFS does not have any surface outlet structure. Runoff travels either through the CAVFS soil column or sheet flows off the CAVFS surface.

The user can change the default name "CAVFS 1" to another more appropriate name, if desired.

The user specifies the CAVFS length, width, and allowed surface ponding depth.



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CAVFS has two material layers: one representing the gravel spreader strip at the edge of the pavement and the second represents the amended soil layer through which the runoff is filtered. The user specifies the thickness and material type for each layer and the embankment height.

Each material layer has appropriate drainage characteristics assigned based on literature values. When a material layer type is selected by the user then WWHM2012 automatically assigns the appropriate values for:

- 1. Wilting: wilting point (0-1)
- 2. K min: minimum hydraulic conductivity (cm/hr)
- 3. K Sat: maximum saturated hydraulic conductivity (cm/hr)
- 4. VG n: Van Genuchten number (from the literature)
- 5. A: alpha (constant)
- 6. L: lambda (constant)
- 7. BPH: bubbling pressure head (cm)

The user can see the values for any of the soil types by selecting the soil type from the pulldown menu:

View / Ed	lit Soil Type	es x
Save	SMMWW	-
Update	Name : St	MMWW
Delete	Wilting :	0.065
	K Min	0.85
	K Sat :	15.24
	VGin:	3
	A	6.5
	L	1.4
	BPH	7.5
		Bestore Defaults
Edit So	il Types	

A full list of Ecology-approved soil mixtures is shown in Table 1 on page 48.

If none of the available soil types represents the amended soil planned for use on the site then the user can select a new soil type and input the appropriate values into the above input table.

The required soil type for the gravel spreader layer is gravel. The CAVFS layer should be the SMMWW soil mix. Note that SMMWW is the required soil mix specified by the Department of Ecology for CAVFS.

The user has the option of including infiltration into the native soil underneath the bottom of the CAVFS amended soil layer.

The CAVFS surface area automatically receives rainfall and produces evapotranspiration. Due to this model input the CAVFS surface area should be excluded from the basin element's total surface area.

Default CAVFS will create a compost amended vegetated filter strip with default values without checking it for compliancy with Ecology standards.

The water movement through the soil column calculations are based on the methodology described in Appendix A: Bioretention Modeling Methodology.

RISER/WEIR

The trapezoidal pond, vault, tank, irregular pond, gravel trench bed, and sand filter all use a riser for the outlet structure to control discharge from the facility.

The riser is a vertical pipe with a height above pond bottom (typically one foot less than the effective depth). The user specifies the riser height and diameter.

The riser can have up to three round orifices. The bottom orifice is usually located at the bottom of the pond and/or above any dead storage in the facility. The user can set the diameter and height of each orifice. The model will automatically calculate the maximum orifice discharge value, QMax (cfs), if the pond dimensions have already been defined.

		10 11		1
aciiny Name	Trapezoida	I Pond I	Outlet 2	Outlet 2
	Outlet I		Outlet 2	Outlet 3
Jownstream Connections	U		U	Ľ
acility lype	Trapezoida	l Pond		
Precipitation Applied to Facility		Aut	o Pond	Quick Pond
Evaporation Applied to Facility				
acility Bottom Elevation (ft)	0]
actiny Dimensions Sottom Length (It) 0 Sottom Vidth (It) 0 Effective Deph (It) 0 Sottom Side Slope (H/V) 0 Sottom Side Slope (H/V) 0 Top Side Slope (H/V) 0 Facility Dimension Diagram nfiltration N0		Outlet S Riser Heigh Riser Diame Riser Type Notch Type Notch Heig Notch Widtl Orifice Number 1 2 3 Pond Volum Pond Increr Show Poo	Diameter (t) 0 Notched Rectangular nt (t) 0 Diameter 0 (t) 0 at (t) 0	Height QMax (Ft) (cfs) 0 0 0 0 0 0 (acre-ft) 0 (acre-ft) 0 0 0 (acre-ft) - 0 (acre-f

The user specifies the riser type as either flat or notched. The weir notch can be either rectangular, V-notch, or a Sutro weir. The shape of each type of weir is shown below.



By selecting the appropriate notch type the user is then given the option to enter the appropriate notch type dimensions.

Riser and orifice equations used in WWHM2012 are provided below.

Headr = the water height over the notch/orifice bottom.

q = discharge

Riser Head Discharge:

Head = water level above riser q = 9.739 * Riser Diameter * Head ^ 1.5

Orifice Equation:

q = 3.782 * (Orifice Diameter) ^ 2 * SQRT(Headr)

Rectangular Notch:

b = NotchWidth *- (1- 0.2 * Headr) where b >= 0.8 q = 3.33 * b * Headr ^ 1.5

Sutro:

Wh = Top Width + {(Bottom Width- Top Width)/Notch Height }* Headr Wd = Bottom Width - Wh (the difference between the bottom and top widths)

Q1 = (rectangular notch q where Notch Width = Wh) Q2 = (rectangular notch q where Notch Width = Wd)

q = Q1 + Q2 / 2

V-Notch:

Notch Bottom = height from bottom of riser to bottom of notch Theta = Notch Angle

a=2.664261 - 0.0018641 * Theta + 0.00005761 * Theta ^2 b=-0.48875+0.003843 * Theta - 0.000092124 * Theta ^2 c=0.3392 - 0.0024318 * Theta + 0.00004715 * Theta ^2

YoverH = Headr / (NotchBottom + Headr) Coef = a + b * Headr + c * Headr 2

 $q = (Coef * Tan(Theta / 2)) * (Headr ^ (5 / 2))$

INFILTRATION

Infiltration of stormwater runoff is a recommended solution if certain conditions are met. These conditions include: a soils report, testing, groundwater protection, pre-settling, and appropriate construction techniques (see Ecology's 2012 *Stormwater Management Manual for Western Washington* for details).

The user clicks on the Infiltration option arrow to change infiltration from NO to YES. This activates the infiltration input options: measured infiltration rate, infiltration reduction factor, and



whether or not to allow infiltration through the wetted side slopes/walls.

The infiltration reduction factor is a multiplier for the measured infiltration rate and should be less than one. It is the same as the inverse of a safety factor. For example, a safety factor of 2 is equal to a reduction factor of 0.5.

Infiltration occurs only through the bottom of the facility. If the wetted surface area option is turned on then infiltration also occurs through the wetted side walls.

After the model is run and flow is routed through the infiltration facility the total volume infiltrated, total volume through the riser, total volume through the facility, and percent infiltrated are reported on the screen. If the percent infiltrated is 100% then there is no surface discharge from the facility. The percent infiltrated can be less than 100% as long as the surface discharge does not exceed Ecology's flow control standards.

Infiltration facilities have the option to allow users to automatically size the facility to meet an infiltration target percentage. The user can set the target percentage for being filtered/infiltrated to 91% to meet the Ecology water quality treatment standard.



AUTOPOND, AUTOVAULT, AUTOTANK

AutoPond, AutoVault, and AutoTank all work the same. Each optimizing routine automatically creates a pond, vault, or tank size and designs the outlet structure to meet Ecology's flow duration criteria. The user can either create a pond, vault, or tank from scratch or optimize an existing design.

The following information applies to all three optimizing routines (AutoPond, AutoVault, and AutoTank), but for the purposes of simplifying the following documentation the term "AutoPond" applies equally to AutoVault and AutoTank.

AutoPond requires that the Predeveloped and Mitigated basins be defined first. Clicking on the AutoPond button brings up the AutoPond window and the associated AutoPond controls.

AutoPond controls:

Pond 1	
Automatic Pond Adjuster	
0-1 min <2-10 min> 10 min+ Fast Thorough Pond Depth (incl. 1 ft freeboard) 7 ft. Pond length to width ratio: 1 to 1 Pond Side Slopes: 3 to 1 Bottom Length: ft Bottom Width: ft Volume at riser head: acre ft	Predeveloped Mitigated
Choose Outlet Structure	
1 orifice & rectangular notch 👻	
Progress:	
Create Pond Optimize Pond Accept pond Close	

Automatic Pond Adjuster: The slider at the top of the AutoPond window allows the user to decide how thoroughly the pond will be designed for efficiency. The lowest setting (0-1 min) at the left constructs an initial pond with checking it for Ecology's flow duration criteria. The second setting to the right creates and sizes a pond to pass Ecology's flow duration criteria; however, the pond is not necessarily optimized. The higher settings increase the amount of optimization. The highest setting (farthest left) will size the most efficient (smallest) pond, but will result in longer computational time.

Pond Depth: Pond depth is the total depth of the pond and should include at least one foot of freeboard (above the riser). The pond's original depth will be used when optimizing an existing pond; changing the value in the Pond Depth text box will override any previous set depth value. The default depth is 7 feet.

Pond Length to Width Ratio: This bottom length to width ratio will be maintained regardless of the pond size or orientation. The default ratio value is 1.0

Pond Side Slopes: AutoPond assumes that all of the pond's sides have the same side slope. The side slope is defined as the horizontal distance divided by the vertical. A typical side slope is 3 (3 feet horizontal to every 1 foot vertical). The default side slope value is 3.

Choose Outlet Structure: The user has the choice of either 1 orifice and rectangular notch or 3 orifices. If the user wants to select another outlet structure option then the pond must be manually sized.

Create Pond: This button creates a pond when the user does not input any pond dimensions or outlet structure information. Any previously input pond information will be deleted.

Optimize Pond: This button optimizes an existing pond. It cannot be used if the user has not already created a pond.

Accept Pond: This button will stop the AutoPond routine at the last pond size and discharge characteristics that produce a pond that passes Ecology's flow duration criteria. AutoPond will not stop immediately if the flow duration criteria has not yet been met.

The bottom length and width and volume at riser head will be computed by AutoPond; they cannot be input by the user.

There are some situations where AutoPond will not work. These situations occur when complex routing conditions upstream of the pond make it difficult or impossible for AutoPond to determine which land use will be contributing runoff to the pond. For these situations the facility will have to be manually sized.

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SCENARIOS		Stage	Area	Storage	Dschrge	Infilt	Ī		
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	_	0.000000	0.918274	0.000000	0.000000	0.000000	^ _		
Mitigated		0.077778	0.922564	0.071588	0.065922	0.000000	1		
		0.155556	0.926864	0.143510	0.093228	0.000000	1		
Hun Scenario		0.233333	0.931174	0.215767	0.114180	0.000000	1		
Basic Elements		0.311111	0.935495	0.288360	0.131844	0.000000			
		0.388889	0.939825	0.361289	0.147406	0.000000			
		0.466667	0.944165	0.434555	0.161475	0.000000			
		0.544444	0.948516	0.508160	0.174413	0.000000	=		
Trapezoidal	Pond 1	0.622222	0.952876	0.582103	0.186455	0.000000			
		0.700000	0.957246	0.656385	0.197766	0.000000			
		0.777778	0.961626	0.731008	0.208463	0.000000			
		0.855556	0.966017	0.805972	0.218638	0.000000			
Pro Elements		0.933333	0.970417	0.881278	0.228360	0.000000			
		1.011111	0.974827	0.956926	0.237685	0.000000			
		1.088889	0.9/924/	1.032918	0.246657	0.000000	_		
		1.166667	0.983678	1.109254	0.255314	0.000000			
		1.244444	0.988118	1.105935	0.263687	0.000000			
LID Toolbox		1.322222	0.992568	1.262961	0.271803	0.000000			
		1.400000	0.997028	1.340335	0.2/9683	0.000000			
		1.4////0	1.001499	1.410035	0.20/34/	0.000000			
		1.000000	1.003979	1.490124	0.294011	0.000000			
		1 711111	1.010469	1.574541	0.302092	0.000000			
Commercial Loolbox		1.700000	1.014969	1.000000	0.309201	0.000000			
		1 966667	1.019400	1 01100/	0.310130	0.000000			
		1 944444	1.024000	1 001715	0.322930	0.000000			
7312		2 022222	1.020550	1 071000	0.329009	0.000000			
Move Elements		2.022222	1.033071	2 052415	0.330137	0.000000			
		2.100000	1 042101	2.032413	0.342340	0.000000			
		2 255556	1 046751	2 214533	0.355000	0.000000			
		2 333333	1 051331	2 296125	0.361069	0.000000			
		2 411111	1 055922	2 378074	0 367037	0.000000			
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		2 644444	1 069752	2 626067	0 384387	0.000000			~
		2.011111	1.000/02	2.020007	0.004007	9/25/2012	_	3.37 DM	

STAGE-STORAGE-DISCHARGE TABLE

The stage-storage-discharge table hydraulically represents any facility that requires stormwater routing. The table is automatically generated by WWHM2012 when the user inputs storage facility dimensions and outlet structure information. WWHM2012 generates 91 lines of stage, surface area, storage, surface discharge, and infiltration values starting at a stage value of zero (facility bottom height) and increasing in equal increments to the maximum stage value (facility effective depth).

When the user or WWHM2012 changes a facility dimension (for example, bottom length) or an orifice diameter or height the model immediately recalculates the stage-storage-discharge table.

The user can input to WWHM2012 a stage-storage-discharge table created elsewhere. This is done using the separate SSD Table element. See the SSD Table description below for more information on how to load such a table into WWHM2012.



HIGH GROUNDWATER/WETLAND

The High Groundwater/Wetland element is a complex element that should only be used in special applications by advanced WWHM2012 users. The purpose of the high groundwater/wetland element is to model hydrologic conditions where high groundwater rises to the surface (or near the surface) and reduces the ability of water to infiltrate into the soil.

The element can be used to represent wetland conditions with surface ponding where the discharge from the wetland is via a surface release. The user is given the choice of using either a natural channel, berm/weir, or control structure to determine the release characteristics.

The user can change the default name "Wetpond 1" to another more appropriate name, if desired.

The high groundwater/wetland surface area automatically receives rainfall and produces evapotranspiration. Due to this model input the high groundwater/wetland surface area should be excluded from the basin element's total surface area.

The element provides default values for some of the parameters, especially as they relate to high groundwater. The user should be fully familiar with these parameters and the

appropriate values for their site prior to attempting to use this element. The high groundwater parameter definitions are shown below.

Cohension water porosity: soil pore space in micropores.

Gravitational water porosity: soil pore space in macropores in the lower and groundwater layers of the soil column.

Upper gravitation water porosity: soil pore space in macropores in the upper layer of the soil column.

Upper zone storage factor: portion of the water stored in macropores in the upper soil layer which will not surface discharge, but will percolate, evaporate or transpire.

Lower zone storage factor: portion of the water stored in micropores in the lower soil layer which will not gravity drain, but will evaporate or transpire.

Additional documentation is available in "WWHM3 Description of HSPF High Groundwater Parameters" available from the Washington State Department of Ecology.

CHANNEL

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Schematic 🔤 🗆 🗙	Channel 1 Mitigated	A ()							
SCENARIOS	Facility Name	Channel 1							
Predeveloped	Downstroom Connection	Outlet 1 Outlet 2 Outlet 3							
	гасшту туре	Channel I Use X-Sections Quick Channel							
Run Scenario	Clean and Straight 0.030	÷							
Basic Elements Channel 1	Channel Dimensions	Browse for file.							
	General Channel Data								
	Channel Length (ft)								
	Manning n coefficient 0.03								
	Slope of Channel (ft/ft)								
Pro Elemente	Right Side Slope (H/V)								
	Maximum Channel Depth (ft)								
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LID Toolbox									
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Move Elements									
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The Channel element allows the user to route runoff from a basin or facility through an open channel to a downstream destination.

The channel cross section is represented by a trapezoid and is used with Manning's equation to calculate discharge from the channel. If a trapezoid does not accurately represent the cross section then the user should represent the channel with an independently calculated SSD Table element or use the Use X-Sections option.

The user can change the default name "Channel 1" to another more appropriate name, if desired.

The user inputs channel bottom width, channel length, channel bottom slope, channel left and right side slopes, maximum channel depth, and the channel's roughness coefficient (Manning's n value). The user can select channel type and associated Manning's n from a table list directly above the Channel Dimensions information or directly input the channel's Manning's n value.

The channel is used to represent a natural or artificial open channel through which water is routed. It can be used to connect a basin to a pond or a pond to a pond or multiple channels can linked together.
Quick Channel will create a channel with default values without checking it for compliancy with Ecology standards.

FLOW SPLITTER

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Schematic	🗗 Flow Splitter 1 Mitigated 🛛 🔍 🖴
SCENARIOS	Facility Name Flow Splitter 1
Predeveloped	Both Exits Primary Exit(1) Secondary Exit(2)
Mitigated	Channel 1 Trapezoidal Pond 1
Bun Scenario	Undergam Charges Area Lawella (9)
Basic Elements	Maximum Depth of Ponding (It) 10
	Primary Exit(1) Structure Secondary Exit(2) Structure
	Control Structure +
Flow Splitter 1	Riser Diameter (in)
	Riser Type Flat
Pro Elements	
	Orifice Diameter Height Orifice Diameter Height
	Number (in) (ft) (in) (ft)
Commercial Loolbox	Volume at Top of Storage area (ac-it) .000
Move Elements	Initial Stage (ft)
Save xy Load xy	
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The flow splitter divides the runoff and sends it to two difference destinations. The splitter has a primary exit (exit 1) and a secondary exit (exit 2). The user defines how the flow is split between these two exits.

The user can change the default name "Flow Splitter 1" to another more appropriate name, if desired.

The user can define a flow control structure with a riser and one to three orifices for each exit. The flow control structure works the same way as the pond outlet structure, with the user setting the riser height and diameter, the riser weir type (flat, rectangular notch, V-notch, or Sutro), and the orifice diameter and height.



The second option is that the flow split can be based on a flow threshold. The user sets the flow threshold value (cfs) for exit 1 at which flows in excess of the threshold value go to exit 2. For example, if the flow threshold is set to 5 cfs then all flows less than or equal to 5 cfs go to exit 1. Exit 2 gets only the excess flow above the 5 cfs threshold (total flow minus exit 1 flow).

TIME SERIES

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Schematic	Time Series 1 Mitigated
SCENARIOS	Name: Time Series 1
Mitigated	Choose WDM Choose WDM
Run Scenario	
Basic Elements	1 PUYALLUP DAILY EVAP W/JENSEN-HAIS 2 Everett
	501 P0C1 Predeveloped flow 701 Inflow to P0C1 Mitigated P0C1 Vitigated
	1000 FOC I Midgated now 1000 Trapezoidal Pond 1 ALL OUTLETS Mitigated 1001 Trapezoidal Pond 1 STAGE Mitigated
	Flows To: Channel 1
Pro Elements	
LID Toolbox	
Commercial Toolbox	
Move Elements	
Save yu Load yu	
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The WWHM2012 stores runoff time series data in its database (HSPF WDM file). The user has the option to create or use a time series file external from the current WWHM2012 project file or use a file created as part of the WHM2012 project file. This includes using a time series of flow values created by another HSPF model. An example is offsite runoff entering a project site. If this offsite runoff is in an existing WDM file and is the same period as the WWHM2012 data and the same simulation time step (15-minute) then it can be linked to the WWHM2012 model using the Time Series element.

To link the external time series to the WWHM2012 the user clicks on the "Choose WDM" button and identifies the external WDM file. The external WDM's individual time series files are shown in the box. The selected input dataset is the time series that will be used by the WWHM2012.

SSD TABLE

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Schematic	SSD Table 1 Mitigated
SCENARIOS	Facility Name: SSD Table 1
	Flows To :
Mitigated	Final Facility Type SSD TABLE
Hun Scenario	
Basic Liements SSD Table 1	Edu File. Browse
	Stage (t) Area Storage Not Lised Not Lised Not Lised Not Lised
	diage (ii) (acres) (acre-ft) Hot osed Hot osed Hot osed Hot osed Hot osed
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LID Toolbox	9
	12
Commercial Toolbox	
	Tide Gate Time Series Demand
	Determine Outlet With Tide Gate
Move Elements	🗖 Use Tide Gate
	Tide Gate Elevation (ft) 0 Downstream Connection 🗨
	Overflow Elevation (ft) 0 Iterations 0
Save xu Lload xu L	
	Intitial stage (II)
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The SSD Table is a stage-storage-discharge table externally produced by the user and is identical in format to the stage-storage-discharge tables generated internally by the WWHM2012 for ponds, vaults, tanks, channels, and other conveyance elements.

The user can change the default name "SSD Table 1" to another more appropriate name, if desired.

The easiest way to create a SSD Table outside of the WWHM2012 is to create a spreadsheet with a separate column for stage, surface area, storage, and discharge (in that order). To input an externally generated SSD Table, first create and save the table outside of the WWHM2012. Use the Browse button to locate and load the file into the WWHM2012.

The SSD Table must use the following units: Stage: feet Surface Area: acres Storage: acre-feet Discharge: cubic feet per second (cfs)

A fifth column can be used to create a second discharge (cfs). This second discharge can be infiltration or a second surface discharge.

Certain rules apply to the SSD Table whether it is created inside or outside of the WWHM2012. These rules are:

- 1. Stage (feet) must start at zero and increase with each row. The incremental increase does not have to be consistent.
- 2. Storage (acre-feet) must start at zero and increase with each row. Storage values should be physically based on the corresponding depth and surface area, but the WWHM2012 does not check externally generated storage values.
- 3. Discharge (cfs) must start at zero. Discharge does not have to increase with each row. It can stay constant or even decrease. Discharge cannot be negative. Discharge should be based on the outlet structure's physical dimensions and characteristics, but the WWHM2012 does not check externally generated discharge values.
- 4. Surface area (acres) is only used if precipitation to and evaporation from the facility are applied.

Save the spreadsheet file as a comma-delimited file. A text file can also be created, if more convenient.



To input columns of values beyond (to the right of) the Storage column click on the "Not Used" title and select the appropriate option. Use "Manual" when the discharge has been included in the external spreadsheet.

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	2 0 0 0 0
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Schematic	📮 🗆 🗙 🗖 SSD Table 1 Mitigated
SCENARIOS	Facility Name: SSD Table 1
Predeveloped	Flows To :
Mitigated	
Buy Compile	Manual Infiltration
Page Elemente	
	✓ Stage Computed Add Lever
	Stare (#) Area Storage Outlet Not Lead Not Lead Not Lead
	(acres) (acre-ft) Structure Hot osed Hot osed Hot osed Hot osed
	3
Pro Elements	SSD Table
	Dutlet Structure
	Outlet: 0
	Riser Height (ft) p
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	Orifice Dia. (in) Height (in)
Mana Elemente	
Save x,y Load x,y	Initial Stage (ff)
#	
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Use "Outlet Structure" to input riser and orifice dimensions.



The fifth column can be used for a second surface outlet (manual or outlet structure), infiltration, or aquifer recharge. Aquifer recharge differs from infiltration in how the model separately accounts for it.

POINT OF COMPLIANCE

WWHM2012 allows for multiple points of compliance (maximum of 50) in a single project. A point of compliance is defined as the location at which the Predeveloped and Mitigated flows will analyzed for compliance with Ecology's flow control standard.

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💿 🐨 💼 🖻 🖄 🎰		
Schematic		🗟 Trapezoidal Pond 1 Mitigated 🛛 🔀
SCENARIOS		Facility Name Trapezoidal Pond Facility Type Trapezoidal Pond
Predeveloped		Outlet 1 Outlet 2 Outlet 3 Downstream Connections 0 0 0
Mitigated		Precipitation Applied to Facility Auto Pond Quick Pond
Pun Comparin		Evaporation Applied to Facility Facility Dimension Diagram
Page Elemente		Facility Dimensions Outlet Structure Data
		Facility Bottom Elevation (it) 0 Riser Height (it) 6 📫
		Bottom Lengm (rt) 200 Riser Diameter (in) 24
		Effective Depth (ft) 7 Notched
		Left Side Slope (H/V) 3 Notch Height (ft)
		Bottom Side Slope (H/V) 3 Notch Width (ft) 2
	Trapezoidal Pond 1	Right Side Slope (H/V) 3
Pro Elements	ement Ontion List	Top Side Slope (H/V) 3 Orifice Diameter Height
	onnect To Element	Infiltration YES · Number (in) (π)
	onnect to Point Of Compliance	Reduction Factor(infilt*factor)
	naiyze isconnect Element	Use Wetted Surface Area (sidewalls) NO ÷ 3 0 ÷ 0
Di	isconnect POC	Total Volume Infiltrated (ac-ft) 0
C	ompute Recharge	Total Volume Through Riser (ac-ft) 0 Pond Volume at Riser Head (ac-ft) 6.646
Fir	nd Element	Percent Infiltrated
Commercial Toolbox	ut Element	Initial Stage (ft)
Pa	opy ciement aste Element	
De	elete Element	Target 70: 100
Du Du	uplicate Predeveloped	Tide Gate Time Series Demand
Sa	ave Element	Determine Outlet With Tide Gate
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	un Preueveloped un Mitigated	I ide Gate Elevation (tt) 0 Downstream Connection
Save x,y Load x,y Ch	lear All	Overflow Elevation (ft) 0 Iterations 0
	nport Basin Location	
Y 24 + 4		 [g/25/2010 [2:00 БМ

The point of compliance is selected by right clicking on the element at which the compliance analysis will be made. In the example above, the point of compliance analysis will be conducted at the outlet of the trapezoidal pond.



A Point of Compliance (POC) box will allow the user to specify which outlet (if there is more than one) to connect to the point of compliance and corresponding number for the POC.

In the above example, there are two outlets shown (Outlet 1 and Outlet 2). Outlet 1 represents the surface discharge through the outlet structure. Outlet 2 is the infiltration discharge through the bottom of the facility. Only the surface discharge (Outlet 1) should be connected to the POC.

When an underdrain is included in the facility (bioretention or porous pavement) the discharge from the underdrain will be considered part of the Outlet 1 total discharge.

A sand filter should include the discharge from both Outlet 1 (surface discharge not filtered by the sand filter) and Outlet 2 (surface discharge filtered by the sand filter) connected to the POC, assuming that the POC is immediately downstream of the sand filter.

Once the point of compliance has been selected the element is modified on the Schematic screen to include a small box with the POC number (1 in this example) and the letter "A" (for Analysis) in the lower right corner. This identifies the outlet from this element as a point of compliance.



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Schematic	💶 🗖 🔀 Basin 1 Mitigated	A ()
SCENARIOS	Subbasin Name Basin 1	Designate as Bypass for POC:
	Surface	Interflow Groundwater
	Flows To : Trapezoidal Pond 1	Trapezoidal Pond 1
Mitigated	Area in Basin	Show Only Selected
Run Scenario	Available Pervious Acres	Available Impervious Acres
Basic Elements	A/B, Forest, Flat	
	A/B, Forest, Mod	
	t Option List	
	t To Element	
	t to Point Of Compliance	
Analyze Disconn	ect Element A/B. Lawn, Flat	
Disconn	ect POC A/B, Lawn, Mod 0	SIDEWALKS/FLAT
Pro Elements Comput	e Recharge A/B, Lawn, Steep 0	
Find Ele	ment 🔽 C, Forest, Flat 0	SIDEWALKS/STEEP
Cut Eler	ment C, Forest, Mod 0	PARKING/FLAT
Copy El	ement C, Forest, Steep 0	PARKING/MOD 0
LID Toolbox Paste El	lement C, Pasture, Flat 0	
Duplicat	te Predeveloped	
	C. Pasture, Steep 0	Porous Pavement 0
Load Ele	ement C, Lawn, Flat	
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CONNECTING ELEMENTS

Elements are connected by right clicking on the upstream element (in this example Basin 1) and selecting and then left clicking on the Connect To Element option. By doing so the WWHM2012 extends a green line from the upstream element to wherever the user wants to connect that element.



The user extends the green connection line and box to the downstream element (in this example, a pond) and left clicks on the destination element. This action brings up the From Basin to Conveyance box that allows the user to specify which runoff components to route to the downstream element.



Stormwater runoff is defined as the sum of surface flow and interflow. Both boxes should be checked. Groundwater should not be checked for the standard land development mitigation analysis. Groundwater should only be checked when there is observed and documented base flow or spring flow occurring from the upstream basin.

After the appropriate boxes have been checked click the OK button.



The final screen will look like the above screen. The basin information screen on the right shows that Basin 1 surface and interflow goes to Trapezoidal Pond 1; groundwater is not connected.

ANALYSIS SCREEN



The Analysis tool bar button (third from the left) brings up the Analysis screen where the user can look at the results. The Analysis screen allows the user to analyze and compare stream protection flow duration, LID flow duration, flow frequency, water quality, hydrographs, wetland fluctuations, and recharge, as needed. In addition, the LID report is automatically generated in the Analysis window.

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Analysis	
Steam Protection Duration LID Duration Flow Frequency Water Quality Hydrograph Wetland Fluctuation LID Report Recharge Duration Recharge Predeveloped Recharge Mitigated Analyze datasets Import Predeveloped flow Duration Bounds Duration Bounds 2E versett 500 POC 1 Predeveloped flow Duration Bounds Duration Bounds 1000 Trapezoidad Pond 1 STAGE Mitigated Durations (mm/dd) Statt Date End Date All Datasets Flood Frequency Method Log Pearson Type III 178 Vebul Cumanee Gringoten Gringoten	
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The user can analyze all time series datasets or just flow, stage, precipitation, evaporation, or point of compliance (POC) flows by selecting the appropriate tab below the list of the different datasets available for analysis.



Stream Protection Duration

Flow duration has been divided into stream protection duration and LID duration. The stream protection duration standard is to meet Ecology's flow control minimum requirement (#7). The LID duration standard is to meet Ecology's on-site stormwater management minimum requirement (#5).

Stream protection flow duration at the point of compliance (POC 1) is the most common analysis. A plot of the stream protection flow duration values is shown on the left, the flow values on the right.

The blue stream protection flow duration curve is a plot of the percent of time that the predevelopment flows (time series 501 for POC 1) are between the lower erosive flow threshold of 50% of the 2-year flow (0.50Q2) and the upper erosive flow threshold of the 50-year flow (Q50). Q2 and Q50 are determined by the flow frequency calculations.

The red stream protection flow duration curve is the mitigated developed flow (time series 801 for POC 1).

The table to the right of the stream protection flow duration curves shows the individual flow levels (starting at 0.50Q2) and the corresponding number of time intervals that the predevelopment and mitigated flows exceed those flow levels. The number of mitigated flows at any specific flow level cannot exceed the number of predevelopment flows at the

same flow level between 0.5Q2 and Q2. Between Q2 and Q50 the number of mitigated flows at any specific flow level cannot exceed the number of predevelopment flows by more than 10% no more than at 50% of the levels. WWHM2012 automatically checks these stream protection flow duration criteria when determining whether or not a stormwater facility passes the Ecology flow control standard.

LID Duration



The LID duration standard is to meet Ecology's on-site stormwater management minimum requirement (#5).

LID flow duration analysis is a requirement for low impact development facilities (bioretention, porous pavement, green roof, etc). A plot of the LID flow duration values is shown on the left, the flow values on the right.

The LID flow duration analysis output includes the stream protection flow duration analysis at the POC. For this reason the blue LID flow duration curve is a plot of the percent of time that the predevelopment flows (time series 501 for POC 1) are between 8% of the 2-year flow (0.08Q2) and the 50-year flow (Q50). Q2 and Q50 are determined by the flow frequency calculations.

The red LID flow duration curve is the mitigated developed flow (time series 801 for POC 1).

The table to the right of the LID flow duration curves shows the individual flow levels (starting at 0.08Q2) and the corresponding number of time intervals that the predevelopment and mitigated flows exceed those flow levels. The number of mitigated flows at any specific flow level cannot exceed the number of predevelopment flows at the same flow level between 0.08Q2 and 0.50Q2. Above 0.5Q2 the stream protection

duration criteria is used to determine whether or not the project flow at the POC meets Ecology's requirements. WWHM2012 automatically checks these flow duration criteria when determining whether or not a stormwater facility passes the Ecology on-site stormwater management standard and the flow control standard.

Flow Frequency



Flow frequency plots are shown on the left and the 2-, 5-, 10-, 25-, 50-, and 100-year frequency values are on the right. Flow frequency calculations are based on a Log Pearson Type III distribution of yearly peak flow values.

It is possible, although unusual, for the mitigated frequency values to be greater than the predeveloped frequency values for the 25-, 50-, and 100-year flow frequency events. This can happen when the mitigated 2-year value is much smaller than the predeveloped frequency value.

The Log Pearson Type III methodology uses the annual peak statistics to compute the mean, standard deviation, and skew of the log of the peak flows. Small mitigated 2-year events can produce a large standard deviation and skew which, in turn, produce large mitigated 25-, 50-, and 100-year flow frequency values. This is okay as long as the stream protection flow control standard (based on flow duration criteria, not flow frequency) is met.

Water Quality

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Analysis		
Water Quality On-Line BMP 24 hour Volume (ac-ft) 0.3029 Standard Flow Rate (cfs) 0.1534 Standard Flow Rate (cfs) Steam Protection Duration LID Duration FI Wetland Fluctuation LID Report Recharge Duration Analyze datasets 1 PUYALLUP DAILY EVAP W/JENSEN:HAIS 2 Everett 500 FDC1 Predeveloped flow 701 Fridow OPC1 Mingated 1001 Trapezoidal Pond 1 STAGE Mingated 1001 Trapezoidal Pond 1 STAGE Mingated	Diff-Line BMP Standard Flow Rate (cfs) 00012 ow Freq ency Water Quality Hy ograph ow Dreat Ency Water Quality Hy ograph ow hype Predeveloped Rector of Miligated Flood Frequency Method Compare User Data State St	
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The water quality screen allows the user to compute the target volumes and flows for offline and online water quality facilities.

Select the dataset 801 POC 1 Mitigated flow for the water quality analysis for a water quality facility downstream of the project flow control facility. Click on the "Run Analysis" button on the left side of the Water Quality analysis results for the WWHM2012 to compute volumes and flows based on Ecology's water quality facility sizing criterion (91% of total runoff volume) or a criterion selected by the user via View, Options, Scaling Factor Water Quality.

Select the 701 Inflow to POC 1 Mitigated flow time series for the water quality analysis for a water quality facility upstream of the project flow control facility.

An online water quality facility is downstream of the project flow control facility; all of the runoff is routed through an online facility. An offline facility receives only a portion of the total runoff.

Hydrographs



The user can graph/plot any or all time series data by selecting the Hydrograph tab.

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🕐 Create Graph		
Image: The second se	Add Data File Previous Plots V Record Plots Start Date 1948/10/01 00.00 End Date 2012/09/29 24.00 Plot Hydrograph 64 Annual Preaks Monthly Average SMinute Graph SMinute Graph SMinute Graph SMinute Graph Color Table DSN# to Copy Color Table S S S	
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The Create Graph screen is shown and the user can select the time series to plot, the time period (start date and end date), the time interval (yearly, monthly, daily, hourly, 30-minute, or 15-minute), and type of data (peaks, average, or volume).

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Click on the "+" to the left of the WDM file name (in this example: "Snohomish 1.wdm"). The selected time series are then shown. Check the box(es) for the time series to be plotted. Multiple time series can be plotted together as long as they are the same data type. Precipitation data can also be plotted at the same time as flow data.

To graph the selected time series the user clicks on the Graph button.



The hydrograph shows the yearly maximum/peak flow values for each time series for the entire simulation period (in this example, from 1949 through 2009).

The graph can be either saved or printed or copied to an Excel spreadsheet for additional analysis.

Wetland Fluctuation

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Analysis			
	Key Deckson Deckson Deckson Millered		
Stream Protection Duration LID Duration	Flow Frequency Water Quality Hydrograph		
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1 PUYALLUP DAILY EVAP W/JENSEN-HAIS 2 Everett 501 DOS 1 Dede also also also also also also also also			
701 Inflow to POC 1 Mitigated 801 POC 1 Mitigated			
1000 Trapezoidal Pond 1 ALL OUTLETS Mitigated 1001 Trapezoidal Pond 1 STAGE Mitigated			
All Datasets Flow Stage Precip Evap POC1	-		
	Flood Frequency Method		
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The wetland fluctuation option in the Analysis screen is selected by clicking on the "Wetland Fluctuation" tab.

The analysis is done at the point of compliance based on the assumption that this is the location at which runoff enters the wetland of interest. If the wetland is upstream of the POC then a new POC should be added to represent the flows entering the upstream wetland.

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The wetland fluctuation calculations are done for the POC-related flow time series by selecting the appropriate POC tab.

WWHM2012 checks the flow time series using two criteria:

- 1. Daily mitigated flow volumes cannot change by more than 20% compared to the same daily predevelopment flow volumes.
- 2. Monthly mitigated flow volumes cannot change by more than 15% compared to the same monthly predevelopment flow volumes.

The wetland fluctuation results are shown in both graphical and tabular format. The graph shows the volumes (scale on the right) for the predevelopment daily flows in blue, the mitigated developed daily flows in red, and the percentage of the predevelopment volume values (scale on the left) in green.

In the above example there is too much daily and monthly mitigated development flow and neither wetland fluctuation criterion is not passed, as shown in the table on the right. As with flow duration, one "Fail" is all that is needed to fail the standard. In this situation the only way to meet the wetland fluctuation standard is to infiltrate or evaporate some of the excess mitigated flow volume so that the reduced mitigated flow volume is more in the range of the predevelopment flows.

LID Analysis

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Analysis	
Wetland Fluctuation UD Recort Reckarge Duration Recharge Mitigated Stream Problem Duration LID Duration Row Frequency Water Quality Hydrograph Analyze datasets 1 PUYALLUP DAILY EVAP W/JENSEN-HAIS Duration Bounds Duration Bounds 2.Event 501 POC1 Mitigated flow 1000 Trapezoidal Ford 1 OLITETS Mitigated Duration Bounds 1000 Trapezoidal Ford 1 OLITETS Mitigated Image Precip Evant Evant All Datasets Flow Stage Precip Evant All Datasets Flow Stage Precip Evant	
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Note that the LID Report can be accessed from both the Analysis screen and the LID Scenario Generator screen.

The LID Report has been created to determine if the modeled LID facilities meet Washington State Department of Ecology (DOE) requirements for low impact development.

WWHM2012 LID Project 1 View Help Summary Report 0 🛩 🖬 🧉 🗶 🖻 🛍 🗹 📴 🎒 🖬 🚟 🛑 💕 💋 🖬 🖷 🖳 (0) (2) (3) 💞 🖬 🖻 🐼 🛻 LID Report POC 1 LID Technique Used for Treatment Total Volume Volume Infiltration Cumulative Percent Water Quality Percent Comment Needs Through Volume Volume Volume Infiltrated Water Quality Treated Treatment Facility (ac-ft) Infiltration ac-ft) ac-ft) Credit Trapezoidal Pond 1 PO 7589.3 8339.96 7899.7 7899.7 94.72 Treat. Credit ☑ 94.72 Sand Filter 1 6803.98 7476.90 0.00 0.00 6729.44 90.00 6258.4 94.94 Treat. Credit Bio Swale 1 6877.4 6368.7 92.60 6529.3 Porous Pavement 1 194.5 213.74 156.3 7476.32 6803.4 Vault 1 0.00 0.00 21158*)* 30384 = 70% Treat. Credit = 70% 27649.7 30384.37 14424.8 47.47 21158.4 Total Volume Infiltrated Duration Compliance with LID Standard 8% of 2-yr to 50-yr Analysis Result = Failed Analyze 1 PUYAL 2 Everett 501 POC 701 Inflo 801 POC 1000 Tra 1001 Tra 1002 Tra All Data Export Close lood Frequency Metho Log Pearson Type III 17B Weibull Cunnane Gringorter Tide Gate Elevation (ft) X 40 # • 0 Downstream Connection -11/13/2012 11:33 AM

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Clicking on the "LID Report" tab produces the LID Report that lists all of the LID facilities in the Mitigated scenario and their performance.

The column "Total Volume Needs Treatment (ac-ft)" is volume that equals 91% of the total runoff volume through the facility for the entire model simulation period.

The column "Volume Through Facility (ac-ft)" is the actual total runoff volume through the facility for the entire model simulation period.

"Infiltration Volume (ac-ft)" is the actual total runoff volume that is infiltrated for the entire model simulation period. In the case of the sand filter the infiltration volume is actually the volume that is filtered and then continues downstream to the next stormwater facility.

"Percent Volume Infiltrated" is the percentage of the "Infiltration Volume" column volume to the "Volume Through Facility" column volume.

"Water Quality" is the actual total runoff volume that is filtered through the soil column. This is not necessarily the same as the infiltration volume. For this example, the bioretention facility has more water quality volume than infiltration volume. This is because some of the flow through the bioretention amended soil layers was then discharged via an underdrain to the next downstream facility (in this case, a stormwater pond with infiltration). "Percent Water Quality Treated" is the precentage of the "Water Quality" column volume to the "Volume Through Facility" column volume.

The Comment column reports "Treat Credit" if the LID facility water quality treatment meets Ecology's water quality treatment standard of treating at least 91% of the total runoff volume through the facility. In this example only the bioretention and pond meet the treatment standard.

If a facility is used for water quality treatment then the corresponding box in the "Used for Treatment" column is checked.

In this example the "Used for Treatment" boxes for the trapezoidal pond, sand filter, and bioretention swale are checked. The percent water quality treated values are 94.72, 90.00, and 94.94, respectively. (The sand filter did not meet the minimum treatment requirement of 91.00 and therefore it does not receive the "Treat Credit" designation.) The total runoff volume treated is 70%.

Note that Porous Pavement 1 facility's "Used for Treatment" box was left unchecked. If porous pavement is going to be used for water quality treatment then soil mix must be used in the sublayers under the porous pavement layer. See the Ecology 2012 *Stormwater Management Manual for Western Washington* for specific details.

The LID flow duration is automatically calculated.

Recharge

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Recharge is the amount of water that becomes groundwater. Recharge can occur both through land use basins (groundwater component of runoff) and conveyance facilities (infiltration discharge).

Groundwater recharge is not a Department of Ecology stormwater requirement. However, some local jurisdictions (for example, Kitsap County) do have a groundwater recharge requirement. Contact the local permitting agency to determine whether or not recharge analysis is required.

There are three recharge tabs in the Analysis screen: Recharge Duration, Recharge Predeveloped, and Recharge Mitigated.

Before recharge can be calculated for any of the three recharge tabs it needs to be turned on for the elements for which recharge data are needed.

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Recharge must be turned on for each individual element for which recharge calculations are required. This is done by right clicking on the element of interest and then selecting the "Compute Recharge" option.

Once "Compute Recharge" is selected the element will include a small "R" in the element picture.

To compute the total recharge for a scenario then all of the elements should have "Compute Recharge" turned on.

If the scenarios have been run prior to turning on the recharge option then they need to be rerun to generate the recharge data. This is done by clicking on the "Run Scenario" button for each of the two scenarios (Predeveloped and Mitigated).

The "Compute Recharge" box in the Options, Recharge screen must also be checked before recharge is calculated.



Recharge Duration

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	Flow(cfs)	Predev	Mit Percenta	ge Pass/Fail		
a constant a	0.0000	2138880	2138880100	Pass		
1 0.33	0.0045	622200	968057 155	Pass		
	0.0090	302652	808497 267	Pass		
	0.0134	181484	685511 377	Pass		
5 0.22	0.0179	150000	614072 409	Pass		
0	0.0224	136204	544559 399	Pass		
	0.0269	132076	500284 378	Pass		
	0.0313	129402	454298 351	Pass		
	0.0358	127777	423712 331	Pass		
	0.0403	126001	390987 310	Pass		
	0.0448	124568	368315 295	Pass		
0.00	0.0492	122836	344146 280	Pass		
	0.0537	121488	327035 269	Pass		
Percent The Exceeding	0.0582	119884	307785 256	Pass		
	0.0627	118430	293668 247	Pass		
Wetland Fluctuation LL Report Recharge Duration Recharge Predeveloped Recharge Mitigated	0.0671	116697	277841 238	Pass		
Stream Protection Duration LID Duration Flow Frequency Water Quality Hydrograph	0.0716	1151/9	266077 231	Pass		
Analyze datasets	0.0761	11314/	252816 223	Pass		
	0.0850	100207	293191 210	Pass		
1000 PUC 1 Hecharge Predeveloped Duration Bounds	0.0895	107714	232000 212	Page		
10.01 Minimum 2 Maximum	0.0030	106003	216027 203	Dage	- 11	
	0.0985	103586	207086 199	Pass		
🔽 Seasonal Durations (mm/dd)	0.1029	101661	200156 196	Pass		
	0.1074	99522	191943 192	Pass		
Start Date	0.1119	97939	185740 189	Pass		
	0.1164	95972	178233 185	Pass		
All Datasets Flow Stage Precip E p PDC 1 End Date	0.1208	94367	172800 183	Pass		
	0.1253	91908	166490 181	Pass		
Flood Frequency Method	0.1298	89833	161763 180	Pass		
• Log Pearson Type III 178	0.1343	87780	156416 178	Pass		
C Weibull	0.1387	86582	152288 175	Pass		
Clunnane	0.1432	85127	147454 173	Pass	•	
C bringorten	0.1477	83844	143797 171	Pass 🗸		
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Recharge duration is similar to flow duration except that the goal is to have the Mitigated recharge greater than or equal to the Predeveloped recharge, rather than less than or equal to for erosive flows in the flow duration analysis.

The user selects "Recharge Duration" and then the POC 1 tab to compute recharge duration. WWHM2012 selects the appropriate recharge time series (in this example, 1000 and 1006) for the duration comparison. This example passes the recharge duration criteria because all of the Mitigated recharge flows occurs more often than the Predeveloped recharge flows.
Recharge Predeveloped

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Year Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec Total 🔨	DECHDES Elements
1948	POC Number: 1
1949 0.291 6.465 3.718 1.831 1.716 0. 0.168 0.001 0.635 2.695 8.435 10.124 36.08	Monthly Volume: Acre Feet
1950 6.197 8.016 7.885 1.897 0.604 0.865 0.249 0.014 0.03 4.019 12.263 8.917 50.96	
1951 7.79 7.445 8.911 0.642 0.868 0.267 0. 0.006 0.186 6.336 7.196 8.919 48.57	Year Predeveloped Mitigated Pass/Fail
1952 4.506 3.729 5.395 1.05 1.011 0.334 0.192 0.013 0. 0.013 0.065 1.908 18.22	1948 1.2592 5.8932 Pass
1953 11.097 4.114 3.217 3.635 1.271 2.343 0.312 0.065 0.134 2.814 11.145 7.704 47.85	1949 36.0782 96.2944 Pass
1954 14.513 5.913 2.455 3.187 2.431 3.682 1.427 1.506 1.82 0.964 10.613 12.135 60.65	1950 50.9552 123.4625 Pass
<u>1955</u> 7,155 6,216 2,556 5,014 3,16 1,887 1,486 0, 0,014 4,156 11,993 16,163 59,80	1951 48.5678 106.6281 Pass
1956 11.148 6.466 6.362 0.471 1.258 4.378 0. 0.005 0.177 5.317 4.138 5.277 45.00	1952 18.2165 44.9158 Pass
1957 5.353 8.171 7.004 1.93 0.951 0.769 0.186 0.018 0.008 0.465 2.674 9.124 36.65	1953 47.8500 116.9555 Pass
1958 7.85 9.969 2.822 3.737 1.082 0.856 0. 0. 0.001 0.666 7.46 8.977 43.42	1954 60.6469 159.7686 Pass
1959 11.28 6.366 5.151 1.609 2.858 1.016 0.454 0.166 0.645 3.831 7.71 8.615 49.70	1955 59.7999 135.6410 Pass
1960 6.886 4.776 1.471 2.162 2.213 1.295 0. 0.678 0.311 2.166 10.673 4.171 36.80	1956 44.9967 102.3868 Pass
1961 5.819 8.966 4.886 3.094 3.181 0. 1.009 0.019 0.002 1.007 3.109 9.499 40.59	1957 36.6527 91.3533 Pass
1962 5.813 2.511 5.293 1.463 3.414 2.201 0.255 0.456 0.246 0.786 7.983 4.515 34.94	1958 43.4194 104.6910 Pass
1963 2.371 4.619 3.566 4.207 0.876 1.835 0.543 0.143 0.071 1.151 9.314 8.236 38.59	1959 49.7015 122.3809 Pass
1964 8.878 4.677 6.258 4.123 1.374 3.706 0.25 1.104 1.558 0.885 7.055 9.33 49.78	1960 36.8001 97.2165 Pass
	1961 40.5894 96.5042 Pass
Wetland Fluctuation LID Report Recharge Dura on Recharge Predeveloped Rectarge Mitigated	1962 34.9449 88.4408 Pass —
Stream Protection Duration LID Duration Flow water Durit Hydrograph	1963 36.9318 87.9046 Pass
Analyze datasets	1964 49.7814 110.1629 Pass
	1965 36.9516 93.5562 Pass
1000 POC 1 Recharge Predeveloped Duration Bounds	1966 46.5673 109.0889 Pass
1005 POC1 Recharge Mitigated 0.01 Minimum 2 Maximum	1967 44.5672 106.0552 Pass
	1960 52.3750 122.4627 Pass
Seasonal Durations (mm/dd)	1909 41.4109 101.2211 Pass
	1971 52 5252 133 5778 Dage
	1972 49 6914 124 4184 Page
' Start Date	1973 39 3254 101 6315 Dage
All Datacete Flow Stage Precip Evan BOC 1 End Date	1974 44,6135 118,2250 Pass
	1975 61.3886 133.1995 Pass
Flood Frequency Method	1976 25.8085 84.7999 Pass
Log Pearson Type III 17B	1977 33.5494 102.2324 Pass
O Weibull	1978 30.9572 94.9951 Pass
C Cunnane	1979 31.8442 88.7043 Pass
🔿 Gringorten	1980 35.0495 96.8301 Pass
	×
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The "Recharge Predeveloped" tab shows a monthly summary of the Predevelopment recharge (in acre-feet) for each simulation year on a calendar-year basis.

The table at the right provides a comparison of the Predeveloped and Mitigated recharge for each calendar year. "Pass" means that the Mitigated recharge is greater than or equal to the Predeveloped recharge.

Recharge Mitigated

WWHM2012 Clear Creek 1	
File Edit View Help Summary Report	
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🚨 Analysis	
👝 Year Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec Total ٨	RECHRES Elements
1948 5.893 0. 0. 5.89	POC Number: 1
1949 1.574 16.3 6.769 3.809 4.947 0.219 4.425 0.581 8.036 10.121 18.649 20.865 96.29	Monthly Volume: Acre Feet
1950 15.254 19.075 17.641 4.805 1.227 2.688 1.543 0.923 2.16 16.734 23.474 17.938 123.46	
1951 17.133 12.569 15.721 1.04 4.124 0.753 0. 1.122 5.764 19.053 15.168 14.182 106.63	Year Predeveloped Mitigated Pass/Fail
<u>1952</u> 6.463 5.083 11.727 2.146 2.747 1.148 1.476 1.053 0.109 1.673 1.667 9.623 44.92	1948 1.2592 5.8932 Pass
1953 24.122 9.198 5.694 8.489 3.258 6.893 1.065 1.649 3.808 13.24 22.948 16.593 116.96	1949 36.0782 96.2944 Pass
1954 28.973 15.567 7.088 6.843 6.686 11.684 4.271 6.144 6.529 3.307 24.033 38.644 159.77	1950 50.9552 123.4625 Pass
1955 18,212 16,957 5,323 12,093 6,217 4,989 3,397 0,007 0,666 14,867 18,728 34,185 135,64	1951 48.5678 106.6281 Pass
1956 24.784 12.513 8.847 1.451 1.651 11.082 1.033 0.659 5.927 17.137 7.877 10.387 102.39	1952 18.2165 44.9158 Pass
1957 8.908 19.104 15.835 4.986 2.746 1.748 1.467 0.614 1.144 6.972 9.501 18.328 91.35	1953 47.8500 116.9555 Pass
1358 15.643 23.667 13.932 8.733 5.174 2.672 0.013 0.028 0.778 8.981 7.532 15.078 104.63	1954 60.6469 159.7686 Pass
1353 26.325 12.233 12.275 4.35 7.227 3.736 2.421 2.106 5.405 12.755 15.547 17.155 122.38	1955 59.7999 135.6410 Pass
1360 13.417 3.733 4.32 4.37 6.030 2.344 0. 7.637 1.606 11.210 26.723 6.476 37.22	1956 44.9967 102.3868 Pass
1361 10.6361 21.761 10.173 3.67 6.6660 0.167 4.174 1.565 0.7 10.434 7.163 16.603 36.30 1622 11.211 4.246 9.007 2.010 10176 0.0071 2.000 4.000 4.000 4.001 20.710 7.000 90.44	1957 36.6527 91.3533 Pass
1002 11.211 4.240 3.307 3.013 0.131 0.170 0.002 3.030 4.000 4.301 20.710 7.000 00.44 1002 2.01 10.720 7.940 7.764 1.717 4.400 2.075 1.940 1.010 1.010 10.001 7.707 0.790	1958 43.4194 104.6910 Pass
1303 3.01 10.733 7.043 7.704 1.777 4.460 2.073 1.342 1.612 3.102 13.063 17.373 07.30 1064 20131 2057 15.299 9.999 2.473 7.97 0.713 4.029 6.693 2.049 14.214 16.559 110.16	1959 49.7015 122.3809 Pass
	1960 36.8001 97.2165 Pass
	1961 40.5894 96.5042 Pass
Wetland Fluctuation LID Report Recharge Duration Recharge Pred veloped Recharge Mitigated	15 2 34.9449 88.4408 Pass
Stream Protection Duration LID Duration Flow Frequency Water Bud Hudrograph	1064 40 7014 110 1620 Pass
Analyze datasets	1965 26 0516 02 5562 Page
Total Provider Development	1966 46 5673 109 0889 Page
1000 POL 1 Hecharge Predeveloped Duration Bounds	1967 44 5672 106 0552 Page
10.01 Minimum j2 Maximum	1968 52,3758 122,4627 Pass
	1969 41,4109 101,2211 Pass
E Seasonal Durations (mm/dd)	1970 40.7833 101.1905 Pass
	1971 52.5252 133.5778 Pass
Start Date	1972 49.6914 124.4184 Pass
	1973 39.3254 101.6315 Pass
All Datasets Flow Stage Precip Evap POC 1 End Date	1974 44.6135 118.2250 Pass
	1975 61.3886 133.1995 Pass
Flood Frequency Method	1976 25.8085 84.7999 Pass
 Log Pearson Type III 178 	1977 33.5494 102.2324 Pass
C Weibull	1978 30.9572 94.9951 Pass
C Lunnane	1979 31.8442 88.7043 Pass
🗇 Gringorten	1980 35.0495 96.8301 Pass 🗸
	10 10 10 10 10 10 10 10 10 10 10 10 10 1
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The "Recharge Mitigated" tab shows a monthly summary of the Mitigated recharge (in acre-feet) for each simulation year on a calendar-year basis.

The table at the right provides a comparison of the Predeveloped and Mitigated recharge for each calendar year. "Pass" means that the Mitigated recharge is greater than or equal to the Predeveloped recharge.

REPORTS SCREEN

SWWHM2012 Clear Creek 1	
File Edit View Zoom Help	
	2 0 0 0 0
Schematic	🗙 🕅 Trapezoidal Pond 1 Mitigated
SCENARIOS	Facility Name Trapezoidal Pond 1 Facility Type Trapezoidal Pond
Predeveloped	Outlet 1 Outlet 2 Outlet 3
Run Scenario	Facility Dimensions
Basic Elements	Facility Bottom Elevation (ft)
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	on rinal text based report. Report opens in Wordpad.
Pro Elements	Formatted report with charts in pdf format. Report opens in pdf viewer.
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Click on the Reports tool bar button (fourth from the left) to generate a project report.

The project report is a separate file that contains all of the user-provided input and a summary of the model output. The project report file can be saved or printed.

The user has the option of producing the report file in a number of different formats.

Click on "Text Report" button to generate the report file in WordPad RTF format.

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WHEM2012 PROJECT REPORT		
WHEN212 PROJECT REPORT Project Name: Clear Creek 1 Site Name: Clear Creek 1 Site Name: Clear Creek 1 Site Address: City : Report Date: 10/10/2012 Gage : Everett Data End: 2009/09/00:00 Precip Scale: 1.20 Version : 2012/10/09 Low Flow Threshold for POC 1: 50 Percent of the 2 Year High Flow Threshold for POC 1: 50 year PREDEVELOPED LAND USE Name : Basin 1 Eypass: No GroundWater: No Pervious Total 10 Impervious Land Use Acres		
WHER2012 PROJECT REPORT Project Name: Clear Creek 1 Site Address: City : Report Data Start : 1949/10/01 00:00 Data End : 2009/09/30 00:00 Precip Scale: 1.20 Version : 2012/10/09 Low Flow Threshold for POC 1 : 50 Percent of the 2 Year High Flow Threshold for POC 1 : 50 Percent of the 2 Year PREDEVELOPED LAND USE Name : Basin 1 Bypass: No GroundWater: No Pervious Land Use Acres Pervious Total 10 Impervious Land Use Acres	E	~
PROJECT REPORT Project Name: Clear Creek 1 Site Name: Clear Creek 1 Site Address: City : Report Date: 10/0/2012 Gage : Everett Data Start : 1948/10/01 00:00 Data End: 2009/09/30 00:00 Precip Scale: 1.20 Version : 2012/10/09 Iow Flow Threshold for POC 1 : 50 Percent of the 2 Year High Flow Threshold for POC 1: 50 year PREDEVELOPED LAND USE Name : Basin 1 Eypass: No GroundWater: No Pervious Land Use C. Forest, Flat 10 Impervious Land Use Acres	WWHM2012	
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Project Name: Clear Creek 1 Site Name: Clear Creek 1 Site Address: City : Report Date: 10/10/2012 Gage : Everet Data Start : 1948/10/01 00:00 Data End : 2009/09/30 00:00 Precip Scale: 1.20 Version : 2012/10/09 		
Site Name: Clear Creek 1 Site Address: City : Report Date: 10/10/2012 Gage : Everett Data Start : 1948/10/01 00:00 Data End: 1.209 /099/30 00:00 Precip Scale: 1.20 Version : 2012/10/09 Low Flow Threshold for POC 1 : 50 Percent of the 2 Year High Flow Threshold for POC 1 : 50 Percent of the 2 Year PREDEVELOPED LAND USE Name : Basin 1 Bypass: No GroundWater: No Pervious Ind Use Acres Low Flow Threshold Joe Acres	Project Name: Clear Creek 1	
Site Address: City : Report Date: 10/10/2012 Gage : Everet Data Start : 1948/10/01 00:00 Date End : 2009/09/30 00:00 Precip Scale: 1.20 Version : 2012/10/09 Low Flow Threshold for POC 1 : 50 Percent of the 2 Year High Flow Threshold for POC 1: 50 year PREDEVELOPED LAND USE Name : Basin 1 Bypass: No GroundWater: No <u>Pervious Land Use Acres</u> 10 Impervious Land Use Acres	Site Name: Clear Creek 1	
City : Report Date: 10/10/2012 Gage : Everett Data Start : 1948/10/01 00:00 Data End : 2009/09/30 00:00 Precip Scale: 1.20 Version : 2012/10/09 Low Flow Threshold for POC 1 : 50 Percent of the 2 Year High Flow Threshold for POC 1 : 50 year PREDEVELOPED LAND USE Name : Basin 1 Bypass: No GroundWater: No Pervious Land Use <u>Acres</u> C. Forest, Flat 10 Pervious Total 10 Impervious Land Use <u>Acres</u>	Site Address:	
Report Date: 10/10/2012 Gage : Everett Data Start : 1948/10/01 00:00 Precip Scale: 1.20 Version : 2012/10/09	City :	
Data Start : 1949/10/01 00:00 Data End : 2009/09/30 00:00 Precip Scale: 1.20 Version : 2012/10/09 Low Flow Threshold for POC 1 : 50 Percent of the 2 Year High Flow Threshold for POC 1: 50 year PREDEVELOPED LAND USE Name : Basin 1 Bypass: No GroundWater: No Pervious Land Use Acres Descriptions Land Use Acres	Report Date: 10/10/2012	
Data End : 2005/09/30 00:00 Precip Scale: 1.20 Version : 2012/10/09 Low Flow Threshold for POC 1 : 50 Percent of the 2 Year High Flow Threshold for POC 1: 50 year PREDEVELOPED LAND USE Name : Basin 1 Bypass: No GroundWater: No <u>Pervious Land Use Acres</u> C, Forest, Flat 10 Pervious Total 10 Impervious Land Use Acres	Dage : EVELEUL Data Start - 1948/10/01 00-00	
Precip Scale: 1.20 Version : 2012/10/09 Low Flow Threshold for POC 1 : 50 Percent of the 2 Year High Flow Threshold for POC 1: 50 year PREDEVELOPED LAND USE Name : Basin 1 Bypass: No GroundWater: No Pervious Land Use <u>Acres</u> C, Forest, Flat <u>10</u> Pervious Total 10 Impervious Land Use Acres	Data End : 2009/09/30 00:00	
Version : 2012/10/09 Low Flow Threshold for POC 1 : 50 Percent of the 2 Year High Flow Threshold for POC 1: 50 year PREDEVELOPED LAND USE Name : Basin 1 Bypass: No GroundWater: No <u>Pervious Land Use Acres</u> 10 Impervious Land Use Acres	Precip Scale: 1.20	
Low Flow Threshold for FOC 1 : 50 Percent of the 2 Year High Flow Threshold for FOC 1: 50 year PREDEVELOPED LAND USE Name : Basin 1 Bypass: No GroundWater: No Pervious Land Use Acres C, Forest, Flat 10 Pervious Total 10 Impervious Land Use Acres	Version : 2012/10/09	
Low Flow Threshold for FOC 1 : 50 Percent of the 2 Year High Flow Threshold for FOC 1: 50 year PREDEVELOPED LAND USE Name : Basin 1 Bypass: No GroundWater: No Pervious Land Use Acres C, Forest, Flat 10 Pervious Total 10 Impervious Land Use Acres		
PREDEVELOPED LAND USE Name : Basin 1 Bypass: No GroundWater: No Pervious Land Use Acres C, Forest, Flat 10 Pervious Total 10 Impervious Land Use Acres	Low Flow Threshold for POC 1 : 50 Percent of the 2 Year High Flow Threshold for POC 1: 50 year	
PREDEVELOPED LAND USE Name : Basin 1 Bypass: No GroundWater: No Pervious Land Use Acres C, Forest, Flat 10 Pervious Total 10 Impervious Land Use Acres		
Name : Basin 1 Bypass: No GroundWater: No <u>Pervious Land Use Acres</u> C, Forest, Flat 10 Pervious Total 10 Impervious Land Use Acres	PREDEVELOPED LAND USE	
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Scroll down the WordPad screen to see all of the results.



Click on "PDF Report" button to generate the report file in PDF format.



Scroll down the PDF screen to see all of the results or select specific sections using the bookmarks at the left.



Click on "Landuse Report" button to generate a listing of the input basin land use data in WordPad RTF format.



Click on "Parameter Report" button to generate a listing of the HSPF input parameter values that have been changed from their default values. The listing is in WordPad RTF format. If the listing is blank then there have been no HSPF input parameter value changes made.

TOOLS SCREEN

🚭 WWHM2012 Clear Creek 1		BX
<u>Eile E</u> dit <u>V</u> iew <u>H</u> elp <u>S</u> ummary Report		
	2 0 0 0	
SCENARIOS	Trapezoidal Pond 1 Mitigated	~
	Facility Name Trapezoidal Pond 1 Facility Type Trapezoidal Pond	
	Outlet 1 Outlet 2 Outlet 3	
	Downstream Connections 0 0 0	
Run Scenario	Precipitation Applied to Facility Auto Pond Quick Pond	
Basic Elements	Evaporation Applied to Facility Facility Dimension Diagram	
Tools		
	ont Features	
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Save x.y Load x.y	Tide Gate Elevation (ft) 0 Downstream Connection	
	Overflow Elevation (ft)	
Mon 9:11a - Clear Creek 1 - Finish Mitigated		~
	10/1/2012 9:32 AM	

The Tools screen is accessed with the Tools tool bar (second from the right). The purposes of the Tools screen are:

(1) To allow users to import HSPF PERLND from existing HSPF UCI files and/or view and edit WWHM2012 PERLND parameter values.

- (2) To allow users to use alternate precipitation time series data.
- (3) To allow users to import or export time series datasets.
- (4) To allow users to do HSPF WDM maintenance tasks, as needed.

Import Parameters



Import Parameters allows the user to import the HSPF parameter values from an HSPF UCI (User Control Input) file that has been created outside of WWHM2012. This UCI file must have a file name with an UCI or INP extension.

Predeveloped

WWHM2012 Clear Creek 1							- - X
File Edit View Help Summary Report							
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SCENARIOS	<u> 6</u>	i Trapezoidal		ated			
Predeveloped	Fa	acility Name	Trapezoidal Po	nd 1	Facility Type Tra	pezoidal Pond	
Militated		6		Outlet 1	Outlet 2	Outlet 3	
Bun Secondia		Description Ass	Connections	U			
Basic Elemente		Frecipitation App	lied to Facility		Auto Pond	Quick Ponc	
	Maria and a state	e vaporation App	nico to racinty		r dointy onin		_
	TOOIS						
	Standard Import Fe	atures					
	HSPF Input File Imp	port/Export Per	inds From:				
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Pro Elements	Predevelop	ped		Section 200			
			port Input (.UCI) file.			<u> </u>
			Look in:	projects		- + E	
	VIEW/EDIT PE	ERLNDS		LID.udi	POCpre	edefault1.uci	PreTest1.uci
	VIEW/EDIT IM	1PLNDS	My Recent	Mitclear Creek	POCpre	edefault[0]1.uci eSnohomish 11.uci	temppeaksClear Creel
	ALTERNATE F	PRECIP	Documents	Mitdefault[0].u	ici POCpre	eTest11.uci	temppeaksdefault.uci
	EXPORT DAT	TASET		MitLID Compar	1.uci POCSn	ohomish 11.uci	temppeaksSnohomish
Commercial Toolbox	IMPORT DAT	TASET	Desktop	MitSnohomish	1.uci POCTe	st11.uci	temppeaksTest1.uci
	WDM Mainte	enance		MitTest1.uci	PreClea	ar Creek 1.uci	emppeaks lest2.uci
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		Overflow Elev	My Network	Files of type:	INPUT FILES(*.uci;*.inp)		Cancel
			Places		C Open as read-only		
Mon 9:11a - Clear Creek 1 - Finish Mitigated	•						A
						10/1/2012	3:16 PM

Predeveloped allows the user to import an entire HSPF UCI (User Control Input) file that has been created outside of WWHM2012. This UCI file is input to the Predeveloped scenario. All HSPF RCHRES are translated into SSD Table elements.

This UCI file must have a file name with an UCI or INP extension.

View/Edit PERLNDS



View/Edit PERLNDS allows the user to view and edit the HSPF PERLND Block values used in WWHM2012. Any changes to these values should be approved by the reviewing/permitting agency. All changes will be reported in the Parameter Report file created in the Reports menu.

View/Edit IMPLNDS

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File Edit View Help SummaryReport						
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SCENARIOS	🔺 🗟 Trapezoidal Pond 1 Mitigated 🛛 🗙					
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	ROADS/STEEP 1 1 1 27 0 0 0 1 0 0 0 0 0					
	ROOF TOPS/FLAT 1 1 1 27 0 0 0 1 0 0 0 0 0					
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	DRIVEWAYS/MOD 1 1 1 27 0 0 0 1 0 0 0 0 0					
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	SIDEWALKS/STEEP 1 1 1 2/ 0 0 0 1 0 0 0 0 0 0					
Move Elements	PARKING//CAUCH 1 1 1 1 27 0 0 0 1 0 0 0 0 0					
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Save xy Load xy						
	Duplicate Save CLOSE					
Mon 9:11a - Clear Creek 1 - Finish Mitigated						
P	10/1/2012 3:25 PM					

View/Edit IMPLNDS allows the user to view and edit the HSPF IMPLND Block values used in WWHM2012. Any changes to these values should be approved by the reviewing/permitting agency. All changes will be reported in the Parameter Report file created in the Reports menu.

Alternate Precip



Alternate Precip allows the user to replace the default precipitation time series data file and/or evaporation (potential evapotranspiration) time series data file with a different file created and stored in a separate HSPF WDM file.

Click on "Load WDM" to select the HSPF WDM file that contains the appropriate alternate precipitation and/or evaporation file. Select the alternate file and whether the file is to be copied to Precip or Evap. If needed, the model simulation run start and/or end dates can be changed to match the start and end dates of the alternate files. Check the "Use Alternate Precip/Evap" box and then click on the "Import" button to import the data.

Once the new data are imported it is always a good idea to plot the new data using Analysis, Hydrograph to double check that the data were imported successfully.

Any changes to either the precipitation or evaporation data should be approved by the reviewing/permitting agency.

Export Dataset

WWHM2012 Clear Creek 1	- 7 🗙
File Edit View Help Summary Report	
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SCENARIOS	^
SCENARIOS Tools Facility Type Trapezoidal Pond Wingsted Standard import Features Itel 1 Outlet 2 Outlet 3 HSPF Inport File Import/Export Hord Existing Input File Perinds From: Auto Pond Outlet 13 Basic Elements Predeveloped VietW/EDIT FERLINDS Select Datasets Predeveloped from: Select Datasets VietW/EDIT FERLINDS Select Datasets Predeveloped from: Select Datasets Predeveloped from: Predeveloped from: Prof. Datasets VietW/EDIT FERLINDS Select Datasets Predeveloped from: Predeveloped from: Prof. Datasets VietW/EDIT Metunds Filts 100 Prof. Datasets Predeveloped from: Predeveloped from: Prof. Datasets VietW/EDIT Metunds Filts 100 Prof. Predeveloped from: Predeveloped from: Prof. Datasets Prof. Datasets VietW/EDIT Metunds Filts 100 Prof. Predeveloped from: Prof. Datasets Prof. Datasets Prof. Datasets VietW/EDIT Metunds Filts 100 Prof. Predeveloped from: Filts 100 Prof. Predeveloped from: Prof. Diameter Height er (in) (th) ILD Toobox Filts 100 Prof. Predeveloped from: Filts 100 Prof. Predeveloped from: Fil	
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10/1/2012 3:45 PM	6

Export Dataset allows the user to export any time series data stored in the WWHM2012 WDM file. This includes precipitation, evaporation, flow, and stage data time series.

Start and end dates can be selected along with the time step and the output option if the time step is greater than the simulation time step. Data can be summed, averaged, or the maximum or minimum selected.

Click on the "Export" button to output the data to a text file for future viewing.

Import Dataset

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Import Dataset allows the user to import any time series data stored in an external text file or Excel comma-delimited file into the WWHM2012 WDM file. This includes precipitation, evaporation, flow, and stage data time series.

The Constituent (data type), Start Date, End Date, and Timestep all must be specified. A WDM data set number between 1 and 9999 must be assigned to the time series file. This data set number should be unique and not in current use in the WDM file. A description of the data set is optional, but highly recommended.

Missing values must be filled in with some appropriate value. This can be -1 to identify them as missing values or zero or some other number.

Click on the "Import" button to input the data to the WWHM2012 WDM file.

Once the new data are imported it is always a good idea to plot the new data using Analysis, Hydrograph to double check that the data were imported successfully.

WDM Maintenance



WDM Maintenance allows the user to make changes to the WWHM2012 WDM file data sets and copy time series data files from one WDM to another.

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 Notch Type
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Western Washington Hydrology Model 2012 User Manual

Selection of a data set time series produces the user with a large range of options, similar to those options available in the EPA HSPF utility program WDMUtil.

LID ANALYSIS SCREEN



The LID tool bar button (farthest on the right) brings up the LID Analysis screen and gives the user two LID Analysis options:

- 1. LID Scenario Generator
- 2. LID Report DOE

LID Scenario Generator



The LID scenario generator can be used to compare the amount of runoff from different land types and combinations. The user can quickly see how changing the land use affects surface runoff, interflow, groundwater, and evapotranspiration.

The LID scenario generator runoff from different land types and combinations for the Mitigated scenario only.

🔂 WWHM2012 <u>File Edit View</u> Zoom Help 2 0 0 0 0 0 🛩 🖬 🧉 👗 🖻 🛍 🍯 💕 🖬 🗾 🖄 🎰 🗖 🔀 🕷 Trapezoidal Pond 1 Mitigate Schematic SCENARIOS Facility Name Trapezoidal Pond 1 Facility Type Trapezoidal Pond Outlet 1 Outlet 2 Outlet 3 🗱 🗖 Predeveloped Downstream Connections 0 0 0 📆 🗹 Mitigated Precipitation Applied to Facility Auto Pond Quick Pond Evaporation Applied to Facility Facility Dimension Diagram Run Scenario **Facility Dimensions** Outlet Structure Data Basic Elements Facility Bottom Elevation (ft) Riser Height (ft) Bottom Length (ft) 200 Riser Diameter (in) 24 1 -2 111 Bottom Width (ft) 200 Riser Type Notched Effective Depth (ft) Notch Type Rectangular + Notch Height (ft) 2 + Left Side Slope (H/V) Notch Height (ft) 2 Bottom Side Slope (H/V) Notch Width (ft) 2 $\mathbf{\nabla}$ Right Side Slope (H/V) Top Side Slope (H/V) Orifice Diameter Height Number (in) (ft) 1 3 + 0 Pro Elements A3 YES ÷ Infiltration 6000 Measured Infiltration Rate (in/hr) 0.25 ÷ Reduction Factor(infilt*factor) 2 0 Use Wetted Surface Area (sidewalls) NO 3 0 LID Toolbox Total Volume Infiltrated (ac-ft) 13969.143 984.901 Total Volume Through Riser (ac-ft) Pond Volume at Riser Head (ac-ft) 6.646 Total Volume Through Facility (ac-ft) 14954.05 Show Pond Table Open Table 93.41 Percent Infiltrated Initial Stage (ft) Commercial Toolbox Size Infiltration Pond Target %: 100 🕂 Tide Gate | Time Series | Demand | Move Elements Determine Outlet With Tide Gate Use Tide Gate Tide Gate Elevation (ft) 0 Downstream Connection -Overflow Elevation (ft) 0 Iterations 0 Save x,y Load x,y × 30 × 36 # 9/27/2012 4:12 PM

Western Washington Hydrology Model 2012 User Manual

The easiest way to compare different land use scenarios is to place all of them on the same Schematic Editor screen grid. Each basin can then represent a different land use scenario.

For this example the three basins are assigned the following land uses: Basin 1: 100 acres C, Forest, Flat Basin 2: 100 acres C, Lawn, Flat Basin 3: 50 acres C, Lawn, Flat; 50 acres Parking Flat

Basin 3 is connected to a pond that includes infiltration.

Basin 1 is assigned to POC 1 for the LID analysis; Basin 2 to POC 2; and the surface discharge from the Basin 3 pond to POC 3.



Click on the Compute LID Base Data button to generate the LID analysis data and summarize the surface runoff, interflow, groundwater, precipitation, evaporation, and total runoff for all of the basins. The results will be shown for each basin in terms of its POC.



For the pervious portion of Basin 3 (50 acres of C, Lawn, Flat) the distribution of the precipitation is:

Surface runoff = 0.513 inches per year Interflow = 20.482 inches per year Groundwater = 7.950 inches per year Evaporation = 16.417 inches per year

This is from a drainage area with an average annual precipitation of 45.411 inches.

For the impervious portion of Basin 3 (50 acres of Parking, Flat) the distribution of the precipitation is:

Surface runoff = 37.832 inches per year Evaporation = 7.576 inches per year

There is no interflow or groundwater from impervious areas.

To look at the other basins click on the "POC To Analyze" arrow and select the basin of interest.

The LID analysis results can be presented in terms of either inches per year or acre-feet per year by checking the appropriate box in the lower right portion of the LID analysis screen.

To compare the different scenarios side-by-side in a graphical format click on the "Water Balance Chart" button.



The water balance chart graphically displays the runoff distribution for all three land use scenarios side-by-side.

The bottom red is the surface runoff. Above in yellow is interflow; then green for groundwater and blue for evaporation.

Basin 1 (Scenario 1) is all forest and produces the least amount of surface runoff and interflow (the sum of surface and interflow is the total stormwater runoff). Basin 2 is all lawn; it produces more surface runoff and interflow than Basin 1. Basin 3 is 50% lawn and 50% impervious and produces the largest amount of surface runoff and interflow and the smallest amount of groundwater and evaporation.

A maximum of seven scenarios can be graphed at one time.

LID Report DOE



The "LID Report DOE" option has been created to determine if the modeled LID facilities meet Washington State Department of Ecology (DOE) requirements for low impact development.

Clicking on the "LID Report DOE" tab produces the LID Report that lists all of the LID facilities in the Mitigated scenario and their performance.

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Western Washington Hydrology Model 2012 User Manual

The column "Total Volume Needs Treatment (ac-ft)" is volume that equals 91% of the total runoff volume through the facility for the entire model simulation period.

The column "Volume Through Facility (ac-ft)" is the actual total runoff volume through the facility for the entire model simulation period.

"Infiltration Volume (ac-ft)" is the actual total runoff volume that is infiltrated for the entire model simulation period. In the case of the sand filter the infiltration volume is actually the volume that is filtered and then continues downstream to the next stormwater facility.

"Percent Volume Infiltrated" is the percentage of the "Infiltration Volume" column volume to the "Volume Through Facility" column volume.

"Water Quality" is the actual total runoff volume that is filtered through the soil column. This is not necessarily the same as the infiltration volume. For this example, the bioretention facility has more water quality volume than infiltration volume. This is because some of the flow through the bioretention amended soil layers was then discharged via an underdrain to the next downstream facility (in this case, a stormwater pond with infiltration).

"Percent Water Quality Treated" is the percentage of the "Water Quality" column volume to the "Volume Through Facility" column volume.

The Comment column reports "Treat Credit" if the LID facility water quality treatment meets Ecology's water quality treatment standard of treating at least 91% of the total runoff volume through the facility. In this example only the bioretention and pond meet the treatment standard.

If a facility is used for water quality treatment then the corresponding box in the "Used for Treatment" column should be checked.

In this example the "Used for Treatment" boxes for the trapezoidal pond, sand filter, and bioretention swale are checked. The percent water quality treated values are 94.72, 90.00, and 94.94, respectively. The total runoff volume treated is 70%.

Note that Porous Pavement 1 facility's "Used for Treatment" box was left unchecked. If porous pavement is going to be used for water quality treatment then soil mix must be used in the sublayers under the porous pavement layer. See the Ecology 2012 *Stormwater Management Manual for Western Washington* for specific details.

The LID flow duration is automatically calculated.

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OPTIONS



Options can be accessed by going to View, Options. This will bring up the Options screen and the ability to modify the duration standards, scaling factors, and simulation model time step, and the recharge options.

Duration Criteria



The Washington State Department of Ecology's flow control standard is based on flow duration. The duration criteria are:

- 1. If the post-development flow duration values exceed any of the predevelopment flow levels between 50% and 100% of the two-year predevelopment peak flow values (100 Percent Threshold) then the flow control standard requirement has not been met.
- 2. If the post-development flow duration values exceed any of the predevelopment flow levels between 100% of the two-year and 100% of the 50-year predevelopment peak flow values more than 10 percent of the time (110 Percent Threshold) then the flow control standard has not been met.
- 3. If more than 50 percent of the flow duration levels exceed the 100 percent threshold then the flow control standard has not been met.

The duration criteria in the WWHM2012 can be modified by the user if appropriate and the permitting/reviewing agency allows.

The user can conduct the duration analysis using either (1) durations based on Predeveloped flow frequency, or (2) durations based on user defined flow values.

If using durations based on Predeveloped flow frequency the percent of the lower limit can be changed from the default of the 2-year flow event to a higher or lower percent value. The lower and upper flow frequency limits (2-year and 50-year) also can be changed.

If using durations based on user defined flow values click on that option and input the lower and upper flow values.

The default pass/fail threshold is 110%. This value can be changed by the user.

The duration standards can be changed for each individual point of compliance. Click on the Update button once all of the changes have been made. To return to the default values click on the Restore Defaults button.

Any change(s) to the default duration standards must be approved by the reviewing/ permitting agencies.

Scaling Factors



The user can change the scaling factors for precipitation (minimum and maximum) and pan evaporation. Neither should be changed without agency approval.

The water quality volume percentage is set to 91% of the total runoff volume. If allowed, this percent value can be changed by the user.

Click on the Update button once all of the changes have been made. To return to the default values click on the Restore Defaults button.

Time Step

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The default HSPF model simulation time step for all counties is 15 minutes. (The City of Seattle model time step is 5 minutes.)

The model simulation time step can be changed from the default value if approved by the reviewing/permitting agencies.

Note that changing the time step will change the model simulation results.

Recharge



Recharge is the amount of water that becomes groundwater. Recharge can occur both through land use basins (groundwater component of runoff) and conveyance facilities (infiltration discharge).

Recharge is only calculated by WWHM2012 if the "Compute Recharge" box is checked. The recharge boxes for the individual elements must also be checked for those elements for which recharge will be calculated. This can be done by either selecting the appropriate elements from the list on the Options, Recharge screen or by individually right clicking on the elements and selecting "Compute Recharge" from the pulldown menu. See Analysis, Recharge for more details.

If the scenarios have been run prior to turning on the recharge option then they need to be rerun to generate the recharge data. This is done by clicking on the "Run Scenario" button for each of the two scenarios (Predeveloped and Mitigated).

APPENDIX A: BIORETENTION MODELING METHODOLOGY

Water Movement Through The Soil Column

Water movement through the soil column is dependent on soil layer characteristics and saturation rates for different discharge conditions.

Consider a simple two-layered bioretention facility designed with two soil layers with different characteristics. As water enters the facility at the top, it infiltrates into the soil based on the modified Green Ampt equation (Equation 1). The water then moves through the top soil layer at the computed rate, determined by Darcy's and Van Genuchten's equations. As the soil approaches field capacity (i.e., gravity head is greater than matric head), we can determine when water will begin to infiltrate into the second layer (lower layer) of the soil column. This occurs when the matric head is less than the gravity head in the first layer (top layer).

Since the two layers have different soil characteristics, water will move through the two layers at different rates. Once both layers have achieved field capacity then the layer that first becomes saturated is determined by which layer is more restrictive. This is determined by using Darcy's equation to compute flux for each layer at the current level of saturation. The layer with the more restrictive flux is the layer that becomes saturated for that time step. The next time step the same comparison is made.

The rate and location of water discharging from the soil layer is determined by the discharge conditions selected by the user.

There are four possible combinations of discharge conditions:

- 1. There is no discharge from the subsurface layers (except for evapotranspiration). This means that there is no underdrain and there is no infiltration into the native soil. Which this discharge condition is unlikely, we still need to be able to model it.
- 2. There is an underdrain, but no native infiltration. Discharge from the underdrain is computed based on head conditions for the underdrain. The underdrain is configured to have an orifice. (It is possible for the orifice to be the same diameter as the underdrain.) With a maximum of three soil layers determining head conditions for the orifice is complicated. Each modeled layer must overcome matric head before flow through the underdrain can begin. Once matric head is overcome by gravity head for all of the layers then the underdrain begins to flow. The flow rate is determined based on the ability of the water to move through the soil layers and by the discharge from the orifice, whichever is smaller. Head conditions are determined by computing the saturation level of the lowest soil layer first. Once the lowest soil layer is saturated and flow begins then the gravity head is considered to be at the saturation level of the lowest soil layer. Once the lowest soil layer is saturated completely then the head will include the gravity head from the next soil layer above until gravity head from all soil layers is included. Gravity head from ponding on the

surface is included in the orifice calculations only if all of the intervening soil layers are saturated.

- 3. There is native infiltration but no underdrain. Discharge (infiltration) into the native soil is computed based a user entered infiltration rate in units of inches per hour. Specific head conditions are not used in determining infiltration into the native soil. Any impact due to head on the infiltration rate is considered to be part of the determination of the native soil infiltration rate. Because it is possible to have a maximum of three soil layers, each modeled layer must overcome matric head before infiltration to the native soil can begin. Once matric head is overcome by gravity head for all modeled layers then infiltration begins at a maximum rate determined either by the ability of the water to move through the soil layers or by the ability of the water to infiltrate into the native soil, whichever is limiting.
- 4. There is both an underdrain and native infiltration. Underdrain flow and native infiltration are computed as discussed above. However, there is one other limitation to consider. In the case where the flow through the soil layer is less than the sum of the discharge through the underdrain and the native infiltration then the flow through the soil layer becomes the limiting flow and must be divided between the native infiltration and the underdrain. This division is done based on the relative discharge rates of each.

Note that wetted surface area can be included in the discharge calculations by adding the infiltration through the wetted surface area to the lower soil layer and the upper surface layer individually. This is done by computing the portion of the wetted surface area that is part of the upper surface layer and computing the infiltration independently from the portion of the wetted surface area that is part of the wetted surface area that is part of the lower soil layers.

Water Movement Equations

There are several equations used to determine water movement from the surface of the bioretention facility, through the soil layers, and into an underdrain or native infiltration. The water movement process can be divided into three different zones:

- 1) Surface ponding and infiltration into the top soil layer (soil layer 1)
- 2) Percolation through the subsurface layers
- 3) Underdrain flow and native infiltration
Surface ponding and infiltration into the top subsurface layer

The modified Green Ampt equation (Equation 1) controls the infiltration rate into the top soil layer:

$$f = K \left(1 + \frac{(\phi - \theta)(d + \varphi)}{F} \right)$$
 (Equation 1; Ref: Rossman, 2009)

f = soil surface infiltration rate (cm/hr) $\phi = \text{soil porosity of top soil layer}$ $\theta = \text{soil moisture content of top soil layer}$ $\varphi = \text{suction head at the wetting front (cm)}$ F = soil moisture content of the top soil layer (cm) d = surface ponding depth (cm)K = hydraulic conductivity based on saturation of top soil layer (cm/hr)

K (relative hydraulic conductivity) can be computed using the following Van Genuchten approximation equation:

Van Genuchten approximation of relative hydraulic conductivity

$$\frac{K(\theta)}{K_{sat}} = \left(\frac{\theta - \theta_r}{\phi - \theta_r}\right)^{\frac{1}{2}} \left[1 - \left(1 - \left(\frac{\theta - \theta_r}{\phi - \theta_r}\right)^{\frac{1}{m}}\right)^m\right]^2$$
(Equation 2; Ref:
Blum et al, 2001)

where

 $K(\theta)$ = relative hydraulic conductivity, K_{sat} = saturated hydraulic conductivity, θ = water content, θ_{r} = residual water content, ϕ = porosity, α = constant, n = constant, m = constant

A few issues arise when dealing with multiple subsurface soil layers. The K value used in Equation 1 must be computed from the top soil layer. Infiltration into the upper soil layer must not exceed the lesser of the maximum percolation rates for each of the soil layers. Finally, the rate of percolation of the top layer may be reduced because the layer or layers beneath the top layer cannot accept the percolation flux because of existing saturation levels.

Percolation through the subsurface layers

Water storage and movement through the three subsurface layers will be computed using Darcy's equation as shown below:

$$q = -K \frac{\partial h}{\partial z}$$
 (Equation 3)

Where:

q = Darcy flux (cm/hr)

K = hydraulic conductivity of the porous medium (cm/hr)

h = total hydraulic head (cm)

z = elevation (cm)

The total head, *h*, is the sum of the matric head, ψ , and the gravity head, *z*:

$$h = \psi + z$$
 . (Equation 4)

Substituting for *h* yields:

$$q = -K \frac{d(\psi + z)}{dz}$$
 (Equation 5)

Hydraulic conductivity and matric head vary with soil moisture content. These values can be computed by solving the Van Genuchten's equation (Equation 6) for both values. Note that $\psi = 0$ when the soil is saturated.

Van Genuchten Equation to calculate total head

$$h = -\frac{1}{\alpha} \left[\frac{1}{SE^{\frac{1}{m}}} - 1 \right]^{\frac{1}{m}} + z$$
 (Equation 6; Ref:
Blum et al, 2001)

where h = total hydraulic head, $\alpha = \text{constant}$, SE = effective saturation, m = constant, n = constant, and z = elevation head

Effective saturation (SE) can be computed using the following Van Genuchten equation: Van Genuchten Equation to calculate effective saturation

$$\frac{\theta - \theta_r}{\phi - \theta_r} = \left[\frac{1}{1 + (\alpha \psi)^n}\right]^m = SE$$
(Equation 7; Ref:
Blum et al, 2001)

where $\theta = \text{water content}, \theta_r = \text{residual water content},$ $\phi = \text{porosity},$ $\alpha = \text{constant} = y_b - 1,$ $n = \text{constant} = \lambda + 1,$ $m = \text{constant} = 1 - \frac{1}{\lambda + 1},$ $\lambda = \text{pore size distribution index},$ $y_b = \text{bubbling pressure}$ $\psi = \text{pressure head} = h - z, h = \text{total hydraulic head},$ z = elevation head, and SE = effective saturation

Ignoring z (elevation head) results in h = hm (matric head).

Evapotranspiration from the Soil Column

Evapotranspiration is an important component of the bioretention facility's hydrologic processes. Evapotranspiration removes water from bioretention surface ponding and the soil column during non-storm periods. The routine will satisfy potential evapotranspiration (PET) demands in the same sequence as implemented in HSPF:

- 1. Water available from vegetation interception storage
- 2. Water available from surface ponding
- 3. Water available from the bioretention soil layers (top layer first)

Water will be removed from vegetation interception storage and surface ponding and the bioretention soil layers (starting at the top layer) down to the rooting depth at the potential rate. Water is taken from the soil layers below the rooting depth based on a percentage factor to be determined. Without this factor there will be no way to remove water from below the rooting depth once it becomes completely saturated.

References

Blum, V.S., S. Israel, and S.P. Larson. 2001. *Adapting MODFLOW to Simulate Water Movement in the Unsaturated Zone*. MODFLOW 2001 and Other Modeling Odysseys, International Groundwater Modeling Center (IGWMC), Colorado School of Mines, Golden, Colorado, September 11-14, 2001. In MODFLOW 2001 and Other Modeling Odysseys, Proceedings. pp.60-65.

Rossman, L.A. 2009. *Modeling Low Impact Development Alternatives with SWMM*. Presented at CHI International Stormwater and Urban Water Systems Conference, Toronto, Ontario, Canada, February 20, 2009.

APPENDIX B: DEFAULT WWHM2012 HSPF PERVIOUS PARAMETER VALUES (except CLARK COUNTY)

The default WWHM2012 HSPF pervious parameter values are found in the WWHM2012 file defaultpers.uci.

The default WWHM2012 HSPF pervious parameter values for all counties except Clark County are based on the USGS report:

Dinicola, R.S. 1990. Characterization and Simulation of Rainfall-Runoff Relations for Headwater Basins in Western King and Snohomish Counties, Washington. Water-Resources Investigations Report 89-4052. U.S. Geological Survey. Tacoma, WA.

For some parameters the default WWHM2012 HSPF pervious parameter values have been modified from the values listed in the USGS report. These modifications are based on the professional judgment and experience of Clear Creek Solutions staff in modeling Western Washington watersheds with HSPF.

The default WWHM2012 HSPF pervious parameter values for Clark County are based on the report:

Beyerlein, D.C. 2010. *Hydrologic Modeling of Clark County Watersheds with the U.S. EPA Hydrologic Simulation Program – FORTRAN (HSPF) Final Report (Revised).* Clear Creek Solutions, Inc., Mill Creek, WA.

HSPF parameter documentation is found in the document: Bicknell, B.R., J.C. Imhoff, J.L. Kittle Jr, T.H. Jobes, and A.S. Donigian Jr. 2001. *Hydrological Simulation Program – Fortran, User's Manual for Version 12*. AQUA TERRA Consultants. Mountain View, CA.

Table 1. W W HW2012 Pervious Land Types							
PERLND No.	Soil	Vegetation/Surface	Slope				
1	A/B	Forest	Flat				
2	A/B	Forest	Moderate				
3	A/B	Forest	Steep				
4	A/B	Pasture	Flat				
5	A/B	Pasture	Moderate				
6	A/B	Pasture	Steep				
7	A/B	Lawn	Flat				
8	A/B	Lawn	Moderate				
9	A/B	Lawn	Steep				
10	С	Forest	Flat				
11	С	Forest	Moderate				
12	С	Forest	Steep				
13	С	Pasture	Flat				
14	С	Pasture	Moderate				
15	С	Pasture	Steep				
16	С	Lawn	Flat				
17	С	Lawn	Moderate				
18	С	Lawn	Steep				
19	Saturated	Forest	Flat				
20	Saturated	Forest	Moderate				
21	Saturated	Forest	Steep				
22	Saturated	Pasture	Flat				
23	Saturated	Pasture	Moderate				
24	Saturated	Pasture	Steep				
25	Saturated	Lawn	Flat				
26	Saturated	Lawn	Moderate				
27	Saturated	Lawn	Steep				
28	С	Impervious dispersed on Lawn	Flat				
29	С	Impervious dispersed on Lawn	Moderate				
30	С	Impervious dispersed on Lawn	Steep				
31	A/B	Impervious infiltrated on Lawn	Flat				
32	A/B	Impervious infiltrated on Lawn	Moderate				
33	A/B	Impervious infiltrated on Lawn	Steep				
34	Saturated	Impervious dispersed on Lawn	Flat				
35	Saturated	Impervious dispersed on Lawn	Moderate				
36	Saturated	Impervious dispersed on Lawn	Steep				
37	n/a	Green/Eco-Roof	user defined				

Table 1. WWHM2012 Pervious Land Types

PERLND No.	LZSN	INFILT	LSUR	SLSUR	KVARY	AGWRC
1	5.0	2.00	400	0.050	0.3	0.996
2	5.0	2.00	400	0.100	0.3	0.996
3	5.0	2.00	400	0.150	0.3	0.996
4	5.0	1.50	400	0.050	0.3	0.996
5	5.0	1.50	400	0.100	0.3	0.996
6	5.0	1.50	400	0.150	0.3	0.996
7	5.0	0.80	400	0.050	0.3	0.996
8	5.0	0.80	400	0.100	0.3	0.996
9	5.0	0.80	400	0.150	0.3	0.996
10	4.5	0.08	400	0.050	0.5	0.996
11	4.5	0.08	400	0.100	0.5	0.996
12	4.5	0.08	400	0.150	0.5	0.996
13	4.5	0.06	400	0.050	0.5	0.996
14	4.5	0.06	400	0.100	0.5	0.996
15	4.5	0.06	400	0.150	0.5	0.996
16	4.5	0.03	400	0.050	0.5	0.996
17	4.5	0.03	400	0.100	0.5	0.996
18	4.5	0.03	400	0.150	0.5	0.996
19	4.0	2.00	100	0.001	0.5	0.996
20	4.0	2.00	100	0.010	0.5	0.996
21	4.0	2.00	100	0.100	0.5	0.996
22	4.0	1.80	100	0.001	0.5	0.996
23	4.0	1.80	100	0.010	0.5	0.996
24	4.0	1.80	100	0.100	0.5	0.996
25	4.0	1.00	100	0.001	0.5	0.996
26	4.0	1.00	100	0.010	0.5	0.996
27	4.0	1.00	100	0.100	0.5	0.996
28	4.5	0.03	400	0.050	0.5	0.996
29	4.5	0.03	400	0.100	0.5	0.996
30	4.5	0.03	400	0.150	0.5	0.996
31	5.0	0.80	400	0.050	0.3	0.996
32	5.0	0.80	400	0.100	0.3	0.996
33	5.0	0.80	400	0.150	0.3	0.996
34	4.0	1.00	100	0.001	0.5	0.996
35	4.0	1.00	100	0.010	0.5	0.996
36	4.0	1.00	100	0.100	0.5	0.996
37	1.0	0.05	50	0.001	0.5	0.100

Table 2.WWHM2012 HSPF Pervious Parameter Values – Part I

LZSN: Lower Zone Storage Nominal (inches) INFILT: Infiltration (inches per hour) LSUR: Length of surface flow path (feet) SLSUR: Slope of surface flow path (feet/feet) KVARY: Variable groundwater recession

AGWRC: Active Groundwater Recession Constant (per day)

PERLND No.	INFEXP	INFILD	DEEPFR	BASETP	AGWETP
1	2	2	0	0	0.00
2	2	2	0	0	0.00
3	2	2	0	0	0.00
4	2	2	0	0	0.00
5	2	2	0	0	0.00
6	2	2	0	0	0.00
7	2	2	0	0	0.00
8	2	2	0	0	0.00
9	2	2	0	0	0.00
10	2	2	0	0	0.00
11	2	2	0	0	0.00
12	2	2	0	0	0.00
13	2	2	0	0	0.00
14	2	2	0	0	0.00
15	2	2	0	0	0.00
16	2	2	0	0	0.00
17	2	2	0	0	0.00
18	2	2	0	0	0.00
19	10	2	0	0	0.70
20	10	2	0	0	0.70
21	10	2	0	0	0.70
22	10	2	0	0	0.50
23	10	2	0	0	0.50
24	10	2	0	0	0.50
25	10	2	0	0	0.35
26	10	2	0	0	0.35
27	10	2	0	0	0.35
28	2	2	0	0	0.00
29	2	2	0	0	0.00
30	2	2	0	0	0.00
31	2	2	0	0	0.00
32	2	2	0	0	0.00
33	2	2	0	0	0.00
34	10	2	0	0	0.35
35	10	2	0	0	0.35
36	10	2	0	0	0.35
37	2	2	0	0	0.80

 Table 3. WWHM2012 HSPF Pervious Parameter Values – Part II

INFEXP: Infiltration Exponent

INFILD: Infiltration ratio (maximum to mean)

DEEPFR: Fraction of groundwater to deep aquifer or inactive storage

BASETP: Base flow (from groundwater) Evapotranspiration fraction

AGWETP: Active Groundwater Evapotranspiration fraction

PERLND No.	CEPSC	UZSN	NSUR	INTFW	IRC	LZETP
1	0.20	0.50	0.35	0.0	0.7	0.70
2	0.20	0.50	0.35	0.0	0.7	0.70
3	0.20	0.50	0.35	0.0	0.7	0.70
4	0.15	0.50	0.30	0.0	0.7	0.40
5	0.15	0.50	0.30	0.0	0.7	0.40
6	0.15	0.50	0.30	0.0	0.7	0.40
7	0.10	0.50	0.25	0.0	0.7	0.25
8	0.10	0.50	0.25	0.0	0.7	0.25
9	0.10	0.50	0.25	0.0	0.7	0.25
10	0.20	0.50	0.35	6.0	0.5	0.70
11	0.20	0.50	0.35	6.0	0.5	0.70
12	0.20	0.30	0.35	6.0	0.3	0.70
13	0.15	0.40	0.30	6.0	0.5	0.40
14	0.15	0.40	0.30	6.0	0.5	0.40
15	0.15	0.25	0.30	6.0	0.3	0.40
16	0.10	0.25	0.25	6.0	0.5	0.25
17	0.10	0.25	0.25	6.0	0.5	0.25
18	0.10	0.15	0.25	6.0	0.3	0.25
19	0.20	3.00	0.50	1.0	0.7	0.80
20	0.20	3.00	0.50	1.0	0.7	0.80
21	0.20	3.00	0.50	1.0	0.7	0.80
22	0.15	3.00	0.50	1.0	0.7	0.60
23	0.15	3.00	0.50	1.0	0.7	0.60
24	0.15	3.00	0.50	1.0	0.7	0.60
25	0.10	3.00	0.50	1.0	0.7	0.40
26	0.10	3.00	0.50	1.0	0.7	0.40
27	0.10	3.00	0.50	1.0	0.7	0.40
28	0.10	0.25	0.25	6.0	0.5	0.25
29	0.10	0.25	0.25	6.0	0.5	0.25
30	0.10	0.15	0.25	6.0	0.3	0.25
31	0.10	0.50	0.25	0.0	0.7	0.25
32	0.10	0.50	0.25	0.0	0.7	0.25
33	0.10	0.50	0.25	0.0	0.7	0.25
34	0.10	3.00	0.50	1.0	0.7	0.40
35	0.10	3.00	0.50	1.0	0.7	0.40
36	0.10	3.00	0.50	1.0	0.7	0.40
37	0.10	0.10	0.55	1.0	0.1	0.80

Table 4. WWHM2012 HSPF Pervious Parameter Values - Part III

CEPSC: Interception storage (inches) UZSN: Upper Zone Storage Nominal (inches) NSUR: Surface roughness (Manning's n) INTFW: Interflow index IRC: Interflow Recession Constant (per day) LZETP: Lower Zone Evapotranspiration fraction

PERLND No.	MELEV	BELV	GWDATM	PCW	PGW	UPGW
1	400	0	0	0.35	0.38	0.45
2	400	0	0	0.35	0.38	0.45
3	400	0	0	0.35	0.38	0.45
4	400	0	0	0.33	0.35	0.42
5	400	0	0	0.33	0.35	0.42
6	400	0	0	0.33	0.35	0.42
7	400	0	0	0.31	0.33	0.40
8	400	0	0	0.31	0.33	0.40
9	400	0	0	0.31	0.33	0.40
10	400	0	0	0.20	0.23	0.28
11	400	0	0	0.20	0.23	0.28
12	400	0	0	0.20	0.23	0.28
13	400	0	0	0.18	0.20	0.25
14	400	0	0	0.18	0.20	0.25
15	400	0	0	0.18	0.20	0.25
16	400	0	0	0.15	0.17	0.20
17	400	0	0	0.15	0.17	0.20
18	400	0	0	0.15	0.17	0.20
19	400	0	0	0.17	0.20	0.25
20	400	0	0	0.17	0.20	0.25
21	400	0	0	0.17	0.20	0.25
22	400	0	0	0.15	0.17	0.22
23	400	0	0	0.15	0.17	0.22
24	400	0	0	0.15	0.17	0.22
25	400	0	0	0.12	0.15	0.18
26	400	0	0	0.12	0.15	0.18
27	400	0	0	0.12	0.15	0.18
28	400	0	0	0.15	0.17	0.20
29	400	0	0	0.15	0.17	0.20
30	400	0	0	0.15	0.17	0.20
31	400	0	0	0.31	0.33	0.40
32	400	0	0	0.31	0.33	0.40
33	400	0	0	0.31	0.33	0.40
34	400	0	0	0.12	0.15	0.18
35	400	0	0	0.12	0.15	0.18
36	400	0	0	0.12	0.15	0.18
37	400	0	0	0.12	0.15	0.18

 Table 5.
 WWHM2012 HSPF Pervious Parameter Values – Part IV

MELEV: Mean surface elevation of the land segment (feet) BELV: Base elevation for active groundwater (feet) GWDATM: Datum for the groundwater elevation (feet) PCW: Cohesion Water Porosity (fraction) PGW: Gravitational Water Porosity (fraction) UPGW: Upper Gravitational Water porosity (fraction)

PERLND							
No.	STABNO	SRRC	SREXP	IFWSC	DELTA	UELFAC	LELFAC
1	1	0.1	0	4	0.2	4	2.5
2	1	0.1	0	4	0.2	4	2.5
3	1	0.1	0	4	0.2	4	2.5
4	1	0.1	0	4	0.2	4	2.5
5	1	0.1	0	4	0.2	4	2.5
6	1	0.1	0	4	0.2	4	2.5
7	1	0.1	0	4	0.2	4	2.5
8	1	0.1	0	4	0.2	4	2.5
9	1	0.1	0	4	0.2	4	2.5
10	1	0.1	0	4	0.2	4	2.5
11	1	0.1	0	4	0.2	4	2.5
12	1	0.1	0	4	0.2	4	2.5
13	1	0.1	0	4	0.2	4	2.5
14	1	0.1	0	4	0.2	4	2.5
15	1	0.1	0	4	0.2	4	2.5
16	1	0.1	0	4	0.2	4	2.5
17	1	0.1	0	4	0.2	4	2.5
18	1	0.1	0	4	0.2	4	2.5
19	1	0.1	0	4	0.2	4	2.5
20	1	0.1	0	4	0.2	4	2.5
21	1	0.1	0	4	0.2	4	2.5
22	1	0.1	0	4	0.2	4	2.5
23	1	0.1	0	4	0.2	4	2.5
24	1	0.1	0	4	0.2	4	2.5
25	1	0.1	0	4	0.2	4	2.5
26	1	0.1	0	4	0.2	4	2.5
27	1	0.1	0	4	0.2	4	2.5
28	1	0.1	0	4	0.2	4	2.5
29	1	0.1	0	4	0.2	4	2.5
30	1	0.1	0	4	0.2	4	2.5
31	1	0.1	0	4	0.2	4	2.5
32	1	0.1	0	4	0.2	4	2.5
33	1	0.1	0	4	0.2	4	2.5
34	1	0.1	0	4	0.2	4	2.5
35	1	0.1	0	4	0.2	4	2.5
36	1	0.1	0	4	0.2	4	2.5
37	1	0.1	0	4	0.2	4	2.5

Table 6. WWHM2012 HSPF Pervious Parameter Values – Part V

STABNO: User's number for the FTABLE in the FTABLES block which contains the outflow properties from the surface storage

SRRC: Surface Runoff Recession Constant (per hour)

SREXP: Surface Runoff Exponent

IFWSC: Maximum Interflow Storage Capacity when the groundwater elevation is greater than the upper influence elevation (inches)

DELTA: groundwater tolerance level used to determine transition between regions when high water table conditions are being simulated UELFAC: multiplier on UZSN which gives the upper zone capacity LELFAC: multiplier on LZSN which gives the lower zone capacity

The selection of the Table 5 and Table 6 default parameter values is based on limited application of these parameters in Western Washington by the staff of Clear Creek Solutions, Inc. The parameter values should be used with caution and only after consultation with the Department of Ecology. Different values should only be selected following detailed local soil analysis, a thorough understanding of the parameters and algorithms, and consultation with the Department of Ecology.

A description of the Table 5 and Table 6 parameters and algorithms is in a separate document titled "WWHM2012 Description of HSPF High Groundwater Parameters" available from the Washington State Department of Ecology.

PERLND No.	CEPS	SURS	UZS	IFWS	LZS	AGWS	GWVS
1	0	0	0	0	3.0	1	0
2	0	0	0	0	3.0	1	0
3	0	0	0	0	3.0	1	0
4	0	0	0	0	3.0	1	0
5	0	0	0	0	3.0	1	0
6	0	0	0	0	3.0	1	0
7	0	0	0	0	3.0	1	0
8	0	0	0	0	3.0	1	0
9	0	0	0	0	3.0	1	0
10	0	0	0	0	2.5	1	0
11	0	0	0	0	2.5	1	0
12	0	0	0	0	2.5	1	0
13	0	0	0	0	2.5	1	0
14	0	0	0	0	2.5	1	0
15	0	0	0	0	2.5	1	0
16	0	0	0	0	2.5	1	0
17	0	0	0	0	2.5	1	0
18	0	0	0	0	2.5	1	0
19	0	0	0	0	4.2	1	0
20	0	0	0	0	4.2	1	0
21	0	0	0	0	4.2	1	0
22	0	0	0	0	4.2	1	0
23	0	0	0	0	4.2	1	0
24	0	0	0	0	4.2	1	0
25	0	0	0	0	4.2	1	0
26	0	0	0	0	4.2	1	0
27	0	0	0	0	4.2	1	0
28	0	0	0	0	2.5	1	0
29	0	0	0	0	2.5	1	0
30	0	0	0	0	2.5	1	0
31	0	0	0	0	3.0	1	0
32	0	0	0	0	3.0	1	0
33	0	0	0	0	3.0	1	0
34	0	0	0	0	4.2	1	0
35	0	0	0	0	4.2	1	0
36	0	0	0	0	4.2	1	0
37	0	0	0	0	0.5	0	0

Table 7. WWHM2012 HSPF Pervious Parameter Values – Part VI

CEPS: Initial interception storage (inches) SURS: Initial surface runoff (inches) UZS: Initial Upper Zone Storage (inches) IFWS: Initial interflow (inches) LZS: Initial Lower Zone Storage (inches) AGWS: Initial Active Groundwater storage (inches) GWVS: Initial Groundwater Vertical Slope (feet/feet) This page has been intentionally left blank.

APPENDIX C: DEFAULT WWHM2012 HSPF IMPERVIOUS PARAMETER VALUES (except CLARK COUNTY)

The default WWHM2012 HSPF impervious parameter values are found in the WWHM2012 file defaultpers.uci.

The default WWHM2012 HSPF impervious parameter values are based on the USGS report:

Dinicola, R.S. 1990. Characterization and Simulation of Rainfall-Runoff Relations for Headwater Basins in Western King and Snohomish Counties, Washington. Water-Resources Investigations Report 89-4052. U.S. Geological Survey. Tacoma, WA.

For some parameters the default WWHM2012 HSPF impervious parameter values have been modified from the values listed in the USGS report. These modifications are based on the professional judgment and experience of Clear Creek Solutions staff in modeling Western Washington watersheds with HSPF.

HSPF parameter documentation is found in the document: Bicknell, B.R., J.C. Imhoff, J.L. Kittle Jr, T.H. Jobes, and A.S. Donigian Jr. 2001. *Hydrological Simulation Program – Fortran, User's Manual for Version 12*. AQUA TERRA Consultants. Mountain View, CA.

IMPLND No.	Impervious Surface	Slope
1	Roads	Flat
2	Roads	Moderate
3	Roads	Steep
4	Roofs	Flat
5	Driveways	Flat
6	Driveways	Moderate
7	Driveways	Steep
8	Sidewalks	Flat
9	Sidewalks	Moderate
10	Sidewalks	Steep
11	Parking	Flat
12	Parking	Moderate
13	Parking	Steep
14	Pond	Flat
15	Porous Pavement	user defined

Table 1. WWHM2012 Impervious Land Types

IMPLND No.	LSUR	SLSUR	NSUR	RETSC
1	400	0.01	0.10	0.10
2	400	0.05	0.10	0.08
3	400	0.10	0.10	0.05
4	400	0.01	0.10	0.10
5	400	0.01	0.10	0.10
6	400	0.05	0.10	0.08
7	400	0.10	0.10	0.05
8	400	0.01	0.10	0.10
9	400	0.05	0.10	0.08
10	400	0.10	0.10	0.05
11	400	0.01	0.10	0.10
12	400	0.05	0.10	0.08
13	400	0.10	0.10	0.05
14	400	0.01	0.10	0.10
15	400	0.01	0.10	0.00

Table 2. WWHM2012 HSPF Impervious Parameter Values - Part I

LSUR: Length of surface flow path (feet) for impervious area SLSUR: Slope of surface flow path (feet/feet) for impervious area NSUR: Surface roughness (Manning's n) for impervious area RETSC: Surface retention storage (inches) for impervious area

IMPLND No.	RETS	SURS
1	0	0
2	0	0
3	0	0
4	0	0
5	0	0
6	0	0
7	0	0
8	0	0
9	0	0
10	0	0
11	0	0
12	0	0
13	0	0
14	0	0
15	0	0

 Table 3.
 WWHM2012 HSPF Impervious Parameter Values – Part II

RETSC: Initial surface retention storage (inches) for impervious area SURS: Initial surface runoff (inches) for impervious area

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APPENDIX D: DEFAULT WWHM2012 HSPF PERVIOUS PARAMETER VALUES FOR CLARK COUNTY

The default WWHM2012 HSPF pervious parameter values are found in the WWHM2012 file defaultpers.uci.

The default WWHM2012 HSPF pervious parameter values for Clark County are based on the report:

Beyerlein, D.C. 2010. *Hydrologic Modeling of Clark County Watersheds with the U.S. EPA Hydrologic Simulation Program – FORTRAN (HSPF) Final Report (Revised).* Clear Creek Solutions, Inc., Mill Creek, WA.

HSPF parameter documentation is found in the document: Bicknell, B.R., J.C. Imhoff, J.L. Kittle Jr, T.H. Jobes, and A.S. Donigian Jr. 2001. *Hydrological Simulation Program – Fortran, User's Manual for Version 12*. AQUA TERRA Consultants. Mountain View, CA.

The soils of Clark County were classified into five different groups based on soil characteristics. From a hydrologic calibration perspective, the most important soil characteristic is infiltration. Therefore, infiltration rates and soil moisture storage capability played the major role in the selection of the soils for each of the five groups. The five groups are:

Soil Group 1: Excessively Drained Soils (Hydrologic Soil Groups A & B)
Soil Group 2: Well Drained Soils (Hydrologic Soil Group B)
Soil Group 3: Moderately Drained Soils (Hydrologic Soil Groups B & C)
Soil Group 4: Poorly Drained Soils (Slowly Infiltrating C Soils, As Well As D Soils)
Soil Group 5: Wetlands Soils (Mucks)

Table 1 lists the soils within each group.

Land slopes were divided into three groups: flat (0-5%), moderate (5-15%), and steep (>15%).

Table 1. Clark County Soil Groups

					Depth from
Map Symbol	Soil Name	HSG	SCS Permeability (in/hr)	Dominant USDA Texture	surface
			Soil Group 1		-
LeB	LAUREN	В	0.63 - 2.0 (6.3 - 20 deeper than 33in)	Very Gravelly Coarse Sandy Loam	33-70
LgB	LAUREN	В	0.63 - 2.0 (6.3 - 20 deeper than 33in)	Very Gravelly Coarse Sandy Loam	33-70
LgD	LAUREN	В	0.63 - 2.0 (6.3 - 20 deeper than 33in)	Very Gravelly Coarse Sandy Loam	33-70
LgF	LAUREN	В	0.63 - 2.0 (6.3 - 20 deeper than 33in)	Very Gravelly Coarse Sandy Loam	33-70
LIB	LAUREN	В	0.63 - 2.0 (6.3 - 20 deeper than 33in)	Very Gravelly Coarse Sandy Loam	33-70
Ro	ROUGH BROKEN LAND	А	Too variable		
SvA	SIFTON	В	2.0 - 6.3 (>20 deeper than 16in)	Very Gravelly Loamy Coarse Sand and Very Gravelly Coarse Sand	10-60 inches
WnB	WIND RIVER VARIANT	В	6.3 - 20	Loamy Coarse Sand and Coarse Sand	24-62 inches
WnD	WIND RIVER VARIANT	В	6.3 - 20	Loamy Coarse Sand and Coarse Sand	24-62 inches
WnG	WIND RIVER VARIANT	В	6.3 - 20	Loamy Coarse Sand and Coarse Sand	24-62 inches
WrB	WIND RIVER VARIANT	В	6.3 - 20	Loamy Coarse Sand and Coarse Sand	24-62 inches
WrF	WIND RIVER VARIANT	В	6.3 - 20	Loamy Coarse Sand and Coarse Sand	24-62 inches
	PITS	А			
	BONNEVILLE STONY SAND LOAM	А			

Soil Group 2

BpB	BEAR PRARIE	В	0.63 - 2.0	Gravelly Loam	51-75 inches
ВрС	BEAR PRARIE	В	0.63 - 2.0	Gravelly Loam	51-75 inches
CnB	CINEBAR	В	0.63 - 2.0	Silt Loam and Loam	0-65 inches
CnD	CINEBAR	В	0.63 - 2.0	Silt Loam and Loam	0-65 inches
CnE	CINEBAR	В	0.63 - 2.0	Silt Loam and Loam	0-65 inches
CnG	CINEBAR	В	0.63 - 2.0	Silt Loam and Loam	0-65 inches

Map Symbol	Soil Name	HSG	SCS Permeability (in/hr)	Dominant USDA Texture	Depth from surface
CrE	CINEBAR	В	0.63 - 2.0	Silt Loam	0-60 inches
CrG	CINEBAR	В	0.63 - 2.0	Silt Loam	0-60 inches
CsF	CISPUS	В	> 20	Very Cobbly Sand	24-53 inches
CtA	CLOQUATO	В	> 6.3	Sandy loam and sand	40-72 inches
HIA	HILLSBORO	В	2.0 - 6.3	Sandy loam and sand	36-62 inches
НІВ	HILLSBORO	В	2.0 - 6.3	Sandy loam and sand	36-62 inches
ніс	HILLSBORO	В	2.0 - 6.3	Sandy loam and sand	36-62 inches
HID	HILLSBORO	В	2.0 - 6.3	Sandy loam and sand	36-62 inches
HIE	HILLSBORO	В	2.0 - 6.3	Sandy loam and sand	36-62 inches
HIF	HILLSBORO	В	2.0 - 6.3	Sandy loam and sand	36-62 inches
KeC	KINNEY	В	0.63 - 2.0	Gravelly silt loam, gravelly silty clay loam, and gravelly clay loam	0-60 inches
KeE	KINNEY	В	0.63 - 2.0	Gravelly silt loam, gravelly silty clay loam, and gravelly clay loam	0-60 inches
KeF	KINNEY	В	0.63 - 2.0	Gravelly silt loam, gravelly silty clay loam, and gravelly clay loam	0-60 inches
KnF	KINNEY	В	0.63 - 2.0	Gravelly silt loam, gravelly silty clay loam, and gravelly clay loam	0-60 inches
LaE	LARCHMOUNT	В	0.63 - 2.0	Cobbly Silt Loam and Clay Loam	0-62 inches
LaG	LARCHMOUNT	В	0.63 - 2.0	Cobbly Silt Loam and Clay Loam	0-62 inches
LcG	LARCHMOUNT	В	0.63 - 2.0	Silty Loam and Clay Loam	0-62 inches
MsB	MOSSYROCK	В	0.63 - 2.0	Silt Loam	23-60 inches
NbA	NEWBERG	В	2.0 - 6.3	Fine Sandy Loam and Sandy Loam	7-52 inches
NbB	NEWBERG	В	2.0 - 6.3	Fine Sandy Loam and Sandy Loam	7-52 inches
PhB	PILCHUCK	С	6.3 - 20	Fine Sand	0-60 inches
PuA	PUYALLUP	В	6.3 - 20	Gravelly Sand	27-60 inches
SaC	SALKUM	В	0.06 - 0.20	Heavy Silty Clay Loam	31-55 inches
VaB	VADER	В	2.0 - 6.3	Silt Loam and Loam	0-30 inches
VaC	VADER	В	2.0 - 6.3	Silt Loam and Loam	0-30 inches

Map Symbol	Soil Name	HSG	SCS Permeability (in/hr)	Dominant USDA Texture	Depth from surface
WaA	WASHOUGAL	В	0.63 - 2.0	Very Gravelly Loam and Very Gravelly Coarse Sandy Loam	22-36 inches
WgB	WASHOUGAL	В	0.63 - 2.0	Very Gravelly Loam and Very Gravelly Coarse Sandy Loam	22-36 inches
WgE	WASHOUGAL	В	0.63 - 2.0	Very Gravelly Loam and Very Gravelly Coarse Sandy Loam	22-36 inches
WhF	WASHOUGAL	В	0.63 - 2.0	Very Gravelly Loam and Very Gravelly Coarse Sandy Loam	22-36 inches
YaA	YACOLT	В	0.63 - 2.0	Cobbly Loam	39-61 inches
YaC	YACOLT	В	0.63 - 2.0	Cobbly Loam	39-61 inches
YcB	YACOLT	В	0.63 - 2.0	Cobbly Loam	39-61 inches

Soil	Group	3

DoB	DOLLAR	С	<0.06	Loam	32-60 inches
HcB	HESSON	С	0.2 - 0.63	Clay	22-91 inches
HcD	HESSON	С	0.2 - 0.63	Clay	22-91 inches
HcE	HESSON	С	0.2 - 0.63	Clay	22-91 inches
HcF	HESSON	С	0.2 - 0.63	Clay	22-91 inches
HgB	HESSON	С	0.2 - 0.63	Gravelly Clay	22-91 inches
HgD	HESSON	С	0.2 - 0.63	Gravelly Clay	22-91 inches
HhE	HESSON	С	0.2 - 0.63	Gravelly Clay	22-91 inches
НоА	HILLSBORO	В	0.63 - 2.0	Silt Loam	0-86 inches
HoB	HILLSBORO	В	0.63 - 2.0	Silt Loam	0-86 inches
HoC	HILLSBORO	В	0.63 - 2.0	Silt Loam	0-86 inches
HoD	HILLSBORO	В	0.63 - 2.0	Silt Loam	0-86 inches
HoE	HILLSBORO	В	0.63 - 2.0	Silt Loam	0-86 inches
HoG	HILLSBORO	В	0.63 - 2.0	Silt Loam	0-86 inches
HsB	HILLSBORO	В	0.63 - 2.0	Silt Loam	0-86 inches
McB	McBEE	С	0.63 - 2.0	Silty Clay Loam, Clay	0-65 inches
MeA	McBEE	С	0.63 - 2.0	Silty Clay Loam, Clay	0-65 inches

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Man Sumbal	Soil Nome	USC	SCS Down on hility (in /ha)	Dominant LISDA Tautum	Depth from
Map Symbol	Son Name	HSG	SCS Permeability (III/IIF)	Dominant USDA Texture	surface
MIA	McBEE	С	0.63 - 2.0 (>20 deeper than 44in)	Gravelly Fine Sandy Loam	19-44 inches
OeD	OLEQUA	В	0.2 - 0.63	Heavy Silt Loam and Silty Clay Loam	17-90 inches
OeE	OLEQUA	В	0.2 - 0.63	Heavy Silt Loam and Silty Clay Loam	17-90 inches
OeF	OLEQUA	В	0.2 - 0.63	Heavy Silt Loam and Silty Clay Loam	17-90 inches
OIB	OLYMPIC	В	0.2 - 0.63	Gravelly Clay Loam	44-59 inches
OID	OLYMPIC	В	0.2 - 0.63	Gravelly Clay Loam	44-59 inches
OIE	OLYMPIC	В	0.2 - 0.63	Gravelly Clay Loam	44-59 inches
OIF	OLYMPIC	В	0.2 - 0.63	Gravelly Clay Loam	44-59 inches
OmE	OLYMPIC	В	0.2 - 0.63	Gravelly Clay Loam	44-59 inches
OmF	OLYMPIC	В	0.2 - 0.63	Gravelly Clay Loam	44-59 inches
ОрС	OLYMPIC VARIANT	С	0.2 - 0.63	Heavy Clay Loam and Heavy silty Clay Loam	0-33 inches
OpE	OLYMPIC VARIANT	С	0.2 - 0.63	Fractured Basalt	0-33 inches
OpG	OLYMPIC VARIANT	С	0.2 - 0.63	Fractured Basalt	0-33 inches
OrC	OLYMPIC VARIANT	С	0.2 - 0.63	Fractured Basalt	0-33 inches
РоВ	POWELL	С	0.06 - 0.20	Silt Loam	23-63 inches
PoD	POWELL	С	0.06 - 0.20	Silt Loam	23-63 inches
PoE	POWELL	С	0.06 - 0.20	Silt Loam	23-63 inches
SmA	SAUVIE	В	0.2 - 0.63	Silty Clay Loam and Silt Loam	0-63 inches
SmB	SAUVIE	В	0.2 - 0.63	Silty Clay Loam and Silt Loam	0-63 inches
SnA	SAUVIE	D	2.0 - 6.3	Fine Sandy Loam	36-63 inches
SpB	SAUVIE	В	0.2 - 0.63	Silty Clay Loam and Silt Loam	0-63 inches

Soil Group 4

CvA	COVE	D	0.06 - 0.20	Gravelly Silty Clay Loam	21-60 inches
CwA	COVE	D	0.06 - 0.20	Silt Loam	21-60 inches
GeB	GEE	С	<0.06	Silty Clay Loam	22-72 inches

Man Symbol	Soil Nama	USC	SCS Dormoshility (in /hr)	Dominant USDA Touturo	Depth from
Map Symbol	Son Name	пзб	SCS Permeability (III/III)	Dominant USDA Texture	surface
GeD	GEE	С	<0.06	Silty Clay Loam	22-72 inches
GeE	GEE	С	<0.06	Silty Clay Loam	22-72 inches
GeF	GEE	С	<0.06	Silty Clay Loam	22-72 inches
GuB	GUMBOOT	D	0.06 - 0.2	Gravelly Silty Clay Loam, Clay Loam	12-50 inches
HtA	HOCKINSON	D	0.06 - 0.2	Fine Sandy Loam and Loam	23-51 inches
HuB	HOCKINSON	D	0.06 - 0.2	Fine Sandy Loam and Loam	23-51 inches
HvA	HOCKINSON	D	0.06 - 0.2	Fine Sandy Loam and Loam	23-51 inches
LrC	LAUREN	С	<0.06	Very Gravelly Clay Loam	14-60 inches
LrF	LAUREN	С	<0.06	Very Gravelly Clay Loam	14-60 inches
MnA	MINNIECE	D	<0.06	Silty Clay and Clay Basalt Bedrock	0-48 inches
MnD	MINNIECE	D	<0.06	Silty Clay and Clay Basalt Bedrock	0-48 inches
MoA	MINNIECE VARIANT	D	<0.06	Very Gravelly Clay Loam	22-60 inches
OdB	ODNE	D	<0.06	Silt Loam, silty Clay Loam, Clay Loam, and Loam	0-50 inches
OhD	OLEQUA VARIANT	С	<0.06	Silty Clay and Clay	32-82 inches
OhF	OLEQUA VARIANT	С	<0.06	Silty Clay and Clay	32-82 inches
SIB	SARA	D	<0.06	Heavy Silty Clay Loam and Silty Clay	10-70 inches
SID	SARA	D	<0.06	Heavy Silty Clay Loam and Silty Clay	10-70 inches
SIF	SARA	D	<0.06	Heavy Silty Clay Loam and Silty Clay	10-70 inches

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Sr	SEMIAHMOO	С	0.63 - 2.0	Muck	0-40 inches
Su	SEMIAHMOO VARIANT	D	0.63 - 2.0	Muck	0-30 inches
ThA	TISCH	D	0.2 - 0.63	Muck	31-45 inches

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PERLND No.	Soil	Vegetation/Surface	Slope
1	Soil Group 1	Forest	Flat
2	Soil Group 1	Forest	Moderate
3	Soil Group 1	Forest	Steep
4	Soil Group 1	Field	Flat
5	Soil Group 1	Field	Moderate
6	Soil Group 1	Field	Steep
7	Soil Group 1	Lawn	Flat
8	Soil Group 1	Lawn	Moderate
9	Soil Group 1	Lawn	Steep
10	Soil Group 2	Forest	Flat
11	Soil Group 2	Forest	Moderate
12	Soil Group 2	Forest	Steep
13	Soil Group 2	Field	Flat
14	Soil Group 2	Field	Moderate
15	Soil Group 2	Field	Steep
16	Soil Group 2	Lawn	Flat
17	Soil Group 2	Lawn	Moderate
18	Soil Group 2	Lawn	Steep
19	Soil Group 3	Forest	Flat
20	Soil Group 3	Forest	Moderate
21	Soil Group 3	Forest	Steep
22	Soil Group 3	Field	Flat
23	Soil Group 3	Field	Moderate
24	Soil Group 3	Field	Steep
25	Soil Group 3	Lawn	Flat
26	Soil Group 3	Lawn	Moderate
27	Soil Group 3	Lawn	Steep
28	Soil Group 4	Forest	Flat
29	Soil Group 4	Forest	Moderate
30	Soil Group 4	Forest	Steep
31	Soil Group 4	Field	Flat
32	Soil Group 4	Field	Moderate
33	Soil Group 4	Field	Steep
34	Soil Group 4	Lawn	Flat
35	Soil Group 4	Lawn	Moderate
36	Soil Group 4	Lawn	Steep
37	Soil Group 5	Forest	Flat
38	Soil Group 5	Forest	Moderate
39	Soil Group 5	Forest	Steep
40	Soil Group 5	Field	Flat
41	Soil Group 5	Field	Moderate
42	Soil Group 5	Field	Steep
43	Soil Group 5	Lawn	Flat
44	Soil Group 5	Lawn	Moderate
45	Soil Group 5	Lawn	Steep
46	n/a	Green/Eco-Roof	user defined

Table 2. WWHM2012 Pervious Land Types

PERLND No.	LZSN	INFILT	LSUR	SLSUR	KVARY	AGWRC
1	12.0	2.00	400	0.050	0.0	0.960
2	12.0	2.00	400	0.100	0.0	0.960
3	12.0	2.00	400	0.150	0.0	0.960
4	12.0	1.50	400	0.050	0.0	0.960
5	12.0	1.50	400	0.100	0.0	0.960
6	12.0	1.50	400	0.150	0.0	0.960
7	12.0	1.00	400	0.050	0.0	0.960
8	12.0	1.00	400	0.100	0.0	0.960
9	12.0	1.00	400	0.150	0.0	0.960
10	11.0	0.20	400	0.050	0.0	0.960
11	11.0	0.20	400	0.100	0.0	0.960
12	11.0	0.20	400	0.150	0.0	0.960
13	11.0	0.15	400	0.050	0.0	0.960
14	11.0	0.15	400	0.100	0.0	0.960
15	11.0	0.15	400	0.150	0.0	0.960
16	11.0	0.10	400	0.050	0.0	0.960
17	11.0	0.10	400	0.100	0.0	0.960
18	11.0	0.10	400	0.150	0.0	0.960
19	6.0	0.08	100	0.050	0.0	0.960
20	6.0	0.08	100	0.100	0.0	0.960
21	6.0	0.08	100	0.150	0.0	0.960
22	6.0	0.06	100	0.050	0.0	0.960
23	6.0	0.06	100	0.100	0.0	0.960
24	6.0	0.06	100	0.150	0.0	0.960
25	6.0	0.05	100	0.050	0.0	0.960
26	6.0	0.05	100	0.100	0.0	0.960
27	6.0	0.05	100	0.150	0.0	0.960
28	6.0	0.04	400	0.050	0.0	0.960
29	6.0	0.04	400	0.100	0.0	0.960
30	6.0	0.04	400	0.150	0.0	0.960
31	6.0	0.03	400	0.050	0.0	0.960
32	6.0	0.03	400	0.100	0.0	0.960
33	6.0	0.03	400	0.150	0.0	0.960
34	6.0	0.02	400	0.050	0.0	0.960
35	6.0	0.02	400	0.100	0.0	0.960
36	6.0	0.02	400	0.150	0.0	0.960
37	6.0	0.50	100	0.001	0.0	0.960
38	6.0	0.50	100	0.010	0.0	0.960
39	6.0	0.50	100	0.100	0.0	0.960
40	6.0	0.40	100	0.001	0.0	0.960
41	6.0	0.40	100	0.010	0.0	0.960
42	6.0	0.40	100	0.100	0.0	0.960
43	6.0	0.30	100	0.001	0.0	0.960
44	6.0	0.30	100	0.010	0.0	0.960
45	6.0	0.30	100	0.100	0.0	0.960
46	1.0	0.05	50	0.001	0.5	0.100

 Table 3.
 WWHM2012 HSPF Pervious Parameter Values – Part I

LZSN: Lower Zone Storage Nominal (inches) INFILT: Infiltration (inches per hour) LSUR: Length of surface flow path (feet) SLSUR: Slope of surface flow path (feet/feet) KVARY: Variable groundwater recession AGWRC: Active Groundwater Recession Constant (per day)

PERLND No.	INFEXP	INFILD	DEEPFR	BASETP	AGWETP
1	2.0	2	0	0	0.00
2	2.0	2	0	0	0.00
3	2.0	2	0	0	0.00
4	2.0	2	0	0	0.00
5	2.0	2	0	0	0.00
6	2.0	2	0	0	0.00
7	2.0	2	0	0	0.00
8	2.0	2	0	0	0.00
9	2.0	2	0	0	0.00
10	2.0	2	0	0	0.00
11	2.0	2	0	0	0.00
12	2.0	2	0	0	0.00
13	2.0	2	0	0	0.00
14	2.0	2	0	0	0.00
15	2.0	2	0	0	0.00
16	2.0	2	0	0	0.00
17	2.0	2	0	0	0.00
18	2.0	2	0	0	0.00
19	2.5	2	0	0	0.00
20	2.5	2	0	0	0.00
21	2.5	2	0	0	0.00
22	2.5	2	0	0	0.00
23	2.5	2	0	0	0.00
24	2.5	2	0	0	0.00
25	2.5	2	0	0	0.00
26	2.5	2	0	0	0.00
27	2.5	2	0	0	0.00
28	3.0	2	0	0	0.00
29	3.0	2	0	0	0.00
30	3.0	2	0	0	0.00
31	3.0	2	0	0	0.00
32	3.0	2	0	0	0.00
33	3.0	2	0	0	0.00
34	3.0	2	0	0	0.00
35	3.0	2	0	0	0.00
36	3.0	2	0	0	0.00
37	10.0	2	0	0	0.70
38	10.0	2	0	0	0.70
39	10.0	2	0	0	0.70
40	10.0	2	0	0	0.50
41	10.0	2	0	0	0.50
43	10.0	2	0	0	0.35
44	10.0	2	0	0	0.35
45	10.0	2	0	0	0.35
46	2.0	2	0	0	0.80

Table 4. WWHM2012 HSPF Pervious Parameter Values – Part II

INFEXP: Infiltration Exponent INFILD: Infiltration ratio (maximum to mean) DEEPFR: Fraction of groundwater to deep aquifer or inactive storage BASETP: Base flow (from groundwater) Evapotranspiration fraction AGWETP: Active Groundwater Evapotranspiration fraction

PERLND No.	CEPSC	UZSN	NSUR	INTFW	IRC	LZETP
1	0.20	1.50	0.35	0.0	0.4	0.70
2	0.20	1.50	0.35	0.0	0.4	0.70
3	0.20	1.50	0.35	0.0	0.4	0.70
4	0.15	1.50	0.30	0.0	0.4	0.40
5	0.15	1.50	0.30	0.0	0.4	0.40
6	0.15	1.50	0.30	0.0	0.4	0.40
7	0.10	1.30	0.25	0.0	0.4	0.25
8	0.10	1.30	0.25	0.0	0.4	0.25
9	0.10	1.30	0.25	0.0	0.4	0.25
10	0.20	1.40	0.35	1.0	0.4	0.70
11	0.20	1.40	0.35	1.0	0.4	0.70
12	0.20	1.40	0.35	1.0	0.4	0.70
13	0.15	1.40	0.30	1.0	0.4	0.40
14	0.15	1.40	0.30	1.0	0.4	0.40
15	0.15	1.40	0.30	1.0	0.4	0.40
16	0.10	1.20	0.25	1.0	0.4	0.25
17	0.10	1.20	0.25	1.0	0.4	0.25
18	0.10	1.20	0.25	1.0	0.4	0.25
19	0.20	1.00	0.35	4.0	0.4	0.70
20	0.20	1.00	0.35	4.0	0.4	0.70
21	0.20	1.00	0.35	4.0	0.4	0.70
22	0.15	1.00	0.30	4.0	0.4	0.40
23	0.15	1.00	0.30	4.0	0.4	0.40
24	0.15	1.00	0.30	4.0	0.4	0.40
25	0.10	0.80	0.25	4.0	0.4	0.25
26	0.10	0.80	0.25	4.0	0.4	0.25
27	0.10	0.80	0.25	4.0	0.4	0.25
28	0.20	0.40	0.35	2.0	0.4	0.70
29	0.20	0.40	0.35	2.0	0.4	0.70
30	0.20	0.40	0.35	2.0	0.4	0.70
31	0.15	0.40	0.30	2.0	0.4	0.40
32	0.15	0.40	0.30	2.0	0.4	0.40
33	0.15	0.40	0.30	2.0	0.4	0.40
34	0.10	0.20	0.25	2.0	0.4	0.25
35	0.10	0.20	0.25	2.0	0.4	0.25
36	0.10	0.20	0.25	2.0	0.4	0.25
37	0.20	3.00	0.50	1.0	0.7	0.80
38	0.20	3.00	0.50	1.0	0.7	0.80
39	0.20	3.00	0.50	1.0	0.7	0.80
40	0.15	3.00	0.50	1.0	0.7	0.60
41	0.15	3.00	0.50	1.0	0.7	0.60
42	0.15	3.00	0.50	1.0	0.7	0.60
43	0.10	3.00	0.50	1.0	0.7	0.40
44	0.10	3.00	0.50	1.0	0.7	0.40
45	0.10	3.00	0.50	1.0	0.7	0.40
46	0.10	0.10	0.55	1.0	0.1	0.80

Table 5. WWHM2012 HSPF Pervious Parameter Values - Part III

CEPSC: Interception storage (inches) UZSN: Upper Zone Storage Nominal (inches) NSUR: Surface roughness (Manning's n) INTFW: Interflow index IRC: Interflow Recession Constant (per day) LZETP: Lower Zone Evapotranspiration fraction

PERLND No.	MELEV	BELV	GWDATM	PCW	PGW	UPGW
1	400	0	0	0.35	0.38	0.45
2	400	0	0	0.35	0.38	0.45
3	400	0	0	0.35	0.38	0.45
4	400	0	0	0.33	0.35	0.42
5	400	0	0	0.33	0.35	0.42
6	400	0	0	0.33	0.35	0.42
7	400	0	0	0.31	0.33	0.40
8	400	0	0	0.31	0.33	0.40
9	400	0	0	0.31	0.33	0.40
10	400	0	0	0.35	0.38	0.45
11	400	0	0	0.35	0.38	0.45
12	400	0	0	0.35	0.38	0.45
13	400	0	0	0.33	0.35	0.42
14	400	0	0	0.33	0.35	0.42
15	400	0	0	0.33	0.35	0.42
16	400	0	0	0.31	0.33	0.40
17	400	0	0	0.31	0.33	0.40
18	400	0	0	0.31	0.33	0.40
19	400	0	0	0.20	0.23	0.28
20	400	0	0	0.20	0.23	0.28
21	400	0	0	0.20	0.23	0.28
22	400	0	0	0.18	0.20	0.25
23	400	0	0	0.18	0.20	0.25
24	400	0	0	0.18	0.20	0.25
25	400	0	0	0.15	0.17	0.20
26	400	0	0	0.15	0.17	0.20
27	400	0	0	0.15	0.17	0.20
28	400	0	0	0.20	0.23	0.28
29	400	0	0	0.20	0.23	0.28
30	400	0	0	0.20	0.23	0.28
31	400	0	0	0.18	0.20	0.25
32	400	0	0	0.18	0.20	0.25
33	400	0	0	0.18	0.20	0.25
34	400	0	0	0.15	0.17	0.20
35	400	0	0	0.15	0.17	0.20
36	400	0	0	0.15	0.17	0.20
37	400	0	0	0.17	0.20	0.25
38	400	0	0	0.17	0.20	0.25
39	400	0	0	0.17	0.20	0.25
40	400	0	0	0.15	0.17	0.22
41	400	0	0	0.15	0.17	0.22
42	400	0	0	0.15	0.17	0.22
43	400	0	0	0.12	0.15	0.18
44	400	0	0	0.12	0.15	0.18
45	400	0	0	0.12	0.15	0.18
46	400	0	0	0.12	0.15	0.18

 Table 6.
 WWHM2012 HSPF Pervious Parameter Values – Part IV

MELEV: Mean surface elevation of the land segment (feet) BELV: Base elevation for active groundwater (feet) GWDATM: Datum for the groundwater elevation (feet) PCW: Cohesion Water Porosity (fraction) PGW: Gravitational Water Porosity (fraction) UPGW: Upper Gravitational Water porosity (fraction)

PERLND							
No.	STABNO	SRRC	SREXP	IFWSC	DELTA	UELFAC	LELFAC
1	1	0.1	0	4	0.2	4	2.5
2	1	0.1	0	4	0.2	4	2.5
3	1	0.1	0	4	0.2	4	2.5
4	1	0.1	0	4	0.2	4	2.5
5	1	0.1	0	4	0.2	4	2.5
6	1	0.1	0	4	0.2	4	2.5
7	1	0.1	0	4	0.2	4	2.5
8	1	0.1	0	4	0.2	4	2.5
9	1	0.1	0	4	0.2	4	2.5
10	1	0.1	0	4	0.2	4	2.5
11	1	0.1	0	4	0.2	4	2.5
12	1	0.1	0	4	0.2	4	2.5
13	1	0.1	0	4	0.2	4	2.5
14	1	0.1	0	4	0.2	4	2.5
15	1	0.1	0	4	0.2	4	2.5
16	1	0.1	0	4	0.2	4	2.5
17	1	0.1	0	4	0.2	4	2.5
18	1	0.1	0	4	0.2	4	2.5
10	1	0.1	0	4	0.2	4	2.5
20	1	0.1	0	4	0.2	4	2.5
20	1	0.1	0	4	0.2	4	2.5
21	1	0.1	0	4	0.2	4	2.5
22	1	0.1	0	4	0.2	4	2.5
23	1	0.1	0	4	0.2	4	2.5
24	1	0.1	0	4	0.2	4	2.5
25	1	0.1	0	4	0.2	4	2.5
20	1	0.1	0	4	0.2	4	2.5
21	1	0.1	0	4	0.2	4	2.5
20	1	0.1	0	4	0.2	4	2.5
29	1	0.1	0	4	0.2	4	2.5
31	1	0.1	0	4	0.2	4	2.5
32	1	0.1	0	4	0.2	4	2.5
33	1	0.1	0	4	0.2	4	2.5
34	1	0.1	0	4	0.2	4	2.5
35	1	0.1	0	4	0.2	4	2.5
36	1	0.1	0	4	0.2	4	2.5
37	1	0.1	0	4	0.2	4	2.5
29	1	0.1	0	4	0.2	4	2.5
30	1	0.1	0	4 1	0.2	4	2.5
40	1	0.1	0	ч Л	0.2	4	2.5
40	1	0.1	0	4	0.2	4	2.0
41	1	0.1	0	4	0.2	4	2.0
42	1	0.1	0	4	0.2	4	2.0
43		0.1	0	4	0.2	4	2.5
44		0.1	U	4	0.2	4	Z.D

Table 7. WWHM2012 HSPF Pervious Parameter Values – Part V

45	1	0.1	0	4	0.2	4	2.5
46	1	0.1	0	4	0.2	4	2.5

STABNO: User's number for the FTABLE in the FTABLES block which contains the outflow properties from the surface storage

SRRC: Surface Runoff Recession Constant (per hour)

SREXP: Surface Runoff Exponent

IFWSC: Maximum Interflow Storage Capacity when the groundwater elevation is greater than the upper influence elevation (inches)

DELTA: groundwater tolerance level used to determine transition between regions when high water table conditions are being simulated UELFAC: multiplier on UZSN which gives the upper zone capacity LELFAC: multiplier on LZSN which gives the lower zone capacity

The selection of the Table 6 and Table 7 default parameter values is based on limited application of these parameters in Western Washington by the staff of Clear Creek Solutions, Inc.. The parameter values should be used with caution and only after consultation with the Department of Ecology. Different values should only be selected following detailed local soil analysis, a thorough understanding of the parameters and algorithms, and consultation with the Department of Ecology.

A description of the Table 6 and Table 7 parameters and algorithms is in a separate document titled "WWHM2012 Description of HSPF High Groundwater Parameters" available from the Washington State Department of Ecology.

PERLND No.	CEPS	SURS	UZS	IFWS	LZS	AGWS	GWVS
1	0	0	0	0	3.0	1	0
2	0	0	0	0	3.0	1	0
3	0	0	0	0	3.0	1	0
4	0	0	0	0	3.0	1	0
5	0	0	0	0	3.0	1	0
6	0	0	0	0	3.0	1	0
7	0	0	0	0	3.0	1	0
8	0	0	0	0	3.0	1	0
9	0	0	0	0	3.0	1	0
10	0	0	0	0	3.0	1	0
11	0	0	0	0	3.0	1	0
12	0	0	0	0	3.0	1	0
13	0	0	0	0	3.0	1	0
14	0	0	0	0	3.0	1	0
15	0	0	0	0	3.0	1	0
16	0	0	0	0	3.0	1	0
17	0	0	0	0	3.0	1	0
18	0	0	0	0	3.0	1	0
19	0	0	0	0	3.0	1	0
20	0	0	0	0	3.0	1	0
21	0	0	0	0	3.0	1	0
22	0	0	0	0	3.0	1	0
23	0	0	0	0	3.0	1	0
24	0	0	0	0	3.0	1	0
25	0	0	0	0	3.0	1	0
26	0	0	0	0	3.0	1	0
27	0	0	0	0	3.0	1	0
28	0	0	0	0	2.5	1	0
29	0	0	0	0	2.5	1	0
30	0	0	0	0	2.5	1	0
31	0	0	0	0	2.5	1	0
32	0	0	0	0	2.5	1	0
33	0	0	0	0	2.5	1	0
34	0	0	0	0	2.5	1	0
35	0	0	0	0	2.5	1	0
36	0	0	0	0	2.5	1	0
37	0	0	0	0	4.2	1	0
38	0	0	0	0	4.2	1	0
39	0	0	0	0	4.2	1	0
40	0	0	0	0	4.2	1	0
41	0	0	0	0	4.2	1	0
42	0	0	0	0	4.2	1	0
43	0	0	0	0	4.2	1	0
44	0	0	0	0	4.2	1	0
45	0	0	0	0	4.2	1	0
46	0	0	0	0	0.5	0	0

 Table 8.
 WWHM2012 HSPF Pervious Parameter Values – Part VI
CEPS: Initial interception storage (inches) SURS: Initial surface runoff (inches) UZS: Initial Upper Zone Storage (inches) IFWS: Initial interflow (inches) LZS: Initial Lower Zone Storage (inches) AGWS: Initial Active Groundwater storage (inches) GWVS: Initial Groundwater Vertical Slope (feet/feet) This page has been intentionally left blank.

APPENDIX E: DEFAULT WWHM2012 HSPF IMPERVIOUS PARAMETER VALUES FOR CLARK COUNTY

The default WWHM2012 HSPF impervious parameter values are found in the WWHM2012 file defaultpers.uci.

The default WWHM2012 HSPF impervious parameter values for Clark County are based on the report:

Beyerlein, D.C. 2010. *Hydrologic Modeling of Clark County Watersheds with the U.S. EPA Hydrologic Simulation Program – FORTRAN (HSPF) Final Report (Revised).* Clear Creek Solutions, Inc., Mill Creek, WA.

HSPF parameter documentation is found in the document: Bicknell, B.R., J.C. Imhoff, J.L. Kittle Jr, T.H. Jobes, and A.S. Donigian Jr. 2001. *Hydrological Simulation Program – Fortran, User's Manual for Version 12*. AQUA TERRA Consultants. Mountain View, CA.

IMPLND No.	Impervious Surface	Slope
1	Roads	Flat
2	Roads	Moderate
3	Roads	Steep
4	Roofs	Flat
5	Driveways	Flat
6	Driveways	Moderate
7	Driveways	Steep
8	Sidewalks	Flat
9	Sidewalks	Moderate
10	Sidewalks	Steep
11	Parking	Flat
12	Parking	Moderate
13	Parking	Steep
14	Pond	Flat
15	Porous Pavement	user defined

Table 1. WWHM2012 Impervious Land Types

IMPLND No.	LSUR	SLSUR	NSUR	RETSC
1	400	0.01	0.10	0.10
2	400	0.05	0.10	0.08
3	400	0.10	0.10	0.05
4	400	0.01	0.10	0.10
5	400	0.01	0.10	0.10
6	400	0.05	0.10	0.08
7	400	0.10	0.10	0.05
8	400	0.01	0.10	0.10
9	400	0.05	0.10	0.08
10	400	0.10	0.10	0.05
11	400	0.01	0.10	0.10
12	400	0.05	0.10	0.08
13	400	0.10	0.10	0.05
14	400	0.01	0.10	0.10
15	400	0.01	0.10	0.00

Table 2. WWHM2012 HSPF Impervious Parameter Values - Part I

LSUR: Length of surface flow path (feet) for impervious area SLSUR: Slope of surface flow path (feet/feet) for impervious area NSUR: Surface roughness (Manning's n) for impervious area RETSC: Surface retention storage (inches) for impervious area

IMPLND No.	RETS	SURS
1	0	0
2	0	0
3	0	0
4	0	0
5	0	0
6	0	0
7	0	0
8	0	0
9	0	0
10	0	0
11	0	0
12	0	0
13	0	0
14	0	0
15	0	0

Table 3. WWHM2012 HSPF Impervious Parameter Values – Part II

RETSC: Initial surface retention storage (inches) for impervious area SURS: Initial surface runoff (inches) for impervious area