

User's Guide for the BMP Sizing Tool

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List of Abbreviations

BMP	best management practice	N/A	not applicable
CI	Clackamas Interceptor	NOAA	National Oceanic and Atmospheric Administration
DMA	Discharge Management Area	PDF	Portable Document Format
ft	foot/feet	PDX	Portland International Airport
ft/ft	foot/feet horizontal: 1 foot vertical	PWR	Pacific Water Resources
GB	gigabyte(s)	SCS	Soil Conservation Service
hr	hour(s)	sq ft	square foot/feet
HSPF	Hydrological Simulation Program-Fortran	SWMM	Storm Water Management Model
in.	inch(es)	TOC	time of concentration
LID	low-impact development	WES	Water Environment Services
MB	megabyte(s)		

Section 1.0 Introduction

Over the last decade, regulatory requirements for stormwater management have included a new focus on hydromodification (i.e., stream erosion from the extended duration of peak flows). To address impacts from hydromodification, municipalities have been implementing design standards to address peak flow control and peak flow duration control from development sites. Specifically, municipalities are guiding developers to design stormwater management facilities so that the post-development peak flow durations from a facility match pre-development peak flow durations from the development site for the range of peak flows that are considered to be channel-forming.

Designing stormwater management facilities to meet flow duration matching requirements is complex and requires continuous simulation flow modeling. Hydromodification design requirements represent a shift away from traditional stormwater detention design practices to match pre- and post-development peak flows for standard (i.e., 24-hour) synthetic design storms. As a result of this changing paradigm, a variety of stormwater facility sizing tools have been developed to assist developers in meeting flow duration matching requirements. The sizing tool described in this user's guide was originally developed to meet flow duration matching standards for select jurisdictions in California. Because the tool uses continuous simulation modeling with long-term rainfall data, it required customization for use in another location to update rainfall, soils and land use cover conditions. In 2010, Clackamas County Water Environment Services initiated development of a sizing tool (the Best Management Practice or BMP Sizing Tool) customized based on County conditions.

With the 2009 recession and a slow-down in development activities, the BMP Sizing Tool was never formally adopted by the County. However, in 2014, the cities of Oregon City and Wilsonville began a process to update their stormwater design standards to address hydromodification. As part of the updates, various sizing tools were evaluated for use in sizing stormwater facilities to meet flow duration matching requirements. The BMP Sizing Tool was selected for use by both cities in conjunction with their individual stormwater standards.

As use of the BMP Sizing Tool has increased, municipalities and the development community have identified desired refinements. A process is planned for future updates to the BMP Sizing Tool.

This User's Guide describes the basic operations of the BMP Sizing Tool.

Depending on the community the user is working in, the BMP Sizing Tool is intended for use in conjunction with one of the following documents/standards:

- City of Oregon City, *Stormwater Grading and Design Standards*
<https://www.orcity.org/publicworks/stormwater-and-grading-design-standards>
- City of Wilsonville, *2015 Stormwater and Surface Water Design and Construction Standards*, Section 3: Public Works Standards
<https://www.ci.wilsonville.or.us/engineering/page/public-works-stormwater-design-bmp>

These jurisdiction-specific design standards include requirements for site assessment and planning, stormwater BMP selection and design, and operations and maintenance. The design standards emphasize low-impact development (LID) BMP facilities that incorporate infiltration to address both pollutant reduction and flow control.

The BMP Sizing Tool automates some of the required calculations to support BMP sizing and design for a specific set of stormwater management facility types, and can be used to conduct the following:

- Perform a preliminary check that the sizing of a BMP meets the minimum criteria in the applicable design standards,
- Facilitate iterative calculations to evaluate alternative design options, and

- Prepare a Summary Report of facility sizing that can be provided to the appropriate agency as part of the design standard submittal requirements.

Section 2.0 Intended Audience

This User's Guide is intended to provide guidance and instruction on the use of the BMP Sizing Tool for sizing BMP facilities to meet the requirements for stormwater quality treatment and flow duration control, as outlined in one of the design standards documents listed above. The BMP Sizing Tool was developed based on local conditions (i.e., estimated rainfall and soil characteristics) in Clackamas County, Oregon.

Section 3.0 Installing and Starting the Application

The BMP Sizing Tool is a desktop application that can be installed on each user's computer. The required hardware and software specifications are provided below.

Hardware Requirements

- Intel® Pentium® 4 +
- 1+GB RAM
- 200+ MB free hard drive space

OS /Software Requirements

- Microsoft® Windows® XP Home, Professional, or Tablet PC Edition with Service Pack 2 or 3, Windows Server® 2003, Windows Vista® Home Premium, Business, Ultimate, or Enterprise (including 64-bit editions) with Service Pack 1, or Windows 7
- Adobe Acrobat Reader 10 or above
- Microsoft .NET Framework 3.5
- Microsoft Internet Explorer 7 or above

The BMP Sizing Tool can be obtained online at following links:

<https://www.ci.wilsonville.or.us/engineering/page/public-works-stormwater-design-bmp>

<https://www.orcity.org/publicworks/stormwater-and-grading-design-standards>

When first opening the link for the installation of the BMP Sizing Tool, a window resembling what is shown Figure 1 below, with an “Install” button will appear.

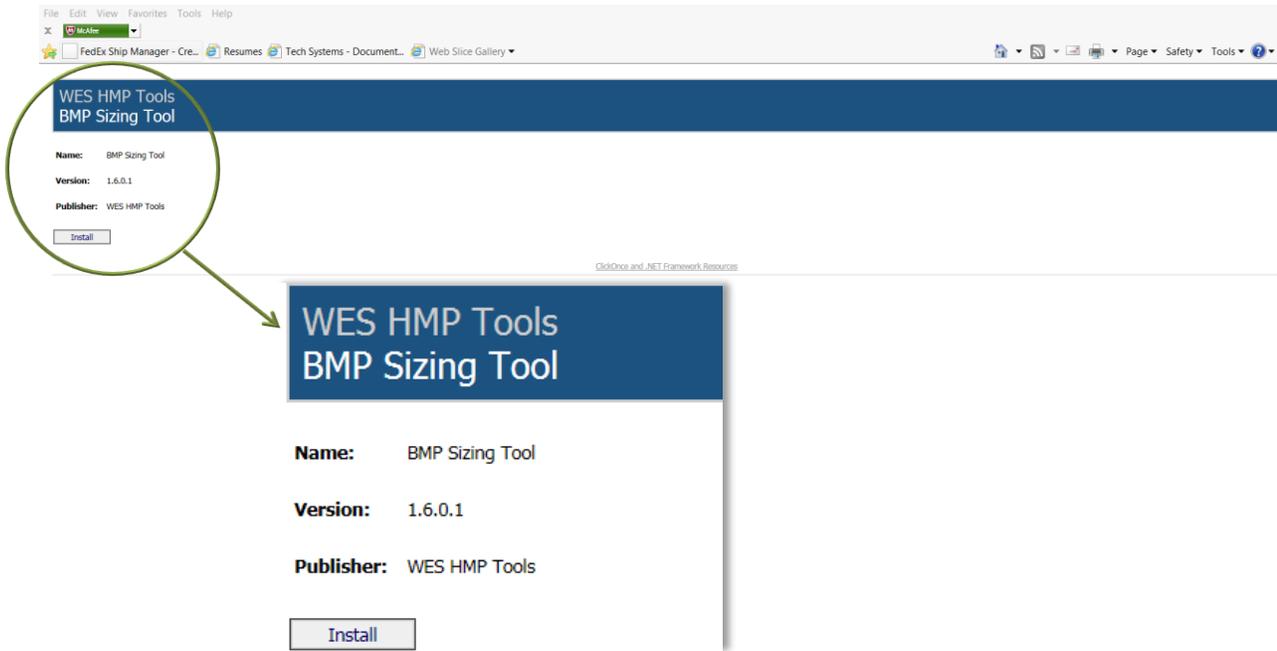


Figure 1. BMP Sizing Tool installation screen

If the user clicks on the “Install” button, the box shown in Figure 2 below will pop up with the terms and conditions for using the tool.



Figure 2. BMP Sizing Tool “Terms and Conditions” screen

The user should scroll through the text in this pop-up box to read the terms and conditions of use prior to accepting or rejecting the tool startup. This box will appear each time the user opens the tool.

Once the user has accepted the terms and conditions, the screen shown in Figure 3 below will appear.

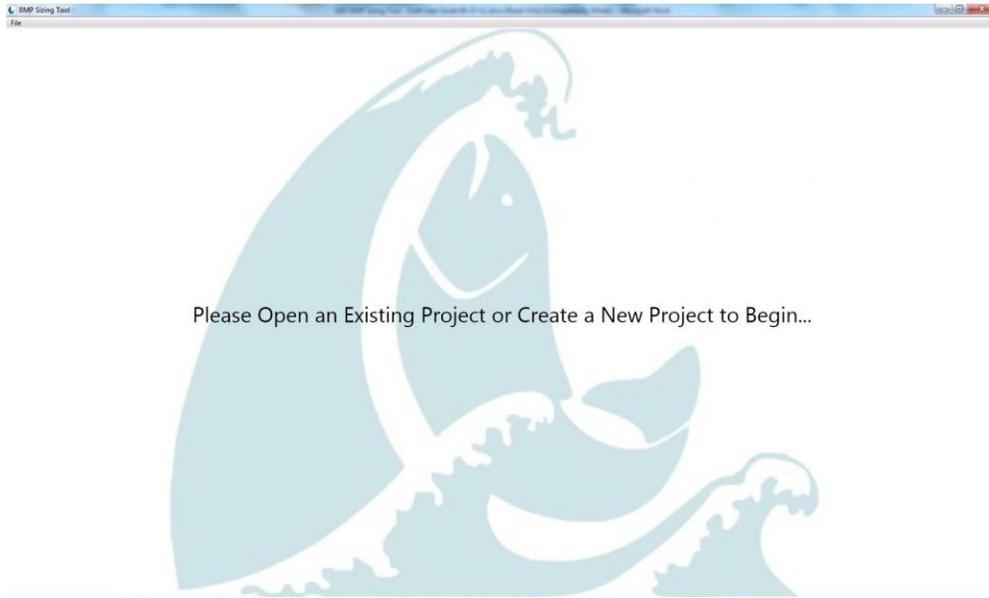


Figure 3. BMP Sizing Tool initial screen

The user should click on the “File” button in the top left corner of the screen to start a new file, open an existing file, or exit the application.

Once the user has exited the tool, it can be accessed again from the Microsoft Windows Start bar under the “All Programs>WES HMP Tools” folder. Within this folder, the user should click on the  icon called “BMP Sizing Tool” to open the application.

The BMP Sizing Tool is configured to update automatically whenever a new version is provided. When opened, the application will check to see if an update exists and automatically download it from the website. This ensures that users are always running the latest version of the program.

Section 4.0 Background on BMP Sizing

The BMP Sizing Tool performs sizing calculations for the following BMP types:

- Rain Garden Filtration
- Rain Garden Infiltration
- Stormwater Planter Filtration
- Stormwater Planter Infiltration
- Vegetated Swale Filtration
- Vegetated Swale Infiltration
- Infiltrator
- Detention Pond

The BMP Sizing Tool offers the following two design options:

- Treatment and flow control
- Treatment only

The BMP types that are available for each design option depend on the native soil infiltration rate at the location of the BMP facility. For example, infiltration-based facilities are only allowed in soils with design infiltration rates of at least 0.5 inches per hour. Facilities in slower draining soils require the use of underdrains to convey flows downstream.

Facility design details and maintenance guides for the BMPs listed above are provided in the applicable design standards for the cities of Oregon City and Wilsonville as listed in the Introduction (Section 1.0) of this guide.

Section 5.0 What Users Need to Prepare before Using This Tool

Use of the BMP Sizing Tool is based on the assumption that initial site planning work has been conducted according to guidance in the applicable design standards. This includes:

Step 1. Develop a Site Layout

A preliminary site layout and drainage plan should be developed that incorporates the following guidelines:

- a. Optimize the site layout by preserving natural drainage features and laying out structures and circulation to minimize the impervious area footprint (i.e., roofs and pavement).
- b. Where practical, use pervious surfaces such as uncompacted gravel, porous pavers, or pervious pavement—or incorporate surfaces that retain rainfall, such as vegetated landscaping.
- c. Direct the runoff from impervious surfaces to dispersed LID facilities, such as rain gardens, planters, and/or swales.
- d. Try to avoid draining large areas to a single BMP facility. BMP facilities will be most effective when they handle smaller drainage areas that are distributed throughout the site.
- e. Designate a percentage of the total site area for BMP facilities (typically 10% of the total site area). It is easier to reduce BMP facility sizes based on results from the BMP sizing tool than to add more BMP facility areas for a site that was designed without sufficiently accounting for BMPs.

Step 2. Delineate the Discharge Management Areas (DMAs)

The project area should be divided into discrete drainage basins (referred to as DMAs). DMAs should be established to define the contributing drainage area (and associated runoff) to each planned BMP facility on the site. Typically, DMA boundaries will follow grade breaks and roof ridge lines. **DMAs must be accurately delineated and cover all areas of the site without overlap for adequate BMP sizing.**

After delineating the DMAs contributing to each of the BMPs, it will be important to further characterize the DMAs for entry into the BMP Sizing Tool. For each DMA, users should conduct the following steps:

- a. Divide the DMA based on pre-development conditions. If the DMA has more than one soil type, it will need to be divided accordingly. For example, a DMA may have a total of 20 acres with 10 acres of C soils and 10 acres of D soils. In this case two 10-acre DMAs will need to be entered in the tool.
- b. Divide the DMA based on post-development conditions. If the DMA has more than one post-development condition, it will also need to be divided accordingly. For example, if one of the 10-acre DMAs from Step 2.a. includes 5 acres of impervious area in the post-development condition and 5 acres of landscape in the post-development condition, it needs to be divided into separate 5-acre DMAs.

Figure 4 illustrates an example project site area delineated into DMAs.

The BMP Sizing Tool is based on LID principles, including the concept of prioritizing small, distributed surface vegetated facilities. As a guideline, it is recommended that **the area draining into a single BMP facility should not exceed approximately 10 acres**. If a facility must be designed to accommodate a larger drainage area, then it is recommended that the designer use a more detailed hydrologic modeling tool (e.g., XP-SWMM, HSPF, etc.).

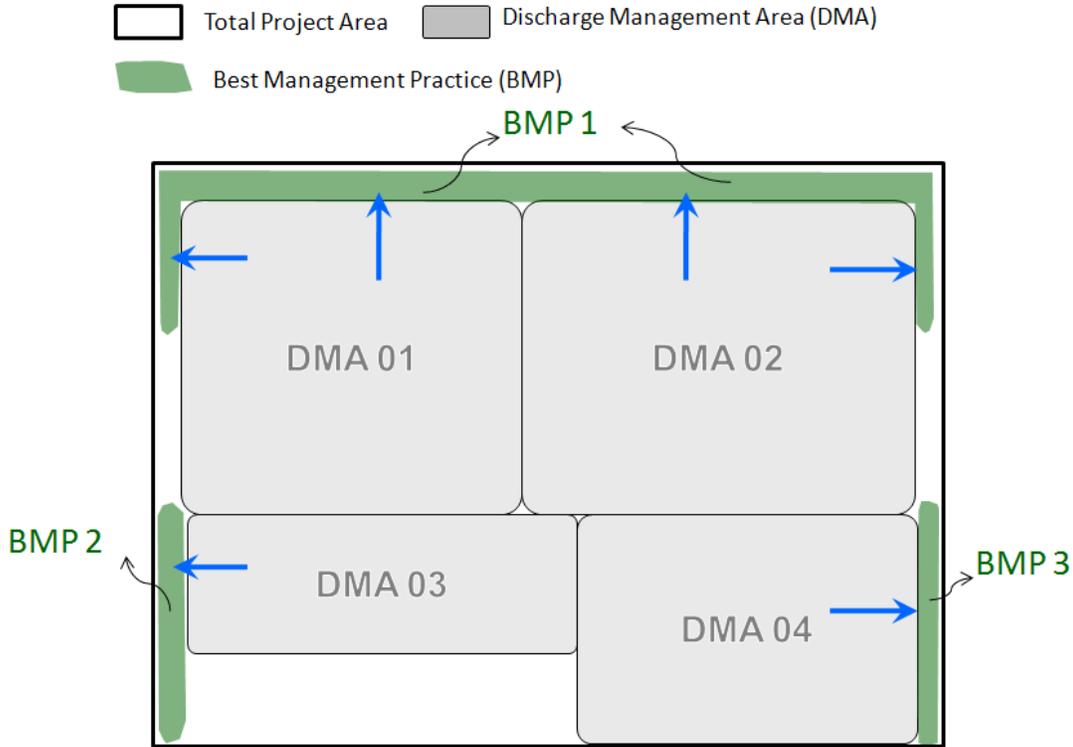


Figure 4. Project site area delineated into DMAs

Once the site layout (Step 1) has been completed and DMAs established (Step 2), BMPs may be selected and sized to mitigate stormwater impacts. Instructions for entering DMA information into the tool and sizing BMPs are provided in the following sections.

Section 6.0 Startup Using the BMP Sizing Tool

After opening the BMP Sizing Tool, the user will have the option of creating a new project file or opening an existing file, as described below.

6.1 Creating a New Project File

To create a new project file, users should open the **File** menu at the top left corner of the opening screen, select **New** to create a new project file (shown in Figure 5 below), and enter project information under the Project tab as instructed in Section 7.0.



Figure 5. File options available on the main screen

6.2 Opening and Saving Existing Project Files

At any point during the BMP sizing process, the user can save a project file and reopen it later to continue working on the project. The files are small and portable for emailing or transferring between computers.

Project data files have an .xml format and must be reopened through the BMP Sizing Tool.

Once a new or existing file has been opened, the top of the main screen of the BMP Sizing Tool will display the five tabs listed in Table 1 below.

Table 1. BMP Sizing Tool Menu Tabs	
Tab Name	Function
Project	Provides a form to enter basic information about the project site
Discharge Management Areas	Provides a place to enter information regarding the areas on the site that are draining to planned BMP facilities
Best Management Practices	Provides a place to select and size proposed stormwater management BMPs
Report	Provides a preview of the project's Summary Report and confirms the entry of project information
Warnings	Produces a list of warnings flagging possible input errors or insufficient BMP sizing

The following sections (Sections 7.0 – 11.0) provide detailed information regarding each of the five BMP Sizing Tool menu tabs.

Section 7.0 *Project* Tab: Entering Project Site Information

The **Project** tab provides the place to enter basic information that applies to the project site, such as name, location, jurisdiction, total site area, and contact information for the project applicant and engineer. This section should be completed prior to entering information about the site drainage and BMP layout in the **Discharge Management Areas** and **Best Management Practices** tabs, respectively. Figure 6 on the following page provides an example of project information in the **Project** tab as filled out by a user.

Additional information to input into the **Project** tab is described as follows:

- **Project Name:** Name of the development or portion of the development evaluated with the BMP Sizing Tool. This project name will appear in the first table at the top of the Summary Report generated by the tool.
- **WES Log #, Zoning # and Tax Lot #:** These three entries were included in the original version of the tool and are currently considered optional. These items do not show up on the Summary Report generated by the tool.
- **Applicant Name, Email, and Phone:** These three entries should be completed by the user. The Applicant Name will appear in the first table at the top of the Summary Report generated by the tool.
- **Engineer Name and Engineer Email:** If these two entries are different from the Applicant Name, they should be provided here. If these fields are left blank, an assumption will be made that the project applicant is also the project engineer.
- **Site Address:** For this entry, the user should provide the general location of the project site. This information will appear in the first table at the top of the Summary Report generated by the tool.
- **Project Type:** This entry is used to describe the project type. The drop-down list provides 13 choices including commercial, industrial, single-family, road, feasibility, planning, etc. This selection does not result in any adjustments to BMP sizing criteria and is **provided simply for informational purposes**. The project type that is selected will appear in the first table at the top of the Summary Report generated by the tool.
- **Jurisdiction:** This entry was included in the original version of the tool and has not yet been updated to include Wilsonville and Oregon City. This selection **does not result in any adjustments to BMP sizing criteria and is provided simply for informational purposes**. The jurisdiction that is selected will appear in the first table at the top of the Summary Report generated by the tool. Projects in Oregon City or Wilsonville should select the "Out of District" entry.

Project	Discharge Management Areas	Best Management Practices	Report	Warnings
Project Name	Test Project			
WES Log #	1			
Zoning #	Commercial			
Tax Lot #	1			
Applicant Name	Jane Doe			
Applicant Email	jane.doe@gmail.com			
Applicant Phone	999-999-9999			
Engineer Name	Jane Doe			
Engineer Email	jane.doe@gmail.com			
Site Address	111 Commercial Street, Oregon City			
Project Type	Commercial			
Jurisdiction	CCSD1-NCSA			
Total Site Area	500000 sq ft			
Total Pre-site Impervious Area	0 sq ft			
Total Post-site Impervious Area	30000 sq ft			
Stormwater Management Area:	0 sq ft			
Notes	This space may be used to provide specific notes if desired.			

Figure 6. Example project input for the *Project* tab

- **Total Site Area:** This entry should include the total area of the project site. It is included only for informational purposes and does not impact the facility sizing calculations. It should be provided in units of square feet.
- **Total Pre-site Impervious Area:** This entry should include the amount of impervious area (in sq ft) that currently exists on the project site area prior to the development or redevelopment activity/project. This value is included only for informational purposes and does not impact the facility sizing calculations.
- **Total Post-site Impervious Area:** This entry should include the amount of impervious area (in square feet) as proposed for the project site area that is planned for development or redevelopment. This value is included only for informational purposes and does not impact the facility sizing calculations.
- **Stormwater Management Area:** This entry should be disregarded and left blank (see Figure 6). It was included in the original version of the tool, is no longer used, and does not impact the facility sizing calculations. Any associated warnings may be disregarded as they were included in the original version of the tool and are no longer used to validate the input information.
- **Notes:** This area provides space for recording any additional notes that the user would like to save with the file. Entering notes is optional.

At the bottom left corner of the screen, two boxes show the “Stormwater Management Area” and “Sum of DMA and BMP Areas.” These boxes, and any associated warning signs, may be disregarded as they were included in the original version of the tool and are no longer used to validate the input information. This will be addressed in future updates to the tool.

Section 8.0 *Discharge Management Areas* Tab: Entering Drainage Areas

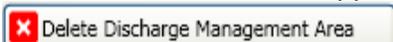
8.1 Defining Drainage Areas

The *Discharge Management Areas* tab enables the user to enter the name, area, soil group, pre-development surface, and post-development surface for each DMA on the project site. A DMA represents a delineated drainage area that will be routed to a BMP. It is assumed that these DMAs have already been delineated and defined by the project developer/engineer on the initial site plan drawings as described in Section 5.0 above.

8.2 Adding/Deleting DMAs

To add a new DMA, the user should select the  button shown highlighted in the green circle in Figure 7. Each time the user clicks on this button, a new DMA entry page will appear as a sub-tab within the *Discharge Management Areas* tab, as shown in Figure 7. All of the project site's DMAs can be entered here, one DMA at a time.

The BMP Sizing Tool has no practical upper limit to the number of DMAs that may be entered for a given project. Multiple DMAs may be set up to drain to a single BMP facility if desired. For example, the user may set up a DMA for a parking lot, and a separate DMA for a landscaped area and direct the tool to drain both DMAs to the same BMP. This is further explained in Section 9.0 regarding the *Best Management Practices* tab.

To delete a DMA, select the appropriate *Discharge Management Areas* tab and click the  button shown at the lower left corner of the screen (see Figure 7).

The screenshot displays the 'Discharge Management Areas' tab in the BMP Sizing Tool. It features a 'Project' tab, 'Discharge Management Areas' tab, and 'Best Management Practices' tab. A green circle highlights the 'Add New Discharge Management Area' button and the input fields for a new DMA. A red circle highlights the 'Delete Discharge Management Area' button. The input fields are: DMA Name (Parking Lot #1), DMA Area (50000 sq ft), DMA Soil Group (C), Predevelopment Surface (Forested), and Postdevelopment Surface (Conventional concrete or asphalt). Below these fields, there are summary statistics: Stormwater Management Area (0 sq ft) and Sum of DMA and BMP Areas (60,000 sq ft). A red warning message at the bottom states: 'The stormwater management area is sufficient.'

Figure 7. Example project input for the *Discharge Management Areas* tab

8.3 Entering Data for a New DMA

The information required for each DMA is based on the type of soil, pre-development surface, and post-development surface associated with the selected DMA. Figure 7 includes an example with three separate DMAs entered under the *Discharge Management Areas* tab. For each DMA, enter the following information:

- **DMA Name:** Name the selected DMA. Provide a unique and descriptive name that distinguishes each DMA from other DMAs. Examples include Parking Area 1, Building 1, Landscape Area 1, etc.
- **DMA Area:** Enter the area of the DMA in square feet. It may be necessary to iteratively adjust DMAs based on the required BMP size (i.e., footprint area) to optimize development areas. DMAs can be revised later under the *Discharge Management Areas* tab when interactively sizing BMPs. However, the sum of the BMP footprint areas and the DMAs should be no greater than the total project site area. If the *DMA Area* field is left at the default value of 0 sq ft, the BMP Sizing Tool will add a *Calculation Warning* on the *Warnings* tab. A review should be completed in the *Summary Report* tab to ensure that a drainage area was entered for each DMA.
- **DMA Soil Group:** Use the drop-down menu to select a soil group for the DMA. The three soil group options provided for selection include B, C, and D. The soil type selected should be reflective of the Hydrologic Soil Group identified by a geotechnical report or the United States Department of Agriculture Natural Resources Conservation Service (USDA NRCS) maps. Type A soils are not provided in the tool as they compose only a very minimal percentage of all the soils within these jurisdictions. Visit <http://soils.usda.gov> for more information about the soil groupings. Calculations related to runoff from the DMAs are based on the soil types that are selected here.
- **Pre-development Surface:** Select the pre-development surface from one of the options provided in the drop-down menu. The options include forested, grass, and impervious. The type of pre-development surface that must be selected may be dependent upon historical vegetation information provided by the relevant jurisdiction. Please see the relevant design standards documentation, listed in the Introduction (Section 1.0) for assumptions that should be made regarding pre-development surfaces.

- Post-development Surface:** Select the post-development surface from one of the options provided in the drop-down menu. In addition to conventional concrete, asphalt paving, and roofs, the tool includes post-development surface types that result in reduced runoff volumes. Table 2 lists those cover types and their associated cover (runoff) coefficients. As an example, if porous asphalt is selected as the post-development surface, the tool will assume 0.1 times the impervious area that is entered when sizing the BMP. Refer to the relevant design standards documentation listed in the Introduction (Section 1.0) for post-development surface types that may be used for sizing BMPs.

Table 2. Post-development Surface Types and Associated Cover Coefficients	
Surface Types	Cover Coefficients
Grass	0.29
Forested	0.20
Roofs	1.00
Conventional Concrete or Asphalt Paving	1.00
Pervious Concrete or Pavement: Parking	0.80
Pervious Concrete or Pavement: Drive Aisle	0.90
Crushed Aggregate	0.80
Porous Asphalt	0.10
Open and Porous Pavers	0.10
Grouted Unit Pavers	1.00
Solid Unit Pavers	0.50
Landscape, B-Soil	0.30
Landscape, C-Soil	0.50
Landscape, D-Soil	0.70

As with the **Project** tab, at the bottom left corner of the screen, two boxes show the “Stormwater Management Area” and “Sum of DMA and BMP Areas.” These boxes, and any associated warning signs, may be disregarded as they were included in the original version of the tool and are no longer used.

Section 9.0 *Best Management Practices Tab: Selecting BMP Types and Conducting BMP Sizing*

The **Best Management Practices** tab is used to select the proposed BMP facility types for the project site and to calculate the required sizes of stormwater management BMPs.

9.1 Adding a New BMP

The **Best Management Practices** tab contains separate buttons for adding and deleting BMPs, as shown in Figure 8. (Note that the button to delete a BMP does not show up until a BMP has been added.)

The screenshot shows the 'BMP Sizing Tool' application window. At the top, there are tabs for 'Project', 'Discharge Management Areas', 'Best Management Practices', and 'Warnings (1)'. Below these, there are sub-tabs for 'BMP1_RainGarden' and 'BMP2_Pond'. The main section is titled 'Rain Garden - Filtration' and contains the following fields:

- Name:** BMP1_RainGarden
- Treatment Type:** Treatment and Flow Control
- Facility Infiltration Rate:** C1 (0.35 - 0.49 in/hr)
- Minimum Size:** 2000 sq ft
- Proposed Size:** 3000 sq ft
- Design Flow:** 0.162 cfs
- Orifice Size:** 2.24 in
- Drains to Pond:** BMP2_Pond

Below this section is a list of 'Upstream Discharge Management Areas' containing 'DMA2_Parking (Type D Soil, Forested Predevelopment Land Cover)'. At the bottom of the window, there are several buttons: 'Delete This Best Management Practice', 'Add New Best Management Practice', 'Remove Selected Upstream DMA', and 'Add Upstream DMA'.

Figure 8. Example project input for BMP selection and sizing

When the user clicks on the **+ Add New Best Management Practice** button, a menu of the following five BMP options appears:

- Rain Garden
- Stormwater Planter
- Vegetated Swale
- Infiltrator
- Detention Pond

Once the user selects a BMP option, a screen will appear that is specific to that BMP type. The user must enter a name for the BMP facility to distinguish it from any other BMP facilities in the Summary Report. An example might be “Rain Garden for Parking Lot 1,” “Detention for South Lots,” etc.

9.2 LID Facility Sizing

Rain gardens, stormwater planters, vegetated swales, and infiltrators are referred to as LID facilities. The BMP Sizing Tool uses different methods for sizing LID facilities and detention ponds. The following text is focused on LID facilities. For sizing detention ponds, refer to Section 9.3

Treatment Type: After selecting a BMP type and entering a BMP name, select the treatment type from the following two choices:

1. *Treatment and flow control:* Select this option to size a BMP to meet both the water quality and flow control criteria as outlined in the applicable design standards. Specifically, the facility will be sized to address peak flow duration matching for flows ranging from 42 percent of the 2-year peak flow to the 10-year peak flow. It will also be sized to ensure treatment of 80 percent of the average annual runoff.

2. *Treatment only*: Select this option for those cases where flow control is not required. For exemptions to the flow control requirement, see Section 301.1.02(c) of Wilsonville's *Public Works Standards*, and contact Oregon City Development Services. When choosing this option, facilities are sized to treat 80 percent of the average annual runoff.

If the design goal changes, it is possible to switch treatment type without losing any information that has been entered. When the treatment type is changed, the tool dynamically updates any computed minimum BMP sizes.

Facility Infiltration Rate: The next step when adding a new BMP is to specify the design infiltration rate at the site of the BMP facility. Infiltration testing is required to obtain this infiltration rate. Infiltration testing requirements are provided in the following documents:

- City of Oregon City, *Stormwater Grading and Design Standards*: Section 4.5 and Appendix D
- City of Wilsonville, *Storm and Surface Water Design and Construction Standards*: Section 301.4.06 and Appendix B

For rain gardens, planters, and swales, there are two facility configuration types (filtration or infiltration). The BMP Sizing Tool will automatically select the facility configuration type depending on the Facility Infiltration Rate that is provided by the user. For facility infiltration rates of 0.5 inch per hour (in./hr) and greater, the tool will specify an infiltration facility (i.e., Rain Garden-Infiltration, Stormwater Planter-Infiltration, or Vegetated Swale-Infiltration). For facility infiltration rates that are less than 0.5 inch per hour or lined, the tool will specify filtration facilities (i.e., Rain Garden Filtration, Stormwater Planter Filtration, or Vegetated Swale Filtration). Infiltration facilities use only infiltration to manage runoff. Filtration facilities include piped underdrain systems and orifice controls.

Table 3 below lists the infiltration rate options used for BMP sizing by facility type.

Table 3. Facility Infiltration Rate Options Used for BMP Sizing			
Infiltration/Filtration Facility Type	Facility Soil Sub-group	Lower Infiltration Rate (in./hr)	Upper Infiltration Rate (in./hr)
Infiltration	A1	2.00	No upper bound
	B1	1.50	1.99
	B2	1.00	1.49
	B3	0.50	0.99
Filtration	C1	0.35	0.49
	C2	0.25	0.34
	C3	0.08	0.24
	D1	0.02	0.07

The infiltration rate that is entered here is separate from the soil type entered under the **Discharge Management Areas** tab. The soil type entered under the **Discharge Management Areas** tab is used in calculations related to runoff generated from the DMA. The infiltration rate that is entered in the **Best Management Practices** tab is used in calculations related to the effectiveness of the planned BMP facility in managing flows.

Upstream Discharge Management Areas: When a BMP is added, the areas that drain to the facility (i.e., the upstream DMAs) must be selected. To do this, click on the  button and select DMAs from this list created under the **Discharge Management Areas** tab. If a DMA has already been selected to drain to another BMP facility, the DMA will still appear in the list, but the ability to select this DMA will be disabled. The sum of DMAs planned for routing to one BMP should not exceed 10 acres (435,600 sq ft).

Minimum Size: After selecting the treatment type, facility infiltration rate, and upstream DMAs, the BMP Sizing Tool will calculate the minimum BMP size (in square feet of surface area) required to manage runoff from the selected upstream DMA(s).

For LID facilities, the BMP Sizing Tool calculates the minimum facility size based on a lookup table of sizing factors. A sizing factor is the percentage of impervious area and represents the surface area required for the selected LID facility. For example, if a DMA has an impervious area of 10,000 sq ft and the selected LID facility uses a sizing factor of 6 percent, then the surface area required for the LID facility is 600 sq ft. Sizing factors vary based on DMA soil types, pre-development conditions, and infiltration rates at the location of the LID facility. Sizing factors were developed by conducting continuous-simulation modeling and flow duration matching for 1-acre unit areas with each potential combination of conditions. Tables showing the sizing factors used in the BMP Sizing Tool are provided in Appendix B. The BMP Sizing Tool calculates an area-weighted sizing factor based on the different DMAs that are entered.

Design Flow/Orifice Size: The BMP Sizing Tool also provides the design flow and the orifice size for the underdrain pipe for filtration type facilities. In some cases, the BMP Sizing Tool may recommend a control orifice that is smaller than allowed by a given jurisdiction. Consult with the reviewing agency to determine if the calculated orifice size should be increased to address facility maintenance concerns.

Drains to Pond: If outflow from any of the planned BMP facilities drains to a downstream detention pond, the user should click on the *Drains to Pond* menu option and select the appropriate downstream pond. A detention pond must be created in the **Best Management Practices** tab first for it to appear as a menu option. See the following section for adding a detention pond as a BMP facility.

Proposed Size: Enter the surface area of the proposed BMP facility. This box is used to verify the proposed design. If the proposed size (as entered by the user) is less than the minimum size (as calculated by the tool), the "proposed size" entry box will turn red and a warning will appear in the **Warnings** tab. In addition, it should be noted that additional surface area will need to be added to the BMP surface area provided by the tool to accommodate any required freeboard for the detention pond, filtration swale and filtration rain garden.

Design Note: The BMP sizes that are provided by this tool are applicable only for BMPs that are designed and constructed with the specific dimensions as provided in the City of Oregon City's and Wilsonville's details. See Oregon City's *Design Standards/Drawings* and Wilsonville's *Detail Drawing Index for Stormwater* at the following links:

<https://www.orcity.org/publicworks/design-and-construction-standardsdrawings>

<https://www.ci.wilsonville.or.us/engineering>

The facility details include design specifications such as, but not limited to, minimum drain rock depths, minimum growing medium depths, minimum widths, and maximum side slopes. Design specifications are also shown in Table 4 below.

Table 4. BMP Dimensions Required for the Sizing Tool to Apply								
Facility	Drain Rock, min. in.	Separation Layer, in.	Growing Media, min. in.	Ponding Depth, in.	Freeboard, min. in.	Side Slope, ratio	Bottom Width, min. in.	Liner
Stormwater Planter - Filtration	12	3	18	12	Specified by City Detail	0	18	If required
Stormwater Planter - Infiltration	28	3	18	12	Specified by City Detail	0	30	No
Rain Garden - Filtration	18	3	18	12	Specified by City Detail	3:1 max	24	If required
Rain Garden - Infiltration	18	3	18	16	N/A	3:1 max	24	No
Vegetated Swale - Filtration	12	3	18	12	Specified by City Detail	3:1 max	24	If required
Vegetated Swale - Infiltration	18	3	18	12	N/A	3:1 max	24n	No
Detention Pond	15	3	18	Per sizing model (12 in. min.)	*Specified by City Detail	3:1 max	N/A	If required

* The surface area of the detention pond, the filtration rain garden and the filtration swale sized by the tool does not take freeboard into account. In addition, see Note 12 on the Detention Pond detail regarding an emergency spillway.

9.3 Detention Pond Sizing

The sizing procedure for detention ponds is different from LID facilities. As described in the previous section, the BMP sizing for LID facilities is based on a lookup table of sizing factors that were developed from prior continuous-simulation modeling iterations.

For detention pond sizing, the BMP Sizing Tool uses a more dynamic and iterative procedure. For the DMA conditions that are entered by the user, the BMP Sizing Tool constructs a pre- and post-project (unmitigated) long-term runoff time series. The post-project, long-term runoff time series is then routed through the detention pond (with dimensions established by the user) using a level pool routing technique. Flow duration curves are calculated for each runoff time series. For the detention pond to be sized appropriately, the flow duration curve from the mitigated outflow will need to be equal to or lower than the flow duration curve representing pre-project conditions for flows ranging from 42 percent of the 2-year peak flow to the 10-year peak flow.

Figure 9 provides a screen shot from the BMP Sizing Tool to illustrate the information required by the user for sizing a detention pond.

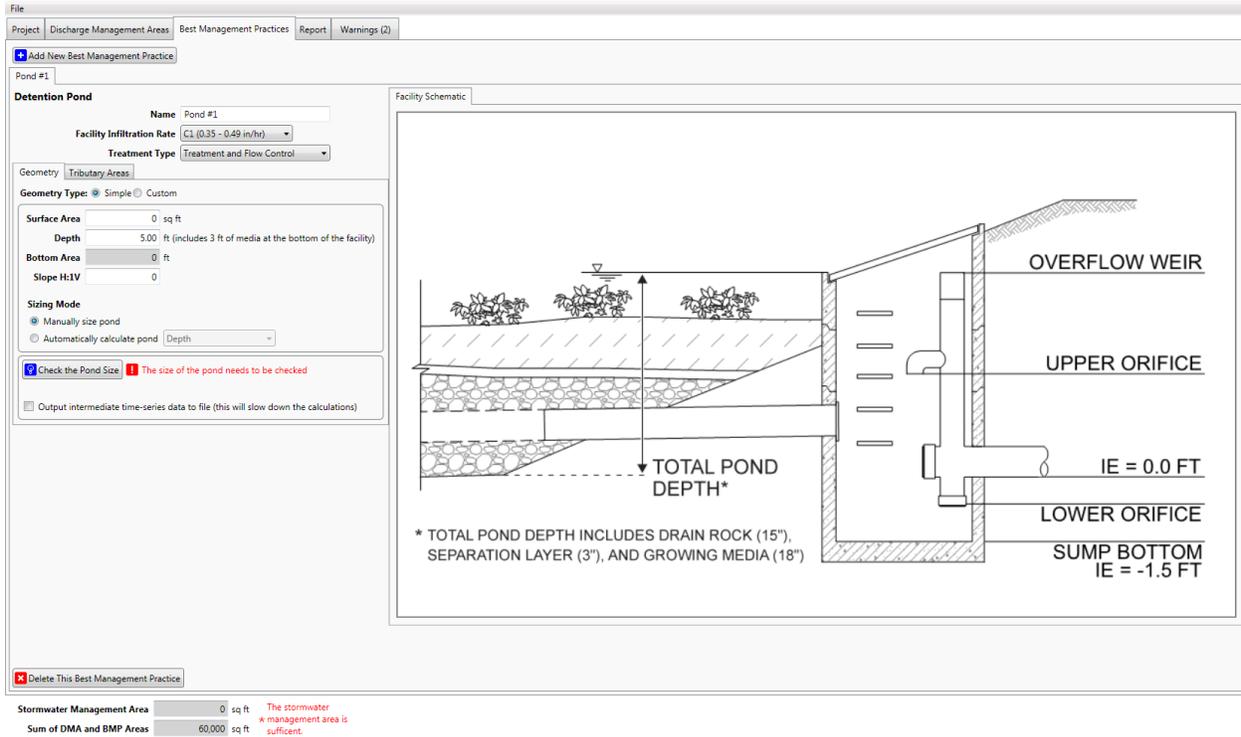


Figure 9. Example input/output for detention pond sizing

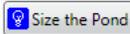
For detention pond sizing, the facility name, facility infiltration rate, and treatment type should all be entered as described for the LID facilities above.

Two tabs initially appear in the center of the screen for the **Detention Pond** sizing: *Geometry* and *Tributary Areas*. Information should be entered as follows.

- **Tributary Areas tab:** Select the DMAs that drain to the detention pond. When the user clicks on this tab, the following two boxes appear:
 - *Upstream Discharge Management Areas:* The top box provides a list of DMAs that have been entered by the user under the **Discharge Management Areas** tab. If a DMA has been selected as draining to another BMP facility, it will appear in this list but will not be available for selection. The user should select the DMAs that drain directly to the pond.
 - *Upstream Low Impact Developments:* The lower box provides a list of LID facilities that have been entered by the user. In some cases, the user may want to route discharge from an upstream LID facility to a detention pond. The LID facility may be selected here. Alternatively, the user can select the "Drains to Pond" option for upstream LID facilities. If the upstream LID facility was sized for "Treatment and Flow Control," then it is assumed that the discharge from the LID facility post-development conditions is the same as what it would be for pre-development conditions and no flow control would be required for those areas in sizing of the detention pond.

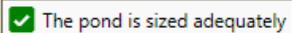
- **Geometry tab:** The BMP Sizing Tool provides two types of pond configuration options: *simple* and *custom*. For each configuration option, the BMP Sizing Tool routes the post-development flow through the pond, performs statistical analyses for flow duration and peak flow criteria, and reports if the pond is sized adequately. The features of both options are described below:

- **Simple Geometry:** In this mode, the user can choose to size the pond either manually or automatically by selecting the appropriate **Sizing Mode**. In automatic sizing, the user inputs either Surface Area or Depth, and the BMP Sizing Tool calculates the required pond size and designs the outlet structure using a built-in pond optimization algorithm.

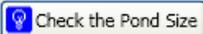
If Depth is chosen from the drop-down menu, the user must enter a surface area and side slope. Once the  button is selected, the sizing tool will calculate the depth required for the pond given the user-supplied surface area and slope. If Surface Area is chosen from the drop-down menu, the user must enter a depth and side slope. Once the  button is selected, the sizing tool will calculate the surface area required for the pond given the user-supplied depth and side slope.

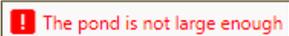
For ponds sized using **Simple Geometry**, the tool assumes that the pond is square-shaped. If the user-specified slope and selected dimensions do not allow the pond to be sized adequately such that the bottom area becomes zero before reaching the required depth, the following error message will appear:

Bottom area could not be calculated:
The bottom becomes zero before the
specified Depth is reached.

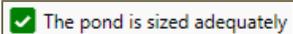
The user must increase the surface area or decrease the side slope to ensure sufficient surface area for the pond bottom. Note that some jurisdictions do not allow side slopes to exceed 3H:1V. Once the dimensions of the pond are adequate, the following message will appear: 

- **Custom Geometry:** In this mode, the user can manually size and develop a custom pond design with a custom outlet configuration that differs from the one provided by the tool. Using this option, the user will need to independently assess the stage-storage-discharge relationship for the custom pond. The user enters a data table of depth, surface area, and total outflow values (Figure 10). These values need to be calculated outside the tool using an Excel spreadsheet or other sizing tool such as HydroCAD. Data may be entered individually for each row or the whole table may be copied and pasted from Excel.

Pond sizing is checked by clicking the  button. The tool routes the post-project hydrograph through the custom stage-storage-discharge table and determines whether the provided size is adequate for meeting the flow duration criteria.

If the pond is too small, the following error message will appear: 

In this case, the user will need to revisit the stage-storage-discharge relationship for the pond. This may require increasing the capacity of the pond, resulting in a larger surface area or adjusting the outlet structure to reduce the discharge (outflow) associated with the specific stage. See the **Warnings** tab (Section 11.0) for more information.

Once the design of the pond is adequate, the following message will appear: 

Detention Pond

Name

Facility Infiltration Rate ▼

Geometry
Tributary Areas

Geometry Type: Simple Custom

Depth (ft)	Area (sq ft)	Flow (cfs)
<input type="text" value="0"/>	<input type="text" value="8714"/>	<input type="text" value="0"/>
<input type="text" value="0.14"/>	<input type="text" value="8875"/>	<input type="text" value="0.0012"/>
<input type="text" value="0.29"/>	<input type="text" value="9037"/>	<input type="text" value="0.0017"/>
<input type="text" value="0.43"/>	<input type="text" value="9201"/>	<input type="text" value="0.0021"/>
<input type="text" value="0.57"/>	<input type="text" value="9366"/>	<input type="text" value="0.0024"/>

[Add Row](#) [Remove Selected Row](#) [Clear Table](#) [Paste from Clipboard](#)

Check the Pond Size ✔ The pond is sized adequately

Automatically check the pond size when changes are made

Output intermediate time-series data to file (this will slow down the calculations)

Figure 10. Custom Detention Pond Sizing Data Input

Once the *Tributary Areas* tab and *Geometry* tab have been populated, the following information is developed and documented via additional tabs in the tool.

Outlet Structure: For ponds sized adequately using **Simple Geometry**, the **Outlet Structure** tab will be generated to summarize the required outlet dimensions for the pond. The outlet dimensions are automatically updated for each iterative step during pond sizing. Inverts and dimensions of lower orifice, upper orifice, and overflow weir are provided, as shown in Figure 11 below. For locations of the various dimensions, reference the **Facility Schematic** tab.

Facility Schematic: For ponds sized using **Simple Geometry**, the schematic is a generic representation of the detention pond facility sized by the tool. The figure depicts the main features of the outlet structure with the locations of their inverts. The overflow weir is at 1 foot below the 10-year pond water surface elevation. It is assumed that the pond will need to include additional freeboard (typically 1 foot) above the 10-year water surface elevation.

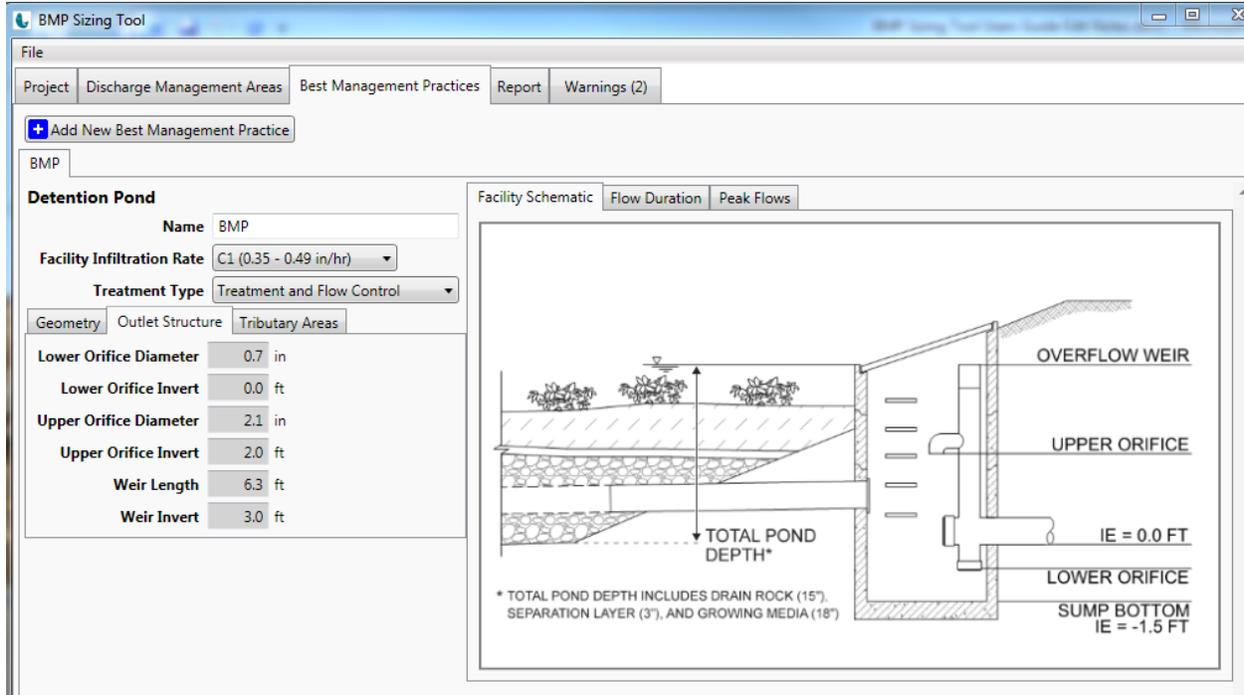


Figure 11. Outlet structure dimensions of the detention pond designed by the tool

Flow Duration: For each iterative step during pond sizing, the tool compares the pre-project and post-project flow duration. The flow duration comparison curves are displayed when the user clicks the **Flow Duration** tab, shown in Figure 12 and indicated by the green arrow. The flow duration comparison is available for ponds sized with both the **Simple Geometry** and **Custom Geometry** options.

Figure 12 also shows the flow duration curve for the flow range of interest, i.e., between the lower flow threshold (0.42Q2) and the upper flow threshold (Q10). Notice that the Mitigated, Post development curve falls below the Pre-development curve for ponds sized adequately.

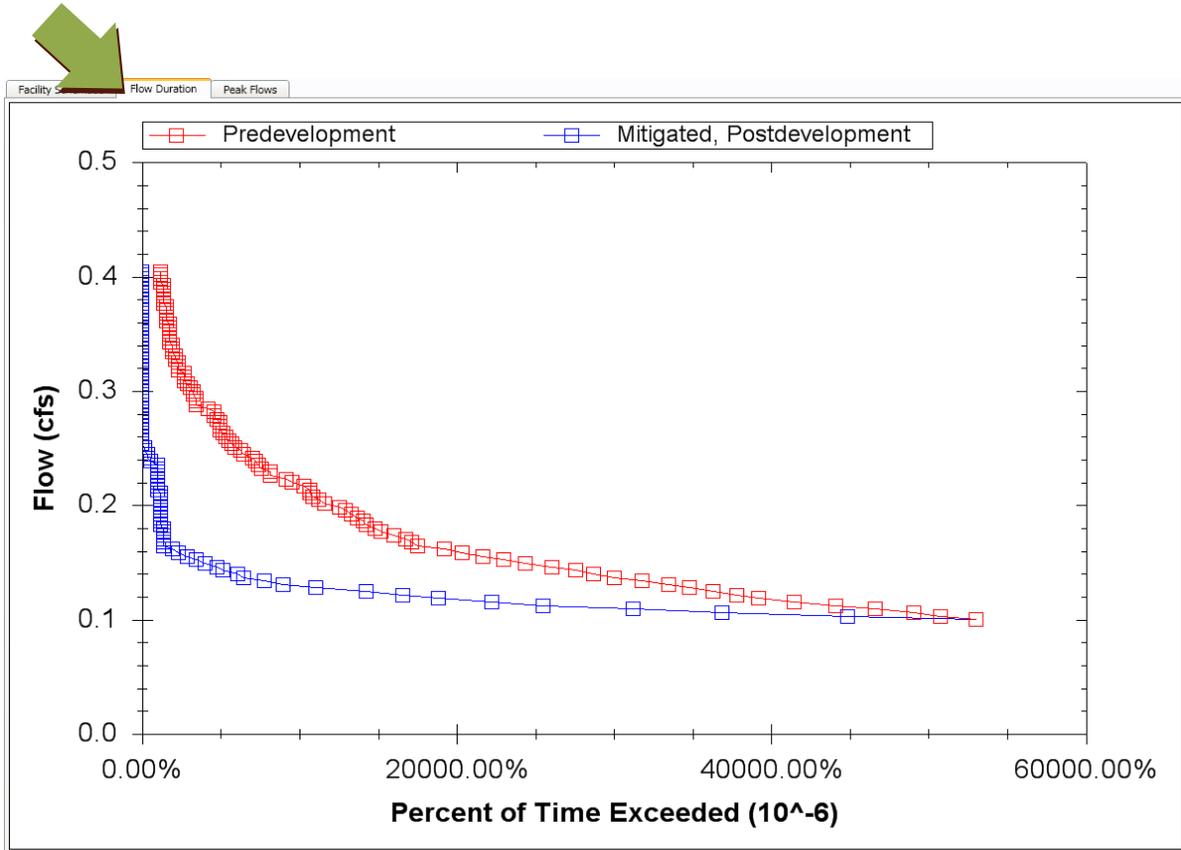


Figure 12. Example flow duration comparison curves displayed by the tool

Peak Flow Frequency: Similar to flow duration curves, the BMP Sizing Tool compares the pre-project and post-project flow frequency. The flow frequency comparison curves are displayed when the user clicks the **Peak Flows** tab, as shown in Figure 13 and indicated by the green arrow. Mitigated, Post-development peak flows are lower than the Pre-development flows for ponds sized adequately. The flow frequency comparison is available for ponds sized with both the **Simple Geometry** and **Custom Geometry** options.

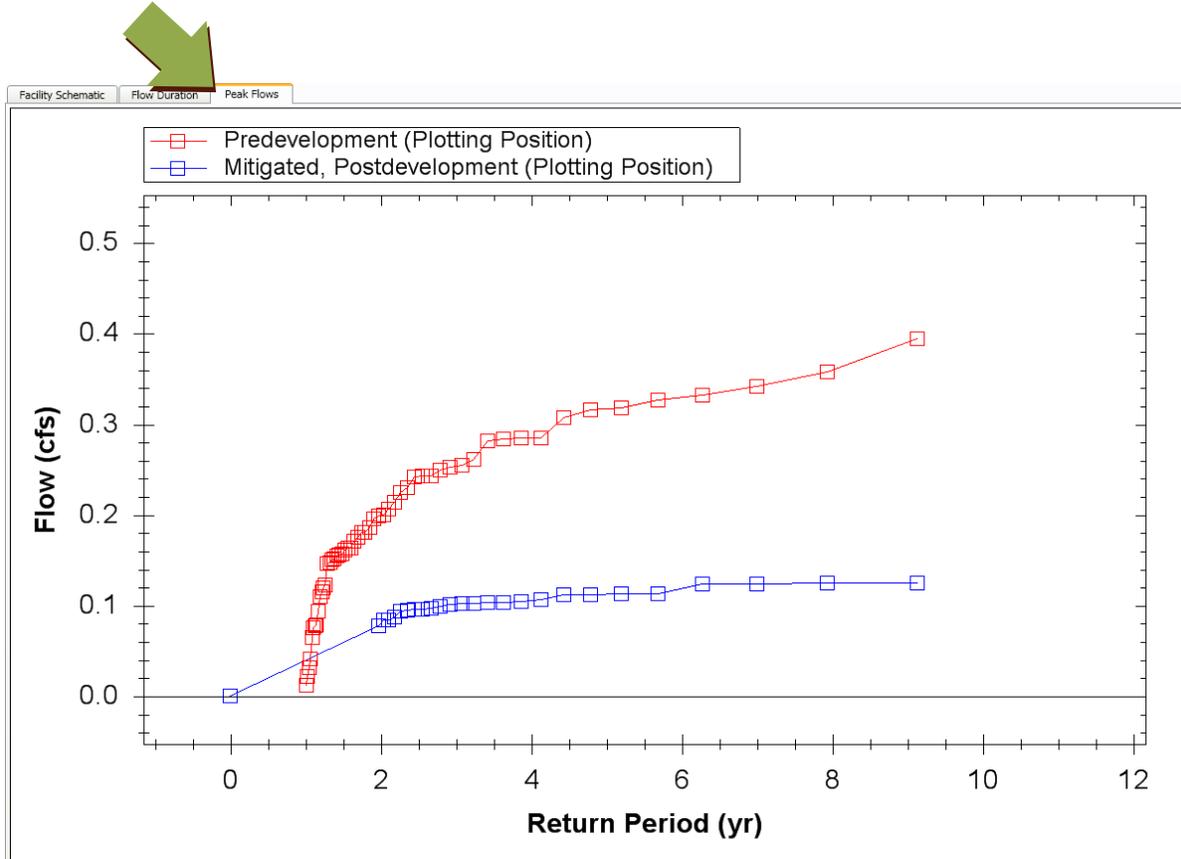


Figure 13. Example peak flow frequency comparison curves displayed by the tool

Output Files: For either the **Simple Geometry** or **Custom Geometry** pond sizing, a selection is provided for providing output files for the time series data. If the user checks the box that says “output intermediate time-series data to file,” the tool will save files for both undeveloped and post-developed mitigated conditions. Files include flow duration curves, flow events, and runoff data. The “output folder path” entry field in the tool allows the user to specify the location for files to be saved.

Section 10.0 Report

The **Report** tab captures all relevant information about the project in one location. View the Summary Report by clicking the **Report** tab. If the user decides to add a detention pond and the pond is undersized, a warning will pop up and a report will not be generated. Additionally, the user may export and save the Summary Report in a PDF file format by choosing the *Export to PDF File* option under the *File* menu (Figure 14).

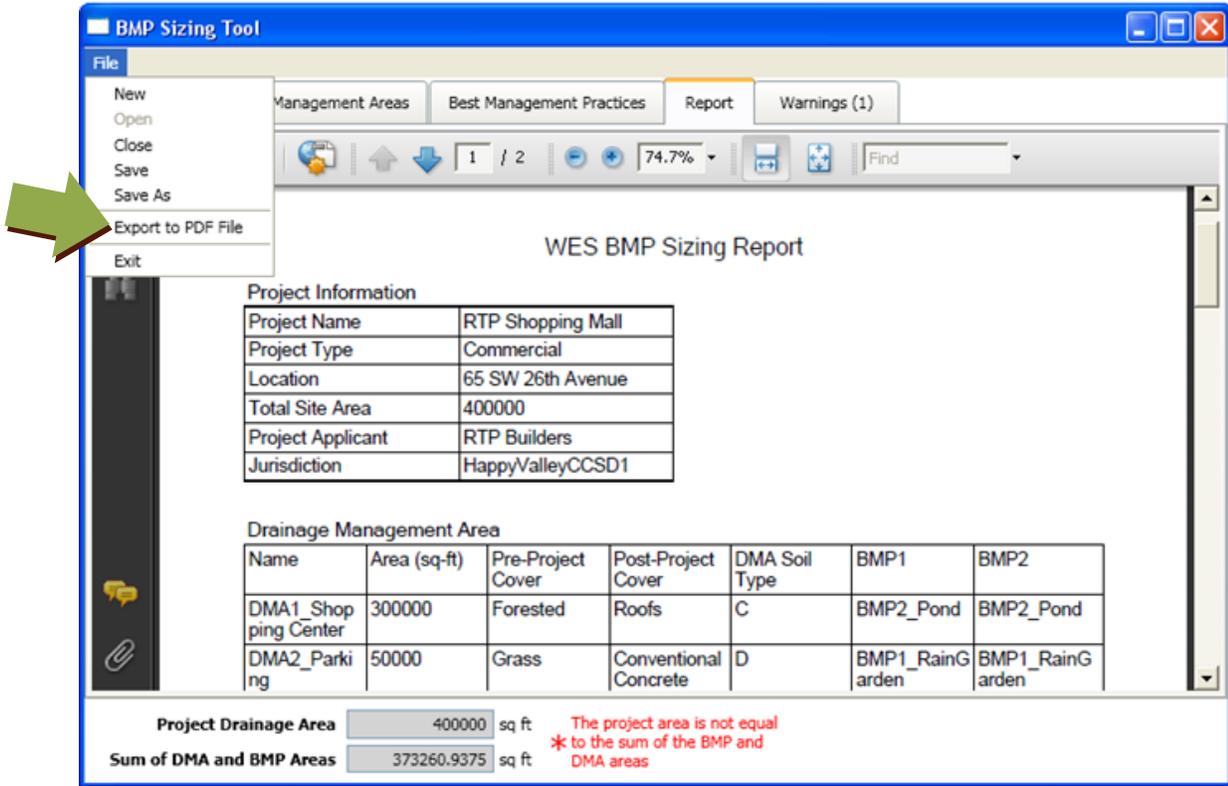


Figure 14. Summary report in PDF file format

Section 11.0 Warnings

The **Warnings** tab collects and reports important calculation warnings and errors for the project. The information in this section may include missing or zero data, BMPs that are undersized, mismatches between total project area and DMA or BMP areas, and other relevant messages. The **Warnings** tab is updated dynamically any time project information is changed and is a useful way to check the validity and completeness of the project input. The information is also included with the Summary Report upon export. An example **Warnings** tab display is shown in Figure 15.

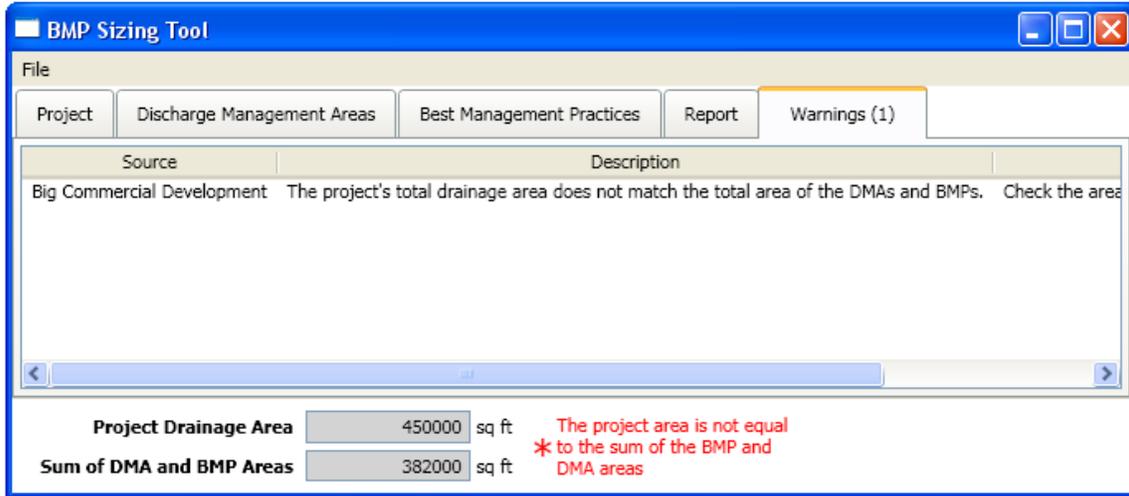


Figure 15. Warnings tab message example

Message displayed when the total drainage area does not match the sum of proposed DMA and BMP areas.

Appendix A: Responses to BMP Sizing Tool Questions

Appendix A

Responses to BMP Sizing Tool Questions

As the development community has been using the BMP Sizing Tool, questions and requests for further clarification have arisen. This appendix provides a list of those requests and associated responses.

1. What is the basis for the LID facility sizing calculations?

In developing the BMP Sizing Tool, LID BMPs were evaluated using a continuous-simulation hydrologic model (Hydrological Simulation Program-Fortran [HSPF]) that runs a long-term (1947 to 2007) record of historical hourly rainfall data. For each pre-development and post-development surface condition, a 1-acre hypothetical drainage area (unit parcel) was defined. The long-term hourly rainfall record was run through the HSPF model to obtain pre-development flows for each unit parcel. For each facility type and facility infiltration rate, the long-term hourly rainfall record was also run through the HSPF model to obtain post-development flows for a 1-acre impervious area. Flow duration curves reflecting runoff from each pre-developed and post-developed unit parcel were then compared to each other. The HSPF model was used to size facilities (based on facility dimensions provided in the facility details) to manage the post-development flows so that outflow from a facility matched the pre-development flow duration curve for the range of flows considered to have the greatest erosive impact on open-channel systems (42 percent of the 2-year peak flow to the 10-year peak flow).

Once a facility was sized for the 1-acre unit parcel, a sizing factor was developed. The sizing factor is the required surface area of the facility by the 1-acre unit area for specific combinations of runoff and infiltration conditions. These sizing factors are provided in Appendix B for both the “flow control and treatment” and “treatment only” sizing options. For LID BMPs, the BMP Sizing Tool acts as a calculator, drawing on these sizing factors to size facilities.

2. How does the BMP Sizing Tool deal with the time of concentration (TOC) for runoff from the drainage areas used to size BMPs?

The long-term runoff hydrographs mentioned above were generated from the hypothetical 1-acre unit drainage areas using HSPF’s runoff routing technique. The routing technique is based on the Chézy-Manning equation and an empirical expression that relates outflow depth to the facility storage. The calculations for routing in the model required the following three inputs:

- NSUR = Manning’s n (roughness coefficient) for the overland flow plane
- LSUR = length of the overland flow plane (ft)
- SLSUR = slope of the overland flow plane (ft/ft)

TOC is not used by the HSPF model for routing flow as it is with more traditional runoff approaches, such as the rational method, which is based on a synthetic 24-hour unit hydrograph instead of a long-term runoff hydrograph. Alternatively, the routing is calculated as a function of the three variables listed above.

Traditional methods of calculating flow are focused on a different outcome from the continuous-simulation method, which is used as the basis for the BMP Sizing Tool. The outcome of traditional methods is typically a single peak flow used to size conveyance systems, which would be more highly sensitive to TOC. The BMP Sizing Tool looks at durations of flows over the long term to see how they compare to each other for pre- and post-development conditions.

3. TOCs vary depending on slope; so how is slope taken into account in the sizing tool?

When the tool was originally being developed for Clackamas County WES, a sensitivity analysis was conducted to see how the slope of the facility drainage areas would affect flows. Hydrologic continuous simulations were run for a unit 1-acre parcel of grass land cover and C soils for three different slopes (5 percent, 10 percent, and 15 percent). The sensitivity analysis was not conducted for forested conditions because grass cover (which generates more runoff) would be more sensitive to changes in slope than forested conditions. After reviewing the sensitivity analysis results for flows, WES elected not to include multiple options in the tool for slope. WES instead elected to assume a 5 percent slope for all pre-developed surface conditions (consistent with the Johnson Creek HSPF model on which the tool is based) and a 1 percent slope for the post-developed impervious areas. The sensitivity analysis was conducted on the drainage area runoff only and not on the ultimate BMP sizing factor.

Runoff parameters for various land surfaces used in the tool were based largely on the calibrated parameters from a Johnson Creek model (previously developed by WES) that did not vary slope; all pervious surfaces were assumed to have a 5 percent slope. In keeping with 5 percent for the BMP Sizing Tool model runs, the tool remained consistent with the calibrated parameters from the Johnson Creek model, which included parameters for infiltration and soil storage.

4. If the user has varying types of post-development surface covers in the drainage area, how can he/she route these various surface covers/drainage areas to one facility?

Yes. If there are multiple types of post-development surface covers on the site, each of the areas should be delineated separately and entered separately in the BMP Sizing Tool under the **Discharge Management Areas** tab. For example, if a school site has three separate post-development areas (e.g., landscape, parking lot, roof) draining into a single stormwater management facility, enter each of these three areas as individual DMAs. Then, create a BMP facility (e.g., a vegetated swale), and add multiple "Upstream DMAs" by repeatedly selecting the "Add upstream DMA." box in the **Best Management Practices** tab.

5. What flows should developers use to size conveyance pipes on the downstream end of a detention facility?

The BMP Sizing Tool sizes facilities to manage the 10-year peak flow (based on continuous simulation.) However, most design standards require conveyance systems to be sized for the peak flow from a 25-year, 24-hour design storm. There are two general approaches to size conveyance systems downstream of detention facilities.

The first option would be to size the conveyance pipe for the 25-year peak flow discharging from the upstream drainage area without accounting for any mitigation of flows from detention. This would be the most conservative option.

The second option would be to take the configuration of the facility sized using the BMP Sizing Tool and use a separate tool/model such as Storm Water Management Model (SWMM) to estimate outflows from the facility for a traditional Soil Conservation Service (SCS) Type 1A 24-hour, 25-year event. Then, the conveyance downstream of the facility could be sized for the flow exiting the facility during a 25-year design event. This option would provide credit for flows mitigated by the detention facility. The disadvantage to this option is that it would require a fair amount of sophistication on the part of a design engineer to simulate the various functions of the detention facility including surface storage, soil media storage, and infiltration.

Individual jurisdictions would need to be consulted regarding the allowable option.

6. Why doesn't the tool allow users to have a pre-development condition of impervious area? Some sites may include the removal of impervious surface and replacement of that impervious surface with a landscaped/pervious area.

The design criteria used to address hydromodification impacts are based on ensuring that the post-development erosive peak flow levels are limited to pre-development conditions. Therefore, for both new development and redevelopment, Oregon City and Wilsonville standards require that the pre-development surface conditions should reflect historical conditions (i.e., grass or forest). Even when the pre-development condition is impervious surface, it should be included in the BMP Sizing Tool as grass or forest. See also the answer to the following question.

7. If the pre-development condition is Oak Savannah, what pre-development land use should be selected: forest or grass?

Guidance for this is provided in the Wilsonville *Stormwater and Surface Water Design and Construction Standards*, Section 301.4.05.a.4 as follows:

For the purposes of hydrologic modeling, the pre-developed conditions of the site will be modeled as the historical vegetation which existed at the site prior to urban settlement. In many areas of the City, the pre-developed vegetation included Oak Savannah, which should be modeled in the sizing tool as grass. Areas of the City that were cultivated for agriculture prior to urban development also may be modeled as grassland under the pre-developed condition requirements. The applicant may use historic photos, reports, or other available sources to document the condition of the site prior to urban settlement.

8. Would it be possible to use the tool to design and reconfigure an existing detention facility so that it would meet the new flow duration standard?

Yes, users can use the BMP Sizing Tool to do this. The user should use the custom pond design feature of the tool, select an appropriate facility infiltration rate, and enter a stage, surface area, and discharge relationship for the existing facility. The user will need to iteratively estimate outlet configurations and enter information in the custom table for area and outflow for selected increments of pond depth. When the user clicks on "check the pond size," the tool will run the hydrographs through the facility based on the stage/area/discharge relationship and report whether the facility passed or failed in terms of meeting the flow duration standard. The tool does not specify an orifice size; that information is entered by the user. The user has to conduct an iterative trial-and-error process with pond and orifice dimensions (outlet configuration) to optimize pond sizing.

9. What level of protection is the detention pond depth providing?

The total pond depth provided by the simple pond configuration in the tool reflects a minimum of 4 feet, which includes the 3 feet of media. So, at a minimum, there should be 1 foot of depth for water. For example, if the tool gives the user a total pond depth of 5 feet, then he/she would have 3 feet of media layers and 2 feet of water depth. The top of the pond depth (maximum water surface elevation) represents the 10-year water surface elevation. The overflow is set at 1 foot below this level. One foot of freeboard is then also recommended on top of the 10-year water surface elevation.

10. Because the BMP Sizing Tool provides flow control only up to the 10-year storm event, how does one account for safe passage of the 100-year storm and set the overflow?

The language in the design standards for both Oregon City (4.7.7.B) and Wilsonville (301.4.09.i) refers to both a pond overflow system and a pond embankment for an emergency spillway. For the pond overflow system, Wilsonville's standards state that "A pond overflow system shall provide for discharge of the design storm event without overtopping the pond embankment or exceeding the capacity of the emergency spillway." The design storm event in this case is the 10-year peak flow event.

The second part of the requirement is to “Provide an emergency spillway sized to pass the 100-year storm event or an approved hydraulic equivalent.” The BMP Sizing Tool would not be used to address the 100-year overflow requirement. The engineer should determine the 100-year flow and design the spillway accordingly and using details provided in the standards (e.g., Wilsonville Detail Drawing S-2275). The engineer needs to ensure passage of the 100-year storm through this spillway but there is discretion in terms of how this is accommodated. The engineer could add depth to the pond and include a relatively narrow spillway—or have less depth added to the pond with a wide and shallow spillway. These calculations are separate from the BMP Sizing Tool and rely on more traditional methods.

11. How does a traditional synthetic 24-hour design storm differ from continuous-simulation design storms used by the tool?

Synthetic design storms are a product of rainfall depth and storm shape/distribution (i.e., hyetograph) as follows:

- a) Rainfall depth: The synthetic storms come from the National Oceanic and Atmospheric Administration (NOAA) Atlas isopluvial maps for each state. In terms of how they are derived, typically, a long-term rainfall record is used. The rainfall data are evaluated for 24-hour periods. The greatest 24-hour rainfall total is pulled from each year in the long-term record. Then a statistical evaluation is conducted on the series of annual maximum 24-hour rainfall totals to find the 24-hour rainfall total for different recurrence intervals (i.e., 24-hour rainfall total that is expected to occur every 5 years, 10 years, etc.). So the rainfall totals are based on real rainfall data.
- b) Rainfall distribution: One of the issues is that the design storm development is based on rainfall amounts in a 24-hour period and not rainfall intensities or how the rainfall is distributed. Given that these distributions/intensities are not evaluated, a synthetic distribution is used to spread that 24-hour rainfall total out over the day (SCS Type IA distribution from a federal publication TR-55). This is where the conservatism comes in as the rainfall distribution includes high intensities. Rainfall in the Northwest is typically more drawn out (beyond 24 hours) and more steady in nature than in other regions. This distribution was intended to be conservative as the focus was on flood protection.

Instead of looking at rainfall depths, the design tool was based on looking at peak flows that result from the actual rainfall record. A long-term rainfall record is run through a model to generate a long-term series of peak flows. The design storms from the tool are based on the recurrence interval of those peak flows instead of the recurrence interval of a rainfall amount.

12. Why do users have to enter a soil type and then also enter an infiltration rate?

In the **Discharge Management Areas** tab, a soil type is required for the drainage area. This is used to calculate the runoff generated from the DMA that is draining to the BMP facility.

The design standards manual requires infiltration testing at the location where the BMP facility is going to be installed. So, the infiltration rate that the user is required to enter in the **Best Management Practices** tab is entered as the result of the infiltration test conducted at the location of the BMP. This information is used to evaluate the effectiveness of the proposed facility in managing flows.

13. What is the infiltration standard that is being met by the tool?

The tool does not have an infiltration standard or level per se. Some of the facilities are actually lined. The standard being met by the tool is that the facilities will achieve treatment of 80 percent of average annual runoff, and that discharges from the facility will match the pre-development duration of peak flows between 42 percent of the 2-year peak flow and the 10-year peak flow. The user inputs the infiltration rate of the soil and the tool takes that information into account in sizing the facility to meet the standards. If the facility infiltration rate at the facility is small, then the facility will need to be bigger than when the facility infiltration rate is high. No specific level of infiltration is required.

14. If the user uses the BMP Sizing Tool to size a facility and selects the “treatment only” option for sizing as opposed to the “flow control and treatment” option, how are the facilities being sized?

The sizing factors were developed based on conducting model runs for all the varying conditions using continuous simulation to iteratively size the facilities until 80 percent of the runoff was treated by the facility, with 20 percent or less of the flow bypassing the facility. If a designer chooses to use the engineered method (as opposed to the BMP Sizing Tool) to size water quality treatment only facilities, he/she would need to use a 1-inch, 24-hour design storm for this sizing if he/she is not using continuous simulation. This 1-inch, 24-hour storm was based on a rainfall analysis that was conducted to identify what size storm represents 80 percent of average annual runoff in the region.

If the facility is sized for flow control and treatment, then it matches flow durations between 0.42Q and 10Q. A check was done when building the tool to ensure that sizing the facility for flow duration matching would also meet the 80 percent treatment requirement. Whichever design criterion was more stringent was the driver for the facility size.

15. How do we size facilities that must be lined regardless of being within soils that have moderate to high infiltration rates? Sometimes lining is needed because of proximity to landslide-prone areas or building foundations.

Sizing factors that were used for tool development are provided in Appendix B. Sizing factors are multiplied by the site impervious area to get the facility size. As seen in Table B-1, when the user has B soils in the basin—or A1, B1, B2, B3 infiltration rates at the location of his/her BMP facility—sizing factors were not developed for the tool. The thought at the time of tool development was that if a project site has good infiltration rates, then the BMP design would take advantage of them as much as possible and get some infiltration benefit from the facility.

In the BMP sizing table, for forested pre-development conditions for C soils, for lined facilities, the sizing factors are quite high. It is likely in these instances that the designer would choose to default to a 10 percent maximum sizing factor as allowed by each jurisdiction. If the project site had B soils draining to a lined facility, the sizing factors would be even higher—so again, designers would likely default to 10 percent maximum facility size and use the orifice sizes specified for the larger facility.

16. When choosing lined facilities, why are planters larger than rain gardens when using similar inputs for DMAs?

This is mostly due to the difference in media depths required for the facilities. The media depth for filtration rain gardens is 39 inches as opposed to 33 inches for filtration planters. This makes the rain gardens more effective and hence smaller in surface area requirements. See Appendix B for sizing factors.

17. When choosing unlined facilities, why are rain gardens larger than planters when using similar inputs for DMAs?

This is due to the difference in media depths required for the facilities. For the infiltration planter, the media is 49 inches deep as opposed to 39 inches deep for the rain garden.

18. Why are facilities larger when the DMA includes B soils as opposed to C soils when B soils have better infiltration?

This result is a bit counterintuitive. In the **Discharge Management Areas** tab, the user is selecting the soil type for the drainage basin. What is entered here plays into the runoff generated from the basin. So, if a project site has a B soil, the site has better infiltration and very low runoff rates in the pre-development condition. Therefore, a larger facility would be required to match the low pre-development runoff rates. As another example, if a site has total infiltration in pre-development, then in post-development the facility must be large enough to match total infiltration. On the other hand, if a project site has D soils for pre-development with high runoff rates, then paving the area makes less of a difference because the site is essentially changing from impervious to impervious. So a smaller facility is required to match a pre-development condition that is not very different from impervious surface.

In the **Best Management Practices** tab, the user enters, a facility infiltration rate. That is the infiltration rate at the location of the proposed facility. That number does not play into the runoff generated for pre-development conditions. That number plays into how effective the facility is. A higher infiltration rate at the facility location will help to reduce the facility size.

19. For the detention pond, is the overflow weir at the same elevation as the total pond depth?

The tool sizes the pond to match pre- and post-development peak flow durations of the pond discharges between 42 percent of the 2-year peak flow and the 10-year peak flow. To meter out the discharge, the tool assumes a lower orifice, upper orifice, and overflow weir as follows:

- **Lower Orifice:** The invert elevation of the lower orifice should be at the pond bottom (i.e., elevation at the bottom of the 3 feet of drain rock/growing media).
- **Upper Orifice:** The upper orifice should be at an elevation of 0.67 (2/3) of the pond depth (pond depth here really refers to the design depth of the water surface).
- **Overflow Weir:** The overflow weir should be at 1 foot below the pond depth (again, pond depth here refers to the design depth of the water surface). The assumption is that the overflow weir is a 2-foot-diameter standpipe and therefore the overflow weir length is the circumference of that standpipe (or 6.28 feet). As water builds up to the pond depth/design water surface depth, the 2-foot-diameter standpipe will restrict the outflow to the point where the head builds up to the 10-year design depth. There needs to be some room between the overflow weir and the design water surface elevation in order for some head to build up above the weir.

There has been confusion over the term “pond depth” in the tool. In the graphic provided in the tool for this BMP type, the term “pond depth” refers to the depth of the design water surface elevation. For Oregon City and Wilsonville, the details show some freeboard depth on top of that design water surface elevation—so the total facility depth would need to include that freeboard.

20. What rainfall record was used as the basis for the tool?

The long-term rainfall file that was used to develop the tool was developed by Pacific Water Resources (PWR) when it developed a calibrated model for Johnson Creek. It is a compilation of data from several gauges as follows:

- Hourly data from the WES Clackamas Interceptor (CI) gauge was used whenever available. Its period of record is 2001 to 2004.
- The Pleasant Valley gauge was used to fill periods before the CI gauge was installed or for which CI data were missing. The Pleasant Valley gauge data begin in 1979 and continue to at least 2004. No adjustment was made to the Pleasant Valley data because there was no significant local variation between this gauge and the study area.

- The Kelly School gauge was used to fill periods before the Pleasant Valley gauge and for which data from the previous gauges were missing. Its period of record begins in 1973. No adjustment was made to the Kelly School data because there was no significant local variation between this gauge and the study area.
- The Portland International Airport (PDX) gauge was used to fill periods before the Kelly School gauge and for which data from the previous gauges were missing. Its period of record begins in 1948. The PDX rainfall was adjusted to account for the difference in intensity-durations between its gauge and Pleasant Valley gauges. The result reflects the rainfall for the study area over a wide range of rainfall intensities. PWR updated the 2004 rainfall record in 2008. The new record runs from 1947 to 2007. The PDX gauge was used for 1947 to 1948 to supplement the 2004 file. It appears that the data from the CI gauge were extended to 2007; however, Brown and Caldwell was not able to locate documentation to confirm this.

21. Does the BMP sizing tool account for added surface area due to required freeboard depths for filtration swales and filtration rain gardens?

No, the surface area provided by the sizing tool is reflective of the surface area at the water surface/overflow elevation. Additional area would be needed for addressing freeboard based on the side slopes of the facility.

Appendix B: BMP Sizing Factors

Table B-1. Sizing Factors for Treatment and Flow Control Facilities

Table B-2. Sizing Factors for Treatment Only Facilities

Table B-1. Sizing Factors for Treatment and Flow Control Facilities

Cover and soil type of drainage area	Forest B				Forest C									Forest D								
Soil type under facility footprint	A1	B1	B2	B3	A1	B1	B2	B3	C1	C2	C3	D1	Lined	A1	B1	B2	B3	C1	C2	C3	D1	Lined
Rain garden filter									0.08	0.09	0.11	0.13	0.15					0.04	0.04	0.04	0.04	0.04
Rain garden infiltration	0.11	0.13	0.17	0.21	0.05	0.05	0.07	0.10						0.04	0.04	0.05	0.07					
Planter filter									0.1	0.11	0.15	0.19	0.23					0.03	0.03	0.03	0.03	0.03
Planter infiltration	0.11	0.12	0.14	0.18	0.04	0.04	0.05	0.07						0.03	0.03	0.04	0.06					
Vegetated swale filter									0.1	0.12	0.15	0.17	0.19					0.04	0.04	0.05	0.05	0.05
Vegetated swale infiltration	0.12	0.15	0.18	0.23	0.05	0.05	0.06	0.09						0.04	0.04	0.05	0.05					
Infiltrator	0.09	0.1	0.13	0.17	0.05	0.05	0.07	0.09						0.04	0.04	0.05	0.05					
Cover and soil type of drainage area	Grass B				Grass C									Grass D								
Soil type under facility footprint	A1	B1	B2	B3	A1	B1	B2	B3	C1	C2	C3	D1	Lined	A1	B1	B2	B3	C1	C2	C3	D1	Lined
Rain garden filter									0.05	0.05	0.05	0.05	0.05					0.04	0.04	0.04	0.04	0.04
Rain garden infiltration	0.1	0.11	0.15	0.18	0.05	0.05	0.05	0.07						0.04	0.04	0.05	0.05					
Planter filter									0.04	0.04	0.04	0.04	0.07					0.03	0.03	0.03	0.03	0.03
Planter infiltration	0.08	0.1	0.11	0.15	0.04	0.04	0.04	0.04						0.03	0.03	0.04	0.04					
Vegetated swale filter									0.05	0.05	0.06	0.07	0.07					0.04	0.04	0.04	0.04	0.04
Vegetated swale infiltration	0.1	0.11	0.15	0.2	0.04	0.04	0.04	0.06						0.04	0.04	0.05	0.05					
Infiltrator	0.07	0.08	0.11	0.14	0.05	0.06	0.07	0.1						0.04	0.04	0.05	0.05					

Table B-2. Sizing Factors for Treatment Only Facilities

Cover and soil type of drainage area	Forest B & Grass B				Forest C & Grass C									Forest D & Grass D								
Soil type under facility footprint	A1	B1	B2	B3	A1	B1	B2	B3	C1	C2	C3	D1	Lined	A1	B1	B2	B3	C1	C2	C3	D1	Lined
Rain garden filter									0.015	0.015	0.015	0.015	0.015					0.015	0.015	0.015	0.015	0.015
Rain garden infiltration	0.015	0.02	0.025	0.035	0.015	0.02	0.025	0.035						0.015	0.02	0.025	0.035					
Planter filter									0.015	0.015	0.015	0.015	0.015					0.015	0.015	0.015	0.015	0.015
Planter infiltration	0.015	0.015	0.02	0.03	0.015	0.015	0.02	0.03						0.015	0.015	0.02	0.03					
Vegetated swale filter									0.015	0.015	0.015	0.015	0.015					0.015	0.015	0.015	0.015	0.015
Vegetated swale infiltration	0.015	0.02	0.025	0.035	0.015	0.02	0.025	0.035						0.015	0.02	0.025	0.035					
Infiltrator	0.015	0.02	0.025	0.035	0.015	0.02	0.025	0.035						0.015	0.02	0.025	0.035					