State of Oregon Department of Environmental Quality

Coquille TMDL Low Impact Development (LID) Implementation Tool: Guidance Document.

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1.1 Introduction

This document is a user guidance for the low impact development (LID) best management practice (BMP) implementation tool for the Coquille subbasin of Coastal Oregon. The intent of the tool is to assist in the implementation of both the Coquille total maximum daily load (TMDL) and Coastal Nonpoint Management Area post-construction runoff requirements. The tool provides stakeholders with an implementation-ready tool to plan, develop, design, and implement LID projects within their jurisdictions. The purpose of this memorandum is to expand upon the Tool Approach Memo (Tetra Tech, 2016) to provide more detailed documentation for the tool and describe its function, inputs, and instructions for operation.

The following information briefly describes the tool format and function and is intended to serve as a “quick-start” guide to operating the tool. Additional, more detailed information on tool development is provided in Section 2.

1.1.1 Overview of Tool Function

The LID implementation tool for coastal Oregon is based on an Excel spreadsheet platform. At first glance, the main tool interface looks similar to the City of Eugene’s SIM tool (City of Eugene, 2014b). The tool interface is organized into sections, with each section requiring a unique set of user inputs. Orange cells require input from the user, and gray cells are automatically calculated based on user inputs provided in the orange cells.

1.1.2 Steps 1-3: Initial User Inputs

The section at the top of the interface is where the user provides general information about their site that informs the design. These inputs are selected in Steps 1-3 and include:

- Community
- Design Storm Type
- Design Storm Depth (in)
- Soil Name
- Infiltration Rate (Method)
- Infiltration Rate (in/hr)
- Impervious Area (sq. ft.)

STEP 1: Select community and design storm	
Community	Coquille
Design Storm Type	2-year 24-hour storm
Design Storm Depth (in)	1.9
STEP 2: Select soil and infiltration rate or provide in-situ measured infiltration rate	
Soil Name	Salander silt loam, 30 to 50 percent slopes
Infiltration Rate (Method)	Based on Soil Texture
Infiltration Rate (in/hr)	0.130
STEP 3: Enter total impervious area to be managed or replaced	
Impervious area (sq. ft.)	40,000.0

Figure 0. Steps 1-3 of TMDL Implementation Tool

Step 1

In Step 1, the inputs for “Community” and “Design Storm Type” incorporate dropdown menus that are accessed by clicking on the orange cells. For “Community,” the user may choose from one of four coastal communities (Coquille, Bandon, Powers, or Myrtle Point). For “Design Storm Type,” the two options provided are the 95th percentile storm depth and [50 percent of] the 2-yr 24-hr storm depth. The cell for “Design Storm Depth (in)” is then automatically populated based on the user’s selection of “Community” and “Design Storm Type.”

Step 2

In Step 2, the inputs for “Soil Name” and “Infiltration Rate (Method)” incorporate dropdown menus. The dropdown options for “Soil Name” are based on soil survey data provided by Oregon DEQ. Three different options are provided for “Infiltration Rate (Method):”

- Based on Saturated Hydraulic Conductivity,
- Based on Soil Texture, or
- User Defined.

The first option (“Based on Saturated Hydraulic Conductivity”) uses the soil saturated hydraulic conductivity values provided by Oregon DEQ as a surrogate for soil infiltration rate. The second option (“Based on Soil Texture”) provides an estimate of soil infiltration rate based the soil texture and slope. The third option (“User Defined”) is the preferred option in which the user has obtained measured infiltration rate data for their site. When “User Defined” is selected, the user must manually enter the measured infiltration rate for their site in the orange cell next to “Infiltration Rate (in/hr).” Otherwise, if one of the first two options are selected for “Infiltration Rate (Method),” the soil “Infiltration Rate (in/hr)” is automatically populated.

If local measured (in situ) soil infiltration data are not available, the tool should only be used to conduct an initial assessment until site specific infiltration rates can be obtained. ***Do not design BMPs until measured infiltration rate data are available for the proposed location.***

Step 3
The user input in Step 3 requires the user to specify the total “Impervious area (sq. ft.)” on their site. This input is used at the bottom of the tool interface to determine whether the practice(s) selected for the site adequately manage all of the impervious area (if this is a requirement of the local jurisdiction).

Once the key user inputs are defined in Steps 1-3, the next step is for the user to select which practice(s) to implement on their site.

1.1.3 Step 4: LID Practices

Following the initial user inputs (Steps 1-3), Step 4 of the tool interface enables to user to select LID practices for their site. This section of the interface is divided into two sets of practices: those that replace impervious area, and those that manage impervious area.

1.1.3.1 Practices that Replace (Reduce) Impervious Area

The following LID practices included in the tool either *reduce* or *replace* impervious area: Vegetated Roof, Tree Planting, and Pervious Pavement (Rainfall). These practices are assumed to manage only the rainfall they receive; they do not manage runoff from other areas. If the site will not incorporate any of these BMPs, simply skip this section after ensuring that all orange (user input) cells are blank.

STEP 4: Select LID practices

Practices that replace impervious area

		Practice Footprint (sq. ft.)			*Adjustment Factor*	*Impervious Area Replaced (sq. ft.)*
Vegetated Roof		5,000.0			0.50	2,500.0
Tree Planting						2,812.7
		Small Canopy	*Medium Canopy*	*Large Canopy*		
	Evergreen Trees	5	3	1	0.50	1,875.1
	Deciduous Trees	5	3	1	0.25	937.6
Pervious Pavement (Rainfall)		5,000.0			1.00	5,000.0

Figure 2. Step 4 of TMDL Implementation Tool (“Practices that replace impervious area”)

For the Vegetated Roof practice, the only user input required is practice footprint (sq. ft.). This represents the total area of rooftop that will be covered by a vegetated roof. The impervious area replaced (sq. ft.) is then automatically calculated by multiplying the practice footprint by an adjustment factor.

For the Tree Planting BMP, the user must specify the quantity of evergreen trees and deciduous trees based on tree size. Tree size (“small”, “medium”, or “large”) is based on the tree canopy diameter at maturity. The tool uses the same assumptions for canopy diameter as the Western Oregon Low Impact Development (WOLID) template tools (Cahill, 2016b). The canopy diameter assumptions are used to calculate the practice footprint, which is then multiplied by an adjustment factor to calculate the impervious area replaced (sq. ft.). Note that although the tool allows the user to adjust the canopy diameter assumptions, it is recommended that these not be modified for consistency with the WOLID template.

The Pervious Pavement (Rainfall) BMP is designed to manage the rainfall that falls on it; it does NOT manage runoff from other impervious areas. Pervious Pavement (Runoff) is included as a BMP option in “Practices that manage impervious area.”

The only user input required for Pervious Pavement (Rainfall) is the practice footprint (sq. ft.). This reflects the total planned square footage of pervious pavement. The impervious area replaced (sq. ft.) is then automatically calculated by multiplying the practice footprint by an adjustment factor.

1.1.3.2 Practices that Manage Impervious Area

The second set of LID practices pertains to practices that *manage* impervious area. These are practices that receive runoff from impervious surfaces, and include: Pervious Pavement (Runoff), Infiltration Stormwater Planter, Soakage Trench, Lined Stormwater Planter, Lined Rain Garden/LID Swale, and Water Quality Conveyance Swale.

Practices that manage impervious area

	Impervious Area Managed (sq. ft.)	Sizing Factor	BMP Surface Area (sq. ft.)
Pervious Pavement (Runoff)	5,000.0	0.01	55.0
Infiltration Stormwater Planter	5,000.0	0.02	115.0
Soakage Trench	5,000.0	0.03	125.0
Lined Stormwater Planter	5,000.0	0.05	245.0
D_{10} of imported soil (mm)	0.050		
Lined Rain Garden/LID Swale	5,000.0	0.04	210.0
D_{10} of imported soil (mm)	0.050		
Water Quality Conveyance Swale	5,000.0	0.14	676.1

Figure 3. Step 4 of TMDL Implementation Tool (Practices that manage impervious area)

For unlined practices, the only user input required is the quantity of impervious area managed by each practice (sq. ft.). The sizing factor and BMP surface area (sq. ft.) are then calculated automatically based on default design assumptions that are hidden from the user (discussed in greater detail below).

Lined practices (Lined Stormwater and Lined Rain Garden/LID Swale) require a second input in addition to impervious area managed. Because these practices incorporate imported soil, the native soil infiltration rate (specified in step 2) does not apply. Instead, the soil infiltration rate is calculated automatically based on the specified D_{10} (mm) for the imported soil mix. The D_{10} for the imported soil represents the size of particles that comprise the smallest 10 percent of the soil mix, and is interpolated based on a table of D_{10} size (mm) and corresponding infiltration rate (in/hr) provided in the WOLID template (Cahill, 2016a).

1.1.4 Impervious Area Verification

The final section of the tool interface is populated automatically and does not require any user input. It includes a calculation that sums "Total Impervious Area Replaced or Managed (sq. ft.)" for impervious area replacement practices and impervious area management practices. The total must be equal to or greater than the total site impervious surface area (sq. ft.) specified in Step 3. When this is true, the output cell for "All Impervious Area Managed?" reads "Yes."

Total Impervious Area Replaced or Managed (sq. ft.)	40,312.7
All Impervious Area Managed?	Yes

Figure 4. Impervious Area Check (last step in TMDL Implementation Tool)

1.1.5 Indicator/Caution Flags

For the Pervious Pavement (Runoff) and Soakage Trench BMPs, the minimum recommended soil infiltration rate is 0.5 in/hr (Cahill, 2016a). The tool interface incorporates an indicator that displays a warning flag if the Infiltration Rate (in/hr) specified in step 2 is lower than this threshold:

ERROR! Infiltration rate less than 0.5 in/hr

Caution flags are also provided for practices that may export nutrients or may contribute thermal loading. Practices with potential nutrient impacts include:

- Vegetated Roof
- Lined Stormwater Planter
- Lined Rain Garden/LID Swale
- Water Quality Conveyance Swale

WARNING! Nutrient export

Practices with potential thermal impacts include:

- Water Quality Conveyance Swale

WARNING! Nutrient export and thermal impacts

In addition to caution flags for soil infiltration rate, nutrient export, and thermal impacts, a blanket warning is provided in Step 4 of the tool interface which reminds the user that it is the designer's responsibility to determine whether underground injection control (UIC) authorization is required for their specific design.

WARNING! Designer is responsible for evaluating if design qualifies as an underground injection control (UIC).

The technical basis and assumptions for nutrient, thermal, and UIC indicators is discussed in detail in Section 2.2 below.

2.0 Detailed Tool Documentation

This section details the tool design and function, including a discussion of the design assumptions and references that were used.

2.1 Design Storm

As discussed previously in the Tool Approach Memo (Tetra Tech, 2016), design storm analysis and sizing information were provided by Oregon DEQ for each of the four coastal communities included in the tool. The 95th percentile 24-hour design storm is included to protect water quality on-site and downstream, and the 2-year, 24- hour design storm (based on NOAA Atlas 2) is included per federal (Endangered Species Act) design requirements (stormwater facilities must be designed to accept and fully treat 50 percent of the cumulative rainfall from the 2-year, 24-hour storm).

Oregon DEQ provided design storm analysis and sizing information to Tetra Tech for each of the four coastal communities. Due to their proximity and hydrologic similarity, the same 2-year, 24-hour design storm is used for Coquille and Myrtle Point. Additionally, due to the lack of a sufficient precipitation period of record for Myrtle Point, 95th percentile design storm values calculated for Coquille are used for Myrtle Point. Oregon DEQ also provided 95th percentile storm depths for two different Bandon stations. Based on discussions with DEQ, the Agrimet station (1.55 in.) was determined to be more central to downtown Bandon and was therefore selected as the more appropriate, representative station for Bandon. The rainfall depths included in the tool are summarized below.

Table 1. Design Storm Options Included in TMDL Implementation Tool

Jurisdiction	50 Percent of 2-year, 24-hour storm (inches)	95th percentile storm (inches)
Coquille	1.90	1.34
Bandon	2.33	1.55
Myrtle Point	1.90	1.34
Powers	2.19	1.67

2.2 Thermal, Nutrient, and UIC Cautions

As part of the technical direction, it was determined that cautions or notes would be included within the tool regarding any potential thermal or nutrient loading associated with applicable LID practices, but would not provide quantification of this loading or detailed instructions on mitigation methods.

2.2.1 Practices that may Export Nutrients

The WOLID template (Cahill, 2016a) provides discussion within Chapter 3 and Appendix H on practices that may contribute nutrient pollution to receiving waters. BMPs in the WOLID tool that may export nutrients include:

- Vegetated Roof
- Lined Stormwater Planter
- Lined Rain Garden/LID Swale
- Water Quality Conveyance Swale

In general, facilities that are not specifically designed to infiltrate and/or are not as effective at reducing runoff volumes are at a greater risk of exporting nutrient pollution. Further, because lined facilities require underdrains, and underdrains are known to contribute nutrient pollution, there is a risk of nutrient export with all lined facilities. An additional source of nutrient export may be the imported soils in some facilities. This is particularly important for phosphorus, as some facilities that export phosphorus have been documented to include imported soils with a compost component that has a high phosphorus content (Cahill, 2016a). In terms of nitrogen export, fertilization with fertilizers having high nitrogen content may cause excess nitrogen to be released.

The following guidelines, though not exhaustive, may help reduce or eliminate nutrient export from BMPs (Cahill, 2016a):

1) Avoid facilities with underdrains in a nutrient limited watershed (*note: this applies to all communities included in the tool)*.
2) Where applicable, ensure imported soils meet acceptable phosphorus levels. (Appendix D in the WOLID template includes specifications for "Treatment Soil").
3) If fertilizing, avoid fertilizers with high nitrogen content, and use only slow release fertilizers.
4) Nitrogen can be reduced by ensuring polluted runoff passes through an anaerobic condition.
5) Require infiltration of excess runoff.

2.2.2 Practices that may Increase Temperature

A study from the University of New Hampshire on thermal impacts from BMPs provides guidance on BMP types that are at a greater risk of increasing runoff temperature and contributing thermal load to receiving waters (UNHSC, 2011).

In general, surface systems that are exposed to direct sunlight have been shown to increase already elevated summer runoff temperatures, while other systems that provide treatment by infiltration and filtration can moderate runoff temperatures by thermal exchange with cool subsurface materials (UNHSC, 2011).

The following BMPs included in the tool may have a risk of thermal loading:

- Water Quality Conveyance Swale

Because water quality conveyance swales incorporate surface conveyance in which runoff is conveyed via shallow flows, the exposure of runoff to UV light may increase runoff temperature. Further, these practices are not designed specifically to infiltrate, whereas exchange with the subsurface has been shown to decrease runoff temperatures.

The following guidelines, though not exhaustive, may help reduce or eliminate thermal loading from BMPs (UNHSC, 2011):

1) In watersheds with thermal sensitivity, avoid surface systems where stormwater is exposed to direct sunlight.
2) Choose systems that provide treatment by infiltration and/or filtration.
3) Deeper systems and/or those with a large subsurface footprint have a greater capacity to buffer temperatures.

2.2.3 Underground Injection Control (UIC) Authorization

Underground injection control (UIC) systems are most commonly used in Oregon to dispose of stormwater runoff. However, not all stormwater management systems that infiltrate runoff are UIC systems. Because UIC systems must be registered and approved by DEQ, it is necessary to differentiate between stormwater best management practices that are UIC systems and those that are not (Oregon DEQ, 2014).

Per Cahill (2014a), although soakage trenches may inject stormwater into the subsurface, they are not generally considered UICs *unless injection occurs via a perforated pipe*. If an incorporated perforated pipe discharges water to the subsurface, then the soakage trench IS considered a UIC and requires authorization, unless it accepts only single-family residential or duplex roof runoff (Cahill, 2014a).

The tool includes a blanket caution message at the top of Step 4 to remind the user that ***it is ultimately the responsibility of the designer to determine the applicability of UIC authorization for a particular site design.***

2.3 Impervious Area Reduction/Replacement BMPs

This section provides detailed information on design assumptions used in the tool for practices that reduce or replace impervious surface area.

2.3.1 Vegetated Roof

In the tool, vegetated roofs are assumed to only manage rainfall that falls on them; they do not manage runoff from other areas. Based on discussion provided in the WOLID template (Cahill, 2016a), the typical vegetated roof in Western Oregon is able to manage about 50 percent of the rainfall it receives through evapotranspiration, with the remaining 50 percent of rainfall converted to runoff. This assumption is reflected in the adjustment factor of 0.50 in the tool interface.

2.3.2 Tree Planting

As discussed above, tree size (“small”, “medium”, or “large”) for the Tree Planting BMP is based on the tree canopy diameter at maturity. The tool uses the same assumptions for canopy diameter as the Western Oregon Low Impact Development (WOLID) template tools (Cahill, 2016b), which assumes a mature canopy diameter of 20 feet for “small” trees, 25 feet for “medium” trees, and 30 feet for “large” trees. The diameter assumptions are the same for deciduous and evergreen trees. The tool calculates the total canopy diameter (“practice footprint”) internally based on the diameter assumptions and user specified numbers of each size of deciduous and evergreen trees. The impervious area replaced (sq. ft.) is then calculated by multiplying the practice footprint (total canopy area) by a fixed adjustment factor for each tree type (deciduous and evergreen).

The tool uses an adjustment factor of 0.50 for evergreen trees and 0.25 for deciduous trees. Similar to the Vegetated Roof BMP, the adjustment factor reflects the assumed BMP effectiveness at reducing runoff. Therefore, an adjustment factor of 0.50 for evergreen trees assumes that they are able to intercept half of the rainfall they receive, while the remaining half is converted to runoff. A lower adjustment factor of 0.25 for deciduous trees reflects the understanding that deciduous trees are less effective at intercepting rainfall and reducing runoff than evergreen trees. This is largely due to the fact that deciduous trees are typically leafless during a large portion of the rainy season in Western Oregon. These assumptions are consistent with the assumptions used in the WOLID tools (Cahill, 2016b).

2.3.3 Pervious Pavement (Rainfall)

The Pervious Pavement (Rainfall) BMP is assumed to only manage rainfall falling on the pavement itself and not any runoff from other areas. If you are designing pervious pavement to receive runoff from other areas, ignore this BMP and use the Pervious Pavement (Runoff) BMP. The adjustment factor of 1.00 for Pervious Pavement (Rainfall) reflects an assumption that porous pavements in Western Oregon that manage only rainfall infiltrate approximately 100% of rainfall and have zero runoff. This is consistent with the assumptions used in the WOLID tools (Cahill, 2016b).\

2.4 Impervious Area Management BMPs

This section provides detailed information on design assumptions used in the tool for practices that manage impervious surface area.

2.4.1 Pervious Pavement (Runoff)

Per guidance in the WOLID template (Cahill, 2016a), porous pavement receiving runoff must be sized via hydrologic modeling provided by a qualified licensed engineer. The template provides some recommendations for accepted modeling methods, which include the Oregon State University (OSU) Extension Service's Porous Pavement Hydrologic Calculator (http://extension.oregonstate.edu/stormwater/porous-pavement-calculator). Like many of the other design tools in the WOLID template, the OSU calculator employs the Santa Barbara Urban Hydrograph (SBUH) method utilizing a Type IA rainfall distribution. The model calculates the SBUH Type 1A rainfall distribution for a 24-hour storm with peak flows generated every 10 minutes by the Rational Method. Tetra Tech adapted this hydrologic model in the tool development for Pervious Pavement (Runoff) as well as several other LID Practices (Infiltration Stormwater Planter, Soakage Trench, Lined Stormwater Planter, and Lined Rain Garden/LID Swale).

The calculation methodology for Pervious Pavement (Runoff) incorporates practice-specific design assumptions that were developed based on guidance in the WOLID template (Cahill, 2016a), the Portland Stormwater Management Manual (City of Portland, 2016), the City of Eugene Stormwater Management Manual (City of Eugene, 2014a) and engineering experience and best professional judgment. Key design assumptions and defaults include:

- Minimum soil infiltration rate of 0.5 in/hr (Cahill, 2016a).
- Runoff coefficient of 0.98 (conservative; this is a representative value for conventional impervious pavement (Cahill, 2016a)).
- Base rock depth of 6 inches (minimum, per City of Portland (2016)).
- Base rock void ratio of 40%.
- Entire design storm volume must infiltrate within 30 hours.

The tool calculates the pervious pavement area (sq. ft.) iteratively based on the maximum ponding depth (equal to the assumed base rock depth) and the depth of water remaining in the rock trench after 30 hours (which must be zero). The pavement area is increased in increments of 1 sq. ft. until all design constraints are satisfied.

2.4.2 Infiltration Stormwater Planter

Similar to Pervious Pavement (Runoff), the calculations for the Infiltration Stormwater Planter BMP in the tool were also developed based on the SBUH Type 1A hydrograph using the Rational Method to generate runoff volume in 10 minute intervals. Many of the design assumptions are the same. However, while Porous Pavement (Runoff) incorporates a storage rock layer, the Infiltration Stormwater Planter is assumed not to have a rock trench; instead, ponding depth over the soil media becomes a key design consideration. For the rock trench calculations in the tool, the ponding depth is assumed to be 6 inches (minimum, per City of Portland (2016)). The assumptions for runoff coefficient and drainage time are the same as for Pervious Pavement (Runoff).

The tool calculates the stormwater planter area (sq. ft.) iteratively based on the maximum ponding depth and the depth of water remaining in the planter after 30 hours (which must be zero). The planter area is increased in increments of 1 sq. ft. until all design constraints are satisfied.

2.4.3 Soakage Trench

The design calculations for the Soakage Trench BMP are similar to Pervious Pavement (Runoff), except that the soakage trench requires a greater minimum storage rock depth (12 inches, per City of Portland (2016)). The maximum ponding depth in the storage rock may not exceed the storage rock depth itself. Otherwise, the facility will not be empty and ready for the next storm within the 30 hour criterion. Like the Pervious Pavement (Rainfall) Lid practice, the minimum soil infiltration rate for the Soakage Trench BMP is also 0.5 in/hr.

The tool calculates the soakage trench area (sq. ft.) iteratively based on the maximum ponding depth and the depth of water remaining in the storage trench after 30 hours (which must be zero). The trench area is increased in increments of 1 sq. ft. until all design constraints are satisfied.

2.4.4 Lined Stormwater Planter

The design calculations and default design assumptions for the Lined Stormwater Planter LID practice are similar to the Infiltration Stormwater Planter (i.e., runoff coefficient of 0.98, ponding depth of 6 inches, 30 hour drain time). The main difference is that the infiltration practice relies on the infiltration rate of the native soil for runoff management, while the lined practice is typically used in soils with prohibitively slow infiltration rates. Instead, the lined practice is sized based on the design infiltration rate of the imported soil mix. In the tool, the user provides the D_{10} size (mm) for the imported soil, and the corresponding infiltration rate (in/hr) is automatically interpolated from an internal design table (provided in Cahill, 2016b).

The tool then calculates the lined stormwater planter area (sq. ft.) iteratively based on the maximum ponding depth and the depth of water remaining in the planter after 30 hours (which must be zero). The planter area is increased in increments of 1 sq. ft. until all design constraints are satisfied.

2.4.5 Lined Rain Garden/LID Swale

The design calculations for the Lined Rain Garden/LID Swale BMP are very similar to the Lined Stormwater Planter BMP. Like the Lined Stormwater Planter, the tool requires the user to specify D_{10} (mm) for the imported soil mix. For this practice, the design ponding depth is also assumed to be 6 inches (minimum, per City of Portland, 2016). The rain garden/swale area (sq. ft.) is then calculated iteratively based on the allowable ponding depth and the depth of water remaining in the rain garden/swale after 30 hours (which must be zero). The practice area is increased in increments of 1 sq. ft. until all design constraints are satisfied.

2.4.6 Water Quality Conveyance Swale

The Water Quality Conveyance Swale BMP is unique in that they cannot be sized using a sizing factor (Cahill, 2016a). The WOLID template (Cahill, 2016a) provides guidance on appropriate design calculation steps for sizing these facilities. In summary, the guidance recommends the following:

1) To size the facility, perform hydrologic modeling to determine the peak flow from the drainage area during the water quality design storm and the flood storm.
2) Then, incorporate the design aspects (listed below), using Manning's equation to determine the average velocity and depth of flow.
3) From this, calculate the required length adequate to treat the water quality design storm and convey the flood storm.

Key design constraints and assumptions include (from WOLID template (Cahill, 2016a) unless indicated):

- Trapezoidal cross-section.
- Bottom width between 1 and 8 feet (the tool assumes a width of 4 feet).
- Side slopes of 3H:1V.
- Maximum longitudinal slope of 6 percent (minimum slope of 0.5 percent if lined) (the tool assumes a longitudinal slope of 5 percent).
- Maximum flow depth (for treatment) of 6 inches.
- Maximum design velocity of 0.9 ft/s (City of Portland, 2016).
- Manning's n value of 0.25 (value for grassy swales, per City of Eugene, 2014a and City of Portland, 2016).
- Hydraulic residence time of 9 minutes (Cahill, 2016a; City of Portland, 2016).

As with the other practices, the tool also assumes a default runoff coefficient of 0.98 for the Water Quality Conveyance Swale BMP.

The tool uses the SBUH Type 1A hydrograph to calculate the peak runoff rate (cfs), then the flow depth is calculated iteratively using Manning's equation and the default design assumptions for channel shape, width, and slope. Once flow depth is determined, the swale area (sq. ft.) is calculated based on the recommended residence time of 9 minutes.

References

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Alternative formats

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Appendices

Coquille TMDL Low Impact Development (LID) Implementation Tool

(Developed by Tetra Tech for EPA Region 10 and Oregon DEQ)

STEP 1: Select community and design storm

Community	Coquille
Design Storm Type	
Design Storm Depth (in)	

STEP 2: Select soil and infiltration rate or provide in-situ measured infiltration rate

Soil Name		***NOTE:*** *Soil name is not required for user-defined infiltration rates.*
Infiltration Rate (Method)		
Infiltration Rate (in/hr)		

STEP 3: Enter total impervious area to be managed or replaced

Impervious area (sq. ft.)	

STEP 4: LID practices ***WARNING! Designer is responsible for evaluating if design qualifies as an underground injection control (UIC).***

Impervious Area Replacement

		Practice Footprint (sq. ft.)						Adjustment Factor	Impervious Area Replaced (sq. ft.)	
Vegetated Roof		5,000.0						0.50	2,500.0	*WARNING! nutrient export*
Tree Planting									2,267.8	
		Small Canopy		*Medium Canopy*		*Large Canopy*				
		#	*diameter (ft)*	*#*	*diameter (ft)*	*#*	*diameter (ft)*			
	Evergreen Trees	2	20	2	25	2	30	0.50	1,511.9	
	Deciduous Trees	2	20	2	25	2	30	0.25	755.9	
Pervious Pavement (Rainfall)		5,000.0						1.00	5,000.0	

Impervious Area Management

		Impervious Area Managed (sq. ft.)	Sizing Factor	BMP Surface Area (sq. ft.)
Pervious Pavement (Runoff)	click to open design worksheet	5,000.0	0.00	0.0
Infiltration Stormwater Planter	click to open design worksheet	5,000.0	0.00	0.0
Soakage Trench	click to open design worksheet	5,000.0	0.00	0.0
Lined Stormwater Planter	click to open design worksheet	5,000.0	0.00	0.0
	D_{10} of imported soil (mm)	0.050		
Lined Rain Garden/LID Swale	click to open design worksheet	5,000.0	0.00	0.0
	D_{10} of imported soil (mm)	0.050		
Water Quality Conveyance Swale	click to open design worksheet	5,000.0	0.00	0.0
Total Impervious Area Replaced or Managed (sq. ft.)				39,767.8
All Impervious Area Managed?				Yes

Figure A-1. The "interface" worksheet

Soil Texture	Infiltration based on Ksat (in/hr)	Infiltration rate based on soil texture(in/hr)
silty clay	0.077	0.171
silt loam	0.199	0.429
silt loam	0.199	0.315
silty clay loam	0.257	0.317
silty clay loam	0.267	0.317
silty clay loam	0.267	0.317
silt loam	0.432	0.130
n/a	0.432	0.500
silt loam	0.432	0.130
n/a	0.432	0.500
silty clay loam	0.526	0.132
silty clay loam	0.526	0.093
silt loam	0.526	0.328
silt loam	0.526	0.130
silt loam	0.551	0.429
silt loam	0.559	0.378
silt loam	0.559	0.130
silt loam	0.580	0.429
silt loam	0.850	0.429
silt loam	1.024	0.429
silt loam	1.276	0.467
silt loam	1.276	0.429
n/a	1.276	0.500
n/a	1.276	0.500
silt loam	1.276	0.130
silt loam	1.276	0.151
silt loam	1.276	0.130
silt loam	1.276	0.130
silt loam	1.276	0.130
silt loam	1.676	0.454
silt loam	1.676	0.265
silt loam	1.676	0.130
mucky peat	1.917	0.500
silty clay loam	2.044	0.093
silty clay loam	2.044	0.093
fine sandy loam	3.968	0.540
fine sandy loam	4.417	0.651
fine sandy loam	4.417	0.540
sandy loam	4.663	0.700
sandy loam	4.663	0.473
sandy loam	4.663	0.190
sandy loam	4.663	0.190
n/a	4.959	0.500
loam	4.959	0.140
n/a	5.757	0.500
n/a	5.757	0.500
loam	6.770	0.357
loam	6.983	0.464
sandy loam	11.667	0.643
fine sand	13.039	0.805
fine sand	13.039	0.876
fine sand	42.520	0.333
n/a	42.520	0.500
fine sand	42.520	0.333
n/a	0.500	0.500
n/a	0.500	0.500

Soil Texture, Type	0-4%	5-8%	8-12%	12-16%	Over 16%	slope	intercept
coarse sand	1.25	1.00	0.75	0.50	0.31	-0.063	1.388
medium sand	1.06	0.85	0.64	0.42	0.27	-0.054	1.180
fine sand	0.94	0.75	0.56	0.38	0.24	-0.047	1.041
loamy sand	0.88	0.70	0.53	0.35	0.22	-0.044	0.976
sandy loam	0.75	0.60	0.45	0.30	0.19	-0.038	0.833
fine sandy loam	0.63	0.50	0.38	0.25	0.16	-0.032	0.699
very fine sandy loam	0.59	0.47	0.35	0.24	0.15	-0.030	0.653
loam	0.54	0.43	0.33	0.22	0.14	-0.027	0.598
silt loam	0.50	0.40	0.30	0.20	0.13	-0.025	0.555
silt	0.44	0.35	0.26	0.18	0.11	-0.022	0.486
sandy clay	0.31	0.25	0.19	0.12	0.08	-0.016	0.347
clay loam	0.25	0.20	0.15	0.10	0.06	-0.013	0.278
silty clay	0.19	0.15	0.11	0.08	0.05	-0.009	0.208
clay	0.13	0.10	0.08	0.05	0.03	-0.007	0.144
silty clay loam	0.37	0.29	0.22	0.15	0.09	-0.018	0.409

source: http://qcode.us/codes/sacramentocounty/view.php?topic=14-14_10-14_10_110

Assumptions:
* Ksat of 0.5 in/hr was assumed if not reported
* Slope of 5% was assumed if not reported
* Infiltration rate based on texture was assumed as 0.5 in/hr if soil texture was not reported

Figure A-2. The "infiltration_rates" worksheet

PERVIOUS PAVEMENT back to interface

Design storm depth (in.):	0.00	Read from 'interface'.
Drainage area (sq. ft.):	5000.0	Read from 'interface'.
Storage rock area (sq. ft.):	0	Iterative. Equivalent to porous pavement area. Adjust until max. ponding depth is just less than depth of storage rock.
Runoff coefficient:	0.98	For guidance, see Runoff Coefficient worksheet in the WOLID Tool.
Soil infiltration rate (in./hr):	0.00	Read from 'interface'. **Must be at least 0.5 inches/hour!**
Depth of storage rock (in.):	6.00	Equivalent to base rock depth. Per Portland manual, minimum depth of 6 inches.
Void ratio of storage rock:	40%	Default is 40% (typical for uniformly graded rock).
Outflow elevation above storage rock (in.):	6.00	Default: depth of storage rock (maximum value possible).
Depth of storage rock ≥ outflow elevation?	TRUE	
Max. ponding depth in storage rock (in.):	#DIV/0!	Cannot exceed outflow elevation.
Water remaining in trench after 30 hours (in.):	#DIV/0!	Must be ≤ 0 if jurisdiction requires facility to be empty in 30 hours.
Is storage trench empty in 30 hours?	#DIV/0!	Must be TRUE if jurisdiction requires facility to be empty in 30 hours.
Is storage trench empty in 72 hours?	#DIV/0!	This should always be TRUE.
SIZING FACTOR:	0.00	Ratio of BMP footprint to drainage area.

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- The user should not make edits to the SBUH hydrograph.
- All cells except those that may be edited by the user are locked in this worksheet.

SBUH HYDROGRAPH *Assumes a conservative time of concentration of zero.*

(1) Time (min)	(2) SBUH Rainfall Depth (in)	(3) Rainfall Intensity (in/hr)	(4) Inflow Rate (cfs)	(5) Inflow Volume (cf)	(6) Runoff Depth (in)	(7) Facility Infiltration Rate (cfs)	(8) Inflow Rate - Facility Infiltration Rate (cfs)	(9) Inflow Volume - Infiltration Volume (cf)	(10) Cumulative Inflow Volume to be Stored (cf)	(11) Storage Rock Ponding without Control Structure (in)	(12) Storage Rock Ponding (in)	(13) Outflow Rate exceeding Control Structure (cfs)
0	0.0000	0.00	0.00	0	0	0				#DIV/0!		
10	0.0000	0.00	0.00	0	0	0	0.00000	0.0000	0.00	#DIV/0!	#DIV/0!	#DIV/0!
20	0.0000	0.00	0.00	0	0	0	0.00000	0.0000	0.00	#DIV/0!	#DIV/0!	#DIV/0!
30	0.0000	0.00	0.00	0	0	0	0.00000	0.0000	0.00	#DIV/0!	#DIV/0!	#DIV/0!
40	0.0000	0.00	0.00	0	0	0	0.00000	0.0000	0.00	#DIV/0!	#DIV/0!	#DIV/0!
50	0.0000	0.00	0.00	0	0	0	0.00000	0.0000	0.00	#DIV/0!	#DIV/0!	#DIV/0!
60	0.0000	0.00	0.00	0	0	0	0.00000	0.0000	0.00	#DIV/0!	#DIV/0!	#DIV/0!
70	0.0000	0.00	0.00	0	0	0	0.00000	0.0000	0.00	#DIV/0!	#DIV/0!	#DIV/0!
80	0.0000	0.00	0.00	0	0	0	0.00000	0.0000	0.00	#DIV/0!	#DIV/0!	#DIV/0!
90	0.0000	0.00	0.00	0	0	0	0.00000	0.0000	0.00	#DIV/0!	#DIV/0!	#DIV/0!
100	0.0000	0.00	0.00	0	0	0	0.00000	0.0000	0.00	#DIV/0!	#DIV/0!	#DIV/0!
110	0.0000	0.00	0.00	0	0	0	0.00000	0.0000	0.00	#DIV/0!	#DIV/0!	#DIV/0!

Figure A-3. The "pervious_pavement" worksheet

INFILTRATION STORMWATER PLANTER back to interface

Design storm depth (in.):	0.00	Read from 'interface'.
Drainage area (sq. ft.):	5,000	Read from 'interface'.
Runoff coefficient:	0.98	For guidance, see Runoff Coefficient worksheet in the WOLID Tool.
Soil infiltration rate (in./hr):	0.00	Read from 'interface'.
Depth of rock below planter (in.):	0	Default is zero (no rock trench).
Note: vegetated stormwater facilities with rock trenches must be hydrologically modeled by a qualified licensed engineer.		
Void ratio of rock trench:	40%	Default is 40% (typical for uniformly graded rock).
Note: vegetated stormwater facilities with rock trenches must be hydrologically modeled by a qualified licensed engineer.		
Desired ponding depth (in.):	6.0	Per Portland manual, may vary from 6 to 9 inches measured from the inlet elevation.
Stormwater planter area (sq. ft.):	0	Adjust until max. ponding depth is just less than desired ponding depth.
Maximum ponding depth in planter (in.):	0.00	
Depth of water in rock trench after 30 hours (in.):	#DIV/0!	Must be ≤ 0 if jurisdiction requires facility to be empty in 30 hours (otherwise ignore).
Note: if jurisdiction doesn't have 30-hour criterion, ignore this calculation and base BMP sizing on ponding depth only.		
Depth of water in planter after 30 hours (in.):	0.0	Must be ≤ 0 if jurisdiction requires facility to be empty in 30 hours (otherwise ignore).
Note: if jurisdiction doesn't have 30-hour criterion, ignore this calculation and base BMP sizing on ponding depth only.		
Stormwater planter area is large enough?	#DIV/0!	
SIZING FACTOR:	0.00	Ratio of BMP footprint to drainage area.
Storage capacity of rock trench (cu. ft.):	0.00	

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- The user should not make edits to the SBUH hydrograph.
- All cells except those that may be edited by the user are locked in this worksheet.

SBUH HYDROGRAPH *Assumes a conservative time of concentration of zero.*

(1) Time (min)	(2) Rainfall Depth (in)	(3) Rainfall Intensity (in/hr)	(4) Inflow Rate (cfs)	(5) Inflow Volume (cf)	(6) Runoff Depth (in)	(7) Facility Infiltration Rate (cfs)	(8) Inflow Rate - Facility Infiltration Rate (cfs)	(9) Inflow Volume - Infiltration Volume (cf)	(10) Cumulative Inflow Volume to be Stored (cf)	(11) Rock Trench Ponding (if incl in design) (in)	(12) SW Planter Ponding Depth (in)
0	0.0000	0.00	0.00	0	0	0	0.00000	0.0000	0.00	#DIV/0!	0.00
10	0.0000	0.00	0.00	0	0	0	0.00000	0.0000	0.00	#DIV/0!	0.00
20	0.0000	0.00	0.00	0	0	0	0.00000	0.0000	0.00	#DIV/0!	0.00
30	0.0000	0.00	0.00	0	0	0	0.00000	0.0000	0.00	#DIV/0!	0.00
40	0.0000	0.00	0.00	0	0	0	0.00000	0.0000	0.00	#DIV/0!	0.00
50	0.0000	0.00	0.00	0	0	0	0.00000	0.0000	0.00	#DIV/0!	0.00
60	0.0000	0.00	0.00	0	0	0	0.00000	0.0000	0.00	#DIV/0!	0.00
70	0.0000	0.00	0.00	0	0	0	0.00000	0.0000	0.00	#DIV/0!	0.00

Figure A-4. The "infiltration_stormwater_planter" worksheet

SOAKAGE TRENCH [back to interface]

Design storm depth (in.):	0.00	Read from 'interface'.
Drainage area (sq. ft.):	5,000	Read from 'interface'.
Runoff coefficient:	0.98	For guidance, see Runoff Coefficient worksheet in the WOLID Tool.
Soil infiltration rate (in./hr):	0.00	Read from 'interface'. **Must be at least 0.5 inches/hour!**
Depth of storage rock (max ponding depth, in.):	12.0	Per Portland manual, minimum is 12 inches.
Void ratio of storage rock:	0.40	Default is 40% (typical for uniformly graded rock).
Soakage trench area (sq. ft.):	0	Adjust until max. ponding depth is just less than desired ponding depth.
Max. ponding depth in storage rock (in.):	#DIV/0!	
Depth of water in storage trench after 30 hours (in.):	#DIV/0!	Must be ≤ 0 if jurisdiction requires facility to be empty in 30 hours (otherwise ignore).

Note: if jurisdiction doesn't have 30-hour criterion, ignore this calculation and base BMP sizing on ponding depth only.

Is the soakage trench adequately sized? #DIV/0!

SIZING FACTOR: 0.00 Ratio of BMP footprint to drainage area.

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- All cells except those that may be edited by the user are locked in this worksheet.

SBUH HYDROGRAPH *Assumes a conservative time of concentration of zero.*

(1) Time (min)	(2) SBUH Rainfall Depth (in)	(3) Rainfall Intensity (in/hr)	(4) Inflow Rate (cfs)	(5) Inflow Volume (cf)	(6) Runoff Depth (in)	(7) Facility Infiltration Rate (cfs)	(8) Inflow Rate - Facility Infiltration Rate (cfs)	(9) Inflow Volume - Infiltration Volume (cf)	(10) Cumulative Inflow Volume to be Stored (cf)	(11) Storage Rock Ponding without Control Structure (in)
0	0.0000	0.00	0.00	0	0	0				#DIV/0!
10	0.0000	0.00	0.00	0	0	0	0.00000	0.0000	0.00	#DIV/0!
20	0.0000	0.00	0.00	0	0	0	0.00000	0.0000	0.00	#DIV/0!
30	0.0000	0.00	0.00	0	0	0	0.00000	0.0000	0.00	#DIV/0!
40	0.0000	0.00	0.00	0	0	0	0.00000	0.0000	0.00	#DIV/0!
50	0.0000	0.00	0.00	0	0	0	0.00000	0.0000	0.00	#DIV/0!
60	0.0000	0.00	0.00	0	0	0	0.00000	0.0000	0.00	#DIV/0!
70	0.0000	0.00	0.00	0	0	0	0.00000	0.0000	0.00	#DIV/0!
80	0.0000	0.00	0.00	0	0	0	0.00000	0.0000	0.00	#DIV/0!
90	0.0000	0.00	0.00	0	0	0	0.00000	0.0000	0.00	#DIV/0!
100	0.0000	0.00	0.00	0	0	0	0.00000	0.0000	0.00	#DIV/0!
110	0.0000	0.00	0.00	0	0	0	0.00000	0.0000	0.00	#DIV/0!
120	0.0000	0.00	0.00	0	0	0	0.00000	0.0000	0.00	#DIV/0!
130	0.0000	0.00	0.00	0	0	0	0.00000	0.0000	0.00	#DIV/0!
140	0.0000	0.00	0.00	0	0	0	0.00000	0.0000	0.00	#DIV/0!
150	0.0000	0.00	0.00	0	0	0	0.00000	0.0000	0.00	#DIV/0!
160	0.0000	0.00	0.00	0	0	0	0.00000	0.0000	0.00	#DIV/0!

Figure A-5. The "soakage_trench" worksheet

LINED STORMWATER PLANTER back to interface

Design storm depth (in.):	0.00	Read from 'interface'.
Drainage area (sq. ft.):	5,000	Read from 'interface'.
Runoff coefficient:	0.98	For guidance, see Runoff Coefficient worksheet in the WOLID Tool.
Infiltration rate of imported soil (in/hr):	0.80	D10 Read from 'interface'.Select infiltration rate based on D_{10} from ASTM D422 Soil Gradation Test. Interpolate, or conservatively, use infiltration rate for D_{10} just below actual D_{10}.

D_{10} Size (mm)	Estimated Design Infiltration Rate (inches/hour)
0.4	9
0.3	6.5
0.1	2
0.05	0.8
0.01	0.6
0.002	0.5

Depth of rock below planter (in.): 0 — Default is zero (no rock trench).

Note: vegetated stormwater facilities with rock trenches must be hydrologically modeled by a qualified licensed engineer.

Void ratio of rock trench: 40% — Default is 40% (typical for uniformly graded rock).

Note: vegetated stormwater facilities with rock trenches must be hydrologically modeled by a qualified licensed engineer.

Desired ponding depth (in.): 6.0 — Per Portland manual, may vary from 6 to 9 inches measured from the inlet elevation.

Stormwater planter area (sq. ft.): 0 — Adjust until max. ponding depth is just less than desired ponding depth.

Maximum ponding depth in planter (in.): 0.00

Depth of water in rock trench after 30 hours (in.): #DIV/0! — Must be ≤ 0 if jurisdiction requires facility to be empty in 30 hours (otherwise ignore).

Note: if jurisdiction doesn't have 30-hour criterion, ignore this calculation and base BMP sizing on ponding depth only.

Depth of water in planter after 30 hours (in.): 0.0 — Must be ≤ 0 if jurisdiction requires facility to be empty in 30 hours (otherwise ignore).

Note: if jurisdiction doesn't have 30-hour criterion, ignore this calculation and base BMP sizing on ponding depth only.

Stormwater planter area is large enough? #DIV/0!

SIZING FACTOR: 0.00 — Ratio of BMP footprint to drainage area.

Storage capacity of rock trench (cu. ft.): 0.00

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- All cells except those that may be edited by the user are locked in this worksheet.

SBUH HYDROGRAPH *Assumes a conservative time of concentration of zero.*

(1) Time (min)	(2) Rainfall Depth (in)	(3) Rainfall Intensity (in/hr)	(4) Inflow Rate (cfs)	(5) Inflow Volume (cf)	(6) Runoff Depth (in)	(7) Facility Infiltration Rate (cfs)	(8) Inflow Rate - Facility Infiltration Rate (cfs)	(9) Inflow Volume - Infiltration Volume (cf)	(10) Cumulative Inflow Volume to be Stored (cf)	(11) Rock Trench Ponding (if incl in design) (in)	(12) SW Planter Ponding Depth (in)
0	0.0000	0.00	0.00	0	0	0	0.00000	0.0000	0.00	#DIV/0!	0.00
10	0.0000	0.00	0.00	0	0	0	0.00000	0.0000	0.00	#DIV/0!	0.00
20	0.0000	0.00	0.00	0	0	0	0.00000	0.0000	0.00	#DIV/0!	0.00
30	0.0000	0.00	0.00	0	0	0	0.00000	0.0000	0.00	#DIV/0!	0.00
40	0.0000	0.00	0.00	0	0	0	0.00000	0.0000	0.00	#DIV/0!	0.00
50	0.0000	0.00	0.00	0	0	0	0.00000	0.0000	0.00	#DIV/0!	0.00
60	0.0000	0.00	0.00	0	0	0	0.00000	0.0000	0.00	#DIV/0!	0.00
70	0.0000	0.00	0.00	0	0	0	0.00000	0.0000	0.00	#DIV/0!	0.00
80	0.0000	0.00	0.00	0	0	0	0.00000	0.0000	0.00	#DIV/0!	0.00

Figure A-6. The "lined_stormwater_planter" worksheet

LINED RAIN GARDEN & LID SWALE back to interface

Design storm depth (in.):	0.00	Read from 'interface'.
Drainage area (sq. ft.):	5,000	Read from 'interface'.
Runoff coefficient:	0.98	For guidance, see Runoff Coefficient worksheet in the WOLID Tool.
Infiltration rate of imported soil (in./hr):	0.80	D10 Read from 'interface'.Select infiltration rate based on D_{10} from ASTM D422 Soil Gradation Test. Interpolate, or conservatively, use infiltration rate for D_{10} just below actual D_{10}.

D_{10} Size (mm)	Estimated Design Infiltration Rate (inches/hour)
0.4	9
0.3	6.5
0.1	2
0.05	0.8
0.01	0.6
0.002	0.5

Depth of rock below rain garden/swale (in.):	0	Default is zero (no rock trench).
Note: vegetated stormwater facilities with rock trenches must be hydrologically modeled by a qualified licensed engineer.		
Void ratio of rock trench:	40%	Default is 40% (typical for uniformly graded rock).
Note: vegetated stormwater facilities with rock trenches must be hydrologically modeled by a qualified licensed engineer.		
Desired ponding depth (in.):	6.0	Per Portland manual, maximum ponding depth is 9 inches.
Rain garden/LID swale area (sq. ft.):	0	Adjust until max. ponding depth is just less than desired ponding depth.
Maximum ponding depth in rain garden/swale (in.):	0.00	
Depth of water in rock trench after 30 hours (in.):	#DIV/0!	Must be ≤ 0 if jurisdiction requires facility to be empty in 30 hours (otherwise ignore).
Note: if jurisdiction doesn't have 30-hour criterion, ignore this calculation and base BMP sizing on ponding depth only.		
Depth of water in garden/swale after 30 hours (in.):	0.0	Must be ≤ 0 if jurisdiction requires facility to be empty in 30 hours (otherwise ignore).
Note: if jurisdiction doesn't have 30-hour criterion, ignore this calculation and base BMP sizing on ponding depth only.		
Rain garden/LID swale is large enough?	#DIV/0!	
SIZING FACTOR:	0.00	Ratio of BMP footprint to drainage area.
Storage capacity of rock trench (cu. ft.):	0.00	

Note:
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- The user should not make edits to the SBUH hydrograph.
- All cells except those that may be edited by the user are locked in this worksheet.

SBUH HYDROGRAPH *Assumes a conservative time of concentration of zero.*

(1) Time (min)	(2) Rainfall Depth (in)	(3) Rainfall Intensity (in/hr)	(4) Inflow Rate (cfs)	(5) Inflow Volume (cf)	(6) Runoff Depth (in)	(7) Facility Infiltration Rate (cfs)	(8) Inflow Rate - Facility Infiltration Rate (cfs)	(9) Inflow Volume - Infiltration Volume (cf)	(10) Cumulative Inflow Volume to be Stored (cf)	(11) Rock Trench Ponding (if incl in design) (in)	(12) SW Planter Ponding Depth (in)
0	0.0000	0.00	0.00	0	0	0	0.00000	0.0000	0.00	#DIV/0!	0.00
10	0.0000	0.00	0.00	0	0	0	0.00000	0.0000	0.00	#DIV/0!	0.00
20	0.0000	0.00	0.00	0	0	0	0.00000	0.0000	0.00	#DIV/0!	0.00
30	0.0000	0.00	0.00	0	0	0	0.00000	0.0000	0.00	#DIV/0!	0.00
40	0.0000	0.00	0.00	0	0	0	0.00000	0.0000	0.00	#DIV/0!	0.00
50	0.0000	0.00	0.00	0	0	0	0.00000	0.0000	0.00	#DIV/0!	0.00
60	0.0000	0.00	0.00	0	0	0	0.00000	0.0000	0.00	#DIV/0!	0.00
70	0.0000	0.00	0.00	0	0	0	0.00000	0.0000	0.00	#DIV/0!	0.00
80	0.0000	0.00	0.00	0	0	0	0.00000	0.0000	0.00	#DIV/0!	0.00

Figure A-7. The "lined_rain_garden" worksheet

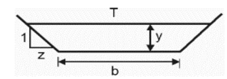
WATER QUALITY CONVEYANCE SWALE back to interface

Design storm depth (in.):	0.00	Read from 'interface'.
Drainage area (sq. ft.):	5,000	Read from 'interface'.
Runoff coefficient:	0.98	For guidance, see Runoff Coefficient worksheet in the WOLID Tool.
Peak runoff rate (cfs):	0.000	
Trapezoidal channel dimensions:		
Longitudinal channel slope (ft/ft):	0.05	Minimum slope 0.5%, maximum slope 6%.
Channel side slope (H:V):	3	:1
Channel bottom width (ft.):	4.00	Per WOLID template, bottom width generally 1 to 8 feet wide.
Assumed Manning's n value:	0.25	Per Eugene manual, use 0.25 for grassy swales and 0.35 for vegetated swales.
Depth of flow (ft.):	0.000	Iterative; adjust until "Flow Target" matches peak runoff rate (cfs) (within ±5% or 0.001 cfs whichever is higher).
Cross-sectional flow area (sq. ft.):	0.00	
Wetted perimeter (ft.):	4.00	
Hydraulic radius (ft.):	0.00	
Flow Target (cfs):	0.000	
Manning's Equation adequately solved?	#DIV/0!	Accepted when "Flow Target" is within ±5% or 0.001 cfs of Peak runoff rate (whichever is higher) and flow veocity is less than 2ft/s.
Flow velocity (ft./s):	#DIV/0!	Flows should not exceed 2 ft/s during 25-yr storm.
Required hydraulic residence time (min.):	9.00	Residence time should be 9 minutes.
Required swale length (ft.):	#DIV/0!	
Required swale area (sq. ft.):	#DIV/0!	
SIZING FACTOR:	0.00	Ratio of BMP footprint to drainage area.

Note:

- Cells highlighted in orange with regular blue font may be edited by the user.
- Cells highlighted in gray with bold orange font are calculated by the tool and should not be changed by the user.
- Cells highlighted in green with regular green font or highlighted in red with red font are used by the tool to check design requirements and should not be changed by the user.
- The user should not make edits to the SBUH hydrograph.
- All cells except those that may be edited by the user are locked in this worksheet.

Manning's Equation for a Trapezoidal Channel



$A = (b + z\,y)y \quad ; \quad P = b + 2y\sqrt{1+z^2} \quad ; \quad T = b + 2zy$

where:
A = flow area (ft^2)
P = wetted perimeter (ft)
b = channel bottom width (ft)
z = channel side slope
y = flow depth (ft)

then hydraulic radius (R_h, ft) = A/P

$$Q = \frac{1.486}{n} A R_h^{2/3} S^{1/2}$$

$$V = \frac{1.486}{n} R_h^{2/3} S^{1/2}$$

where:
Q = flow rate (cfs)
V = velocity (ft/s)
A = flow area (ft^2)
R_h = hydraulic radius (ft)
S = channel slope (ft/ft)

SBUH HYDROGRAPH

(1) Time (min)	(2) SBUH Rainfall Depth (in)	(3) Rainfall Intensity (in/hr)	(4) Inflow Rate (cfs)	(5) Inflow Volume (cf)	(6) Runoff Depth (in)
0	0.0000	0.00	0.00	0	0
10	0.0000	0.00	0.00	0	0
20	0.0000	0.00	0.00	0	0
30	0.0000	0.00	0.00	0	0
40	0.0000	0.00	0.00	0	0
50	0.0000	0.00	0.00	0	0
60	0.0000	0.00	0.00	0	0
70	0.0000	0.00	0.00	0	0
80	0.0000	0.00	0.00	0	0
90	0.0000	0.00	0.00	0	0

Figure A-8. The "water_quality_swale" worksheet