SPLASH BOXX

DEMONSTRATING COMPLIANCE WITH ECOLOGY'S MINIMUM REQUIREMENTS AND USING THE WESTERN WASHINGTON HYDROLOGY MODEL (WWHM 2012) TO SIZE AND EVALUATE WATER QUALITY AND FLOW CONTROL PERFORMANCE OF SPLASH BOXX

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Note:
Some pages in this document have been purposely skipped or blank pages inserted so that this document will copy correctly when duplexed.

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Introduction

Splash Boxx is a vertical-walled, bioretention planter box, constructed of steel. Splash Boxx accommodates a profile of aggregate (with underdrain), bioretention soil, vegetation (including trees, shrubs, grasses, and/or other herbaceous plants), and live storage (ponding) to promote the detention and filtration of stormwater runoff. Splash Boxx provides treatment as water infiltrates through the bioretention soil. An orifice on the Splash Boxx underdrain detains flows, providing flow control (i.e., peak reduction). The soil media also provides some attenuation of flows as water ponds and filters through the soil.

Designers can route stormwater runoff to a Splash Boxx from areas such as roofs, elevated parking structures, and other surfaces where site grades permit. Additionally, designers can pump stormwater from catch basins or oil/water separators to a Splash Boxx for mitigation.

This document aims to assist designers in applying Splash Boxx facilities to meet the Washington State Department of Ecology (Ecology) stormwater requirements presented in the 2012 Stormwater Management Manual for Western Washington (SWMMWW). This document includes:

- Guidance for demonstrating compliance with Ecology's stormwater Minimum Technical Requirements #5, #6, and #7
- Step-by-step instructions for sizing and evaluating the performance of Splash Boxx using the Western Washington Hydrology Model, Version 2012 (WWHM2012)

This guidance includes methods for sizing Splash Boxx best management practices (BMPs) to fully comply with Ecology minimum requirements for water quality treatment (Minimum Requirement #6) and for evaluating the performance (i.e., partial or full compliance) of Splash Boxx BMPs relative to Ecology flow control (Minimum Requirement #7) and On-site Stormwater requirements (Minimum Requirement #5).

Refer to the 2012 SWMMWW for a complete list of criteria for each Minimum Requirement, including thresholds for installation of BMPs and infeasibility criteria for each BMP. For guidance on general model setup, including selection of a precipitation series, representation of pre- and post-developed (mitigated) land covers, and general model framework, refer to the WWHM2012 Manual.

Using Splash Boxx for Compliance with Minimum Requirements

The applicability of Ecology's Minimum Requirements to a particular project is determined based on the type and size of the proposed development relative to Ecology-defined thresholds outlined in the 2012 SWMMWW. Refer to Volume I, Chapter 2, of the 2012 SWMMWW to determine stormwater requirements for a particular project.

The following sections supplement the 2012 SWMMWW by providing additional guidance to support designers in using Splash Boxx to partially or fully comply with the Minimum Requirements. On sites where multiple requirements are triggered for a given surface, the

designer must meet each of the requirements at the designated point of compliance. Note that compliance with any of the Minimum Requirements at the outlet of the Splash Boxx is not proof of overall site compliance.

Minimum Requirement #6 - Water Quality Treatment

Per the 2012 SWMMWW, sites triggering Minimum Requirement #6 must infiltrate or filter at least 91 percent of the total runoff volume through a soil mix that meets Ecology's requirements for bioretention soil media. Using continuous hydrologic modeling (described in *Part 5: Evaluating Splash Boxx Performance*, below), the designer can size Splash Boxx to provide basic, enhanced, and oil control treatment for a contributing pollution-generating surface. In addition to complying with the requirements for bioretention facilities with underdrains outlined in the 2012 SWMMWW, the designer should review the following design and siting considerations to help ensure Splash Boxx compliance with the treatment requirements.

Co-mingling Splash Boxx-Treated Runoff: As is the case for all bioretention facilities with underdrains (and other treatment BMPs), if treated effluent from the Splash Boxx is mixed with runoff from other pollution generating surfaces that trigger water quality treatment under Minimum Requirement #6, the project cannot take credit for the treatment provided by the Splash Boxx. Instead, the downstream treatment system would need to be sized to treat both the Splash Boxx effluent and any additional contributions from the site.

Because Splash Boxx is a modular system, often located above the finished grade of the site (i.e., not subsurface), treated effluent will likely re-enter the conveyance network in one of two primary ways: either via surface (such as direct discharge to sidewalk, parking lot, or road) or subsurface (such as piped) connection. In either case, the designer must consider the fate of treated flows from the underdrain to ensure that there is no co-mingling with untreated stormwater runoff from the site that triggers Minimum Requirement #6. To avoid commingling, the design should not:

1. Connect the underdrain pipe to a conveyance system carrying untreated runoff triggering Minimum Requirement #6
2. Directly discharge treated water to a surface (pollution- or non-pollution-generating) where the water will mix with untreated runoff, triggering Minimum Requirement #6, either at the surface or in the downstream conveyance network

Even if co-mingling of treated flows from the Splash Boxx with untreated runoff cannot be avoided, the addition of a Splash Boxx may still provide water quality treatment benefits. For example, if the Splash Boxx drainage area triggers both basic and enhanced treatment requirements, and the untreated runoff with which it is comingled triggers only basic treatment requirements, the downstream facility would need to provide only basic treatment for the combined flows. The designer should refer to the 2012 SWMMWW to determine the appropriate treatment measures (if any).

Modeling Multiple Splash Boxx Facilities in Series: Some applications may require, or may benefit from, the use of multiple Splash Boxx facilities to meet water quality objectives. If a contributing area requires more than one Splash Boxx and it is not possible or prudent to split flows for routing to separate facilities, the entire area may be routed to multiple Splash Boxxes designed as hydraulically connected systems in series. To meet water quality treatment objectives, the Splash Boxxes should be connected at the surface of the facility, allowing the entire water quality treatment volume (91 percent of contributing runoff) to filter through the approved bioretention soil media.

Minimum Requirement #7 – Flow Control

Per the 2012 SWMMWW, sites triggering Minimum Requirement #7 (Flow Control) are required to match pre-developed condition stormwater discharge durations for the range of pre-developed discharge rates from 50 percent of the 2-year peak flow up to the 50-year peak flow. A forested land cover is typically the target pre-developed condition; however, the 2012 SWMMWW outlines criteria for matching alternate "pre-project" conditions. Should a project satisfy those criteria, it would be subject to a less protective (e.g., pasture or existing) flow control standard. Refer to the 2012 SWMMWW to determine if a project qualifies for these provisions.

Where the pre-developed condition is forested, Splash Boxx cannot meet the flow control standard alone, but it may be used as part of a BMP train (e.g., Splash Boxx routed to an infiltration or detention facility) to reduce the size of the downstream facility by detaining stormwater and decreasing peak flows. In areas where the flow control standard allows for matching of flow durations from an existing land cover condition (i.e., basins satisfying the 40%/1985[1] criterion per the 2012 SWMMWW), Splash Boxx may be able to meet the flow control standard depending upon the facility's contributing area and outlet orifice diameter. The designer should determine the number of Splash Boxxes required and iteratively size the orifice diameter based on the area contributing runoff to the Splash Boxx and the desired performance using continuous hydrologic modeling as described in *Part 5: Evaluating Splash Boxx Performance*, below. Note that compliance with any of the Minimum Requirements at the outlet of the Splash Boxx is not proof of overall site compliance.

In addition to the Ecology-prescribed flow control requirements, many jurisdictions have other flow control standards to target their specific needs. One common requirement for combined sewer overflow control involves reducing the 1-year storm to a specified percentage of the unmanaged runoff (e.g., 95 percent reduction in the 1-year peak flow). The designer should evaluate these standards via continuous hydrologic modeling as described below.

The designer should review the following design and siting considerations to help ensure Splash Boxx compliance with the flow control requirements. Refer to the 2012 SWMMWW

[1] The 40%/1985 criterion allows areas that have had at least 40 percent total impervious area since 1985 to match existing land cover conditions instead of the default forested land cover. Appendix I-F in the 2012 SWMMWW illustrates the areas within western Washington that meet this criterion.

for complete guidance on meeting the Minimum Requirements with Splash Boxx and other bioretention facilities.

Modeling Multiple Splash Boxx Facilities in Series: Similar to the water quality treatment configuration described above, some applications may require, or may benefit from, the use of multiple Splash Boxx facilities in series to meet flow control objectives. To realize the full benefit of Splash Boxx facilities in series, they should be designed as hydraulically connected systems controlled by a single orifice. The designer should check to ensure adequate conveyance capacity through the overflow structure and should upsize the riser, as needed, to convey the design flows.

Splash Boxx Siting Considerations: Because Splash Boxx (and other bioretention facilities) is not an Ecology-approved phosphorus control facility, designers should not use Splash Boxx facilities within one-quarter mile of phosphorus-sensitive water bodies.

Minimum Requirement #5 – On-site Stormwater Management

Per the 2012 SWMMWW, sites triggering Minimum Requirement #5 (On-site Stormwater Management) are required to either:

1. Meet the Low Impact Development (LID) Performance Standard (i.e., match pre-developed-condition [typically forest] stormwater discharge durations for the range of pre-developed discharge rates from 8 percent of the 2-year peak flow up to 50 percent of the 2-year peak flow)

2. Implement BMPs from Ecology's prescribed Lists 1 and 2 (provided in the 2012 SWMMWW) for each surface type (e.g., roofs, roadway)

As with the flow control standard, it is difficult to meet the LID Performance Standard requirements with Splash Boxx (or any bioretention facility serviced by an underdrain). Further, it is infeasible to fully satisfy these requirements with a Splash Boxx on sites where the pre-developed condition is forest. However, on sites where the requirement is to match existing flow durations, the designer can size a Splash Boxx to meet the LID Performance Standard (provided the contributing area is sufficiently large). The designer should determine the number of Splash Boxxes required and iteratively size of the orifice diameter based on the area contributing runoff to the Splash Boxx and the desired performance using continuous hydrologic modeling as described in *Part 5: Evaluating Splash Boxx Performance*, below.

As an alternative to complying with the quantitative LID Performance Standard, the designer may specify a Splash Boxx to partially or fully satisfy the On-site Stormwater Management requirements per Ecology's prescribed lists. To meet the list requirements for bioretention, the Splash Boxx facility area must be 5 percent of the contributing area.

Splash Boxx Modeling Guidance

The following guidelines apply to the sizing, and evaluation of, Splash Boxx BMPs in WWHM2012 using the "Bioretention Swale" element. Splash Boxx, LLC, does not recommend

using earlier versions of the model (e.g., WWHM3) to size or evaluate the performance of Splash Boxx because the bioretention swale element in older versions of the software has limited functionality. Specifically, the WWHM2012 element allows for explicit representation of the detention function of both the bioretention soil (via infiltration into the soil media) and orifice control at the underdrain, yielding more accurate estimates of the flow control performance of Splash Boxx.

For additional information on WWHM assumptions and modeling guidance, including background information on precipitation and evaporation series selection and scaling, soil classification, HSPF parameter values, guidance for flow- and water-quality-related standards, and other model features, refer to the following documents:

- Volume III and Volume V of the 2012 SWMMWW
- Volume III, Appendix III-B, and Appendix III-C (Part 2) of the 2012 SWMMWW
- WWHM 2012 User's Manual

This document serves as supplementary guidance to that provided in the WWHM User's Manual and 2012 SWMMWW. **Users are responsible for ensuring that they adhere to the standards and modeling requirements outlined in current versions of the 2012 SWMMWW and the WWHM User's Manual.**

Users should follow the guidance provided in the 2012 SWMMWW and WWHM 2012 User's Manual to determine facility performance objectives, including the target pre-developed condition[2], and to set up their model file. Once a user selects the site precipitation series in the "Map Information" dialog box, he/she can construct the pre-project (pre-developed) and proposed (mitigated) scenarios in the "General Project Information" dialog box. The following section provides steps for defining and evaluating the Splash Boxx BMP.

Part 1: Defining the "Pre-Developed" Scenario

1. **Add and characterize the pre-developed area:**
    a. Drag and drop the "Land Use Basin" element (listed under "Basic Elements") into the schematic editor (denoted as a grid to the right of the tool bar)
    b. Enter the pre-developed area by land use type (e.g., acres of roof)
2. **Set the "point of compliance" at the pre-developed land use basin outlet:**
    a. Right click the "Land Use Basin" element and select "Connect to Point of Compliance"

[2] For evaluation of Splash Boxx performance relative to Ecology Minimum Requirements #5 and #7, the user must determine the appropriate target "pre-developed" condition for their development site. See *Part 5: Evaluating Splash Boxx Performance* and the 2012 SWMMWW for additional guidance.

b. Verify that the appropriate outlet is selected and click "Connect"

Users should always select both surface flow and interflow, and select groundwater flow only when observations of groundwater expression on the site support modeling of groundwater. For most Splash Boxx applications, interflow and groundwater flow is negligible because the contributing drainage area is predominately roof, driving, or other impervious surface.

Part 2: Defining the "Mitigated" Scenario

Figure 1 shows the Splash Boxx "Mitigated" scenario schematic editor screen.

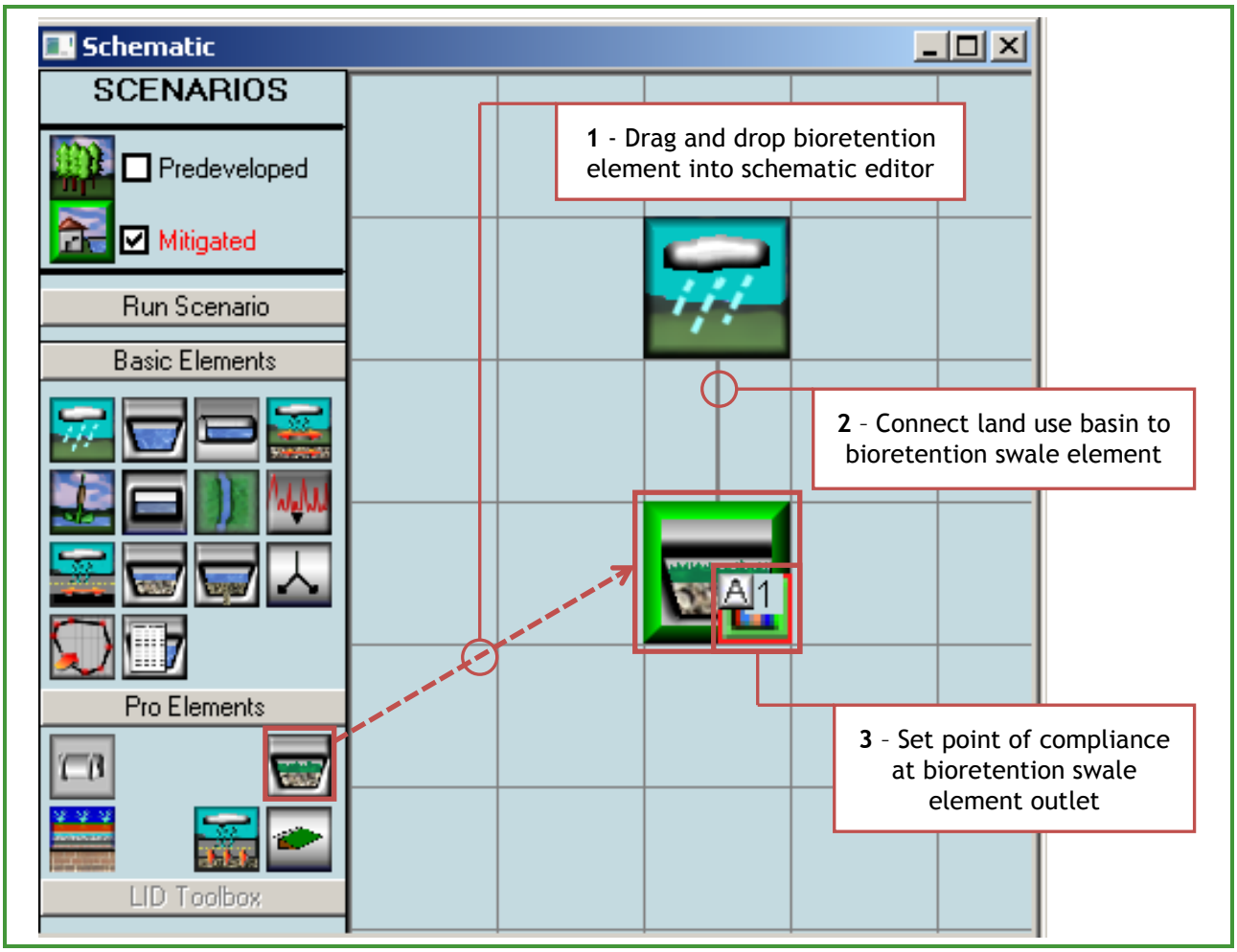

Figure 1. "Mitigated" Scenario Schematic Editor.

3. Add and characterize the area contributing runoff to the Splash Boxx BMP:

   a. Drag and drop the "Land Use Basin" element (listed under "Basic Elements") into the schematic editor (denoted as a grid to the right of the tool bar)

   b. Enter the area contributing runoff to the splash box by land use type (e.g., acres of roof).

4. **Add the Splash Boxx BMP**:

    a. Drag and drop the "Bioretention Swale" element (listed under "Pro Elements") into the schematic editor:

    This element represents the Splash Boxx BMP.

5. **Route flows from the contributing drainage area (denoted by the "Land Use Basin" element) to the Splash Boxx in the schematic editor**:

    a. Right click on the "Land Use Basin" element and select "Connect to Element"

    b. Click on the "Bioretention Swale" element defined in Step 1 to connect the basin element to the bioretention element

    c. Select desired flows to route from basin to bioretention swale in the "From Basin to Conveyance" pop-up dialog box (options include surface flow, interflow, and groundwater):

    Users should always select both surface flow and interflow, and select groundwater flow only when observations of groundwater expression on the site support modeling of groundwater. For most Splash Boxx applications, interflow and groundwater flow is negligible because the contributing drainage area is predominately roof, driving, or other impervious surface.

    d. Once the appropriate flows have been selected, click "OK" to return to the schematic editor

6. **Set the "point of compliance" at Splash Boxx outlet**:

    The SWMMWW defines "point of compliance" as "the location at which compliance with a discharge performance standard or a receiving water quality standard is measured" (2012 SWMMWW). Compliance with standards at the outlet of the Splash Boxx is not proof of overall site compliance. The designer must demonstrate that all surfaces on the site triggering requirements per the 2012 SWMMWW meet the standards at the designated point of compliance.

    a. Right click the "Bioretention Swale" element and select "Connect to Point of Compliance"

    b. Verify that the appropriate outlet is selected and click "Connect"

Part 3: Defining Splash Boxx Elements

7. Define the facility type:

    a. Click on the "Bioretention Swale" element in the schematic editor to bring up the element input screen (see Figure 2)

b. Confirm that "Use Simple Bioretention" is not selected

c. Confirm that "Underdrain Used" is selected

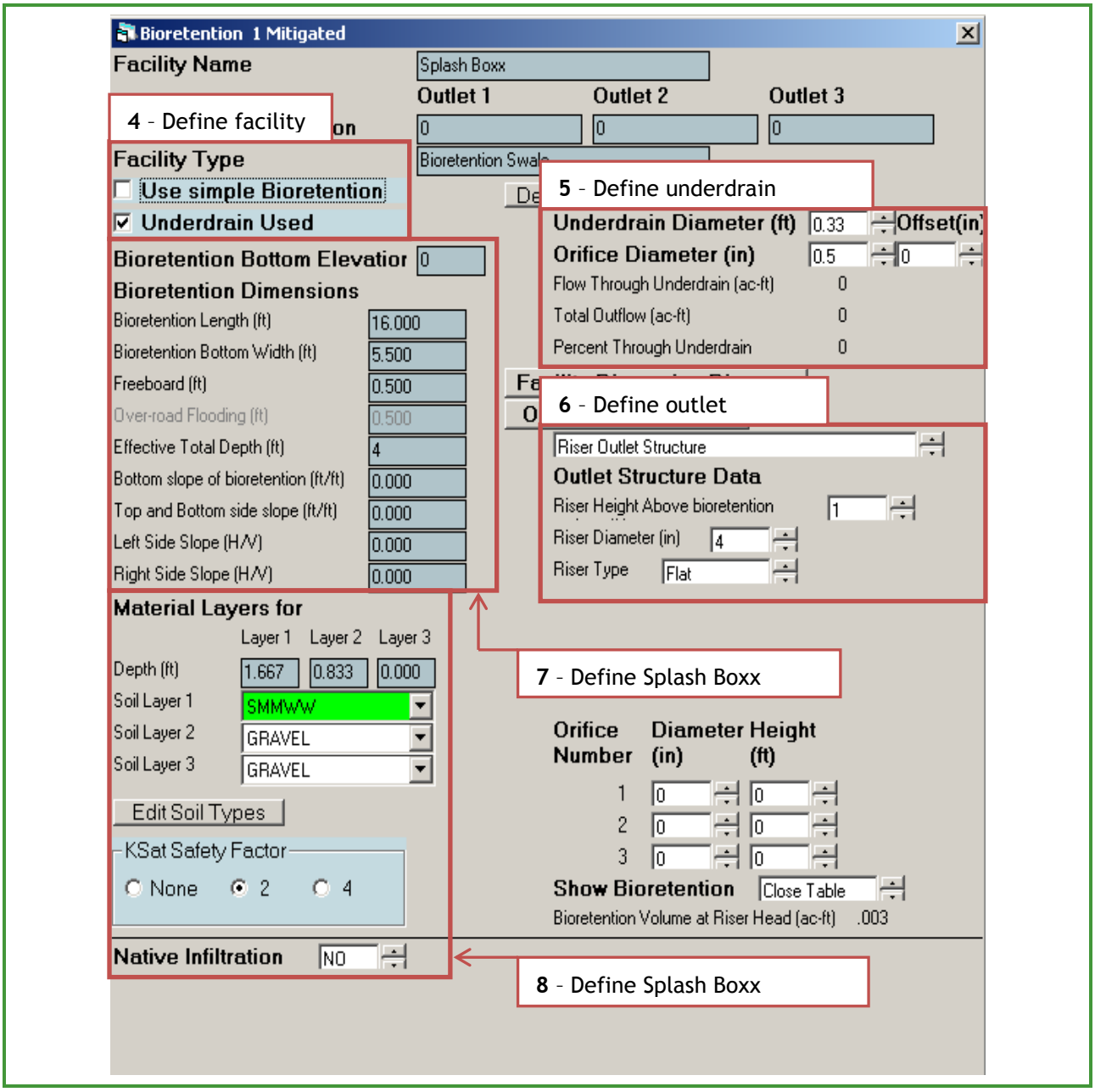

Figure 2. Bioretention Swale Element Input Screen.

8. **Define the underdrain configuration:**

a. Enter Splash Boxx underdrain configuration and dimensions, as follows:

- **Underdrain Diameter (feet):** 0.33 foot (varies) - assumes 4-inch underdrain pipe, user may specify different underdrain diameter per the design

- **Orifice Diameter (inches):** 0.5 inch (varies) – 0.5-inch diameter orifice assumed for default Splash Boxx configuration, user may specify orifice diameter per the design requirements

- **Offset (inches):** 0 inches (varies) – represents orifice offset height, measured from invert of underdrain, user may specify orifice offset per the design

9. **Define the outlet configuration**:

   a. Specify outlet configuration as "Riser Outlet Structure" (toggle outlet field from the default "Vertical Orifice + Overflow" to "Riser Outlet Structure")

   b. Enter Splash Boxx outlet configuration dimensions, as follows:

      - **Riser Height Above Bioretention (feet):** 1 foot – assumes 12 inches of ponding, user may specify riser height to satisfy design requirements

      - **Riser Diameter (inches):** 4 inches – assumes default Splash Boxx configuration, user to verify capacity of overflow structure for their site and modify riser size, accordingly

      - **Riser type:** flat – assumes no notch

10. **Define Splash Boxx dimensions**:

    a. Enter Splash Boxx dimensions in the "Bioretention Bottom Elevation" and "Bioretention Dimensions" section of the dialog box, as follows:

       - **Bioretention Bottom Elevation (feet):** 0 feet - represents the bottom of the Splash Boxx facility and serves as a reference elevation for all other facility dimensions. The user may set this elevation at the model default value of zero or enter the actual elevation of the proposed facility.

       - **Bioretention length (feet):** 16 feet - represents interior length of Splash Boxx.

       - **Bioretention bottom width (feet):** 5.5 feet (without bench seat), 4.33 feet (with bench seat) - represents interior width of Splash Boxx

       - **Freeboard (feet):** 0.5 foot, varies – calculated as the depth of storage available from the top of the Splash Boxx to the outlet riser crest. Freeboard depth may vary depending on local jurisdiction requirements or other design considerations.

       - **Over-road Flooding (feet):** 0 feet/NA (not applicable) – represents the maximum depth of water above the emergency spillway. This could be a driveway, roadway, or weir. This element does not apply to the current Splash Boxx configuration because a riser outlet controls overflow from the system instead of a weir or other surface overflow. The model greys out this cell when the user selects "Riser Outlet Structure" as the outlet structure.

- **Effective Total Depth (feet):** represents the total facility depth. The user does not need to specify the effective total depth. The model automatically populates this field as a sum of the facility freeboard, ponding depth (riser height), bioretention soil media depth, and gravel storage depth.

- **Bottom Slope of Bioretention (feet/feet):**0 feet/feet – if model is producing error messages during simulation, the user should set the facility bottom slope at a minimum of 0.001 feet/feet to reduce model instability.

- **Top and Bottom/Left/Right Side Slope (H:V):** 0 –vertical side slopes on all four sides of the Splash Boxx

11. **Define Splash Boxx material layers**:

    a. Enter Splash Boxx material layer types/dimensions, as follows:

    - **Layer 1 Depth (feet):** 1.667 feet – assumes 18 inches of bioretention soil and 2 inches of mulch, user may specify layer depth to satisfy design requirements:

      Ecology requires 12 inches of bioretention soil media to meet the flow control requirements and 18 inches to meet water quality requirements.

    - **Layer 2 Depth (feet):** 0.833 foot – assumes 10 inches of gravel storage under bioretention soil, user may specify layer depth to satisfy design requirements

    - **Layer 3 Depth (feet):** 0 feet/NA – assumes no additional storage layers provided, user may specify depth of an addition layer to satisfy design requirements

    - **Soil Layer 1:** Select "SWMMWW" from the dropdown menu – corresponds to the Ecology prescribed bioretention soil media

    - **Soil Layer 2:** Select "GRAVEL" from the dropdown menu – represents standard gravel storage layer of Splash Boxx

    - **Soil Layer 3:** NA

    - **Ksat Safety Factor:** 2 (typical) – assumes drainage area routed to a single Splash Boxx is less than 10,000 square feet of impervious surface, less than 5,000 square feet of pollution-generating hard surface, and less than 3/4 acre of native vegetation converted to lawn/landscaping. If the site design exceeds any of these thresholds, the designer should use a safety factor of 4 inches, in accordance with the 2012 SWMMWW.

    - **Native Infiltration:** Select "No"- Splash Boxx has a closed bottom that does not permit infiltration to native soil:

      Per the 2012 SWMMWW, users that opt to use soils that deviate from the recommended specifications should use the "Gravel Trench" element in WWHM3 to represent the bioretention facility. However, this approach is

not recommended for modeling Splash Boxx Facilities because the Gravel Trench element is not capable of representing the detention function of the bioretention soil; a key mechanism in the Splash Boxx flow control performance.

Part 4: Additional Modeling Considerations

Modeling Multiple Splash Boxx Facilities in Series: The user can represent Splash Boxxes in series in the model by changing the length or width parameters while holding all other parameters constant (e.g., material layer thickness, orifice diameter). If the design calls for multiple Splash Boxx facilities, each acting independently (i.e., not in series), the user should model each Splash Boxx separately.

Splash Boxx as Part of a BMP Train: The designer may specify Splash Boxx as part of a BMP train to reduce the size of the downstream facility by detaining stormwater flows and decreasing peaks. To represent treatment trains in the model, the user can connect the BMPs in series and set the point of compliance at the outlet of the downstream BMP.

Part 5: Evaluating Splash Boxx Performance

This section includes protocol for evaluating Splash Boxx performance relative to the performance standard prescribed in Minimum Requirements #5, #6, and #7. For a complete summary of Ecology's performance standards and methodologies, see the 2012 SWMMWW and the WWHM User's Manual.

Water Quality Performance: Per the 2012 SWMMWW, sites triggering Minimum Requirement #6 (Water Quality Treatment) are required to infiltrate or filter at least 91 percent of the total runoff volume through a media that meets the Ecology's requirements for bioretention soil media.

Compliance with the water quality treatment standard at the outlet of the Splash Boxx is not proof of overall site compliance. The designer must demonstrate that all surfaces on the site triggering water quality treatment per the 2012 SWMMWW meet the standard at the designated point of compliance.

The user can evaluate the water quality performance of a Splash Boxx facility in the Bioretention Swale element input screen, as follows.

1. **Run both the pre-developed and mitigated scenarios in the schematic editor**.
2. **Click on the "Bioretention Swale" element in the schematic editor to bring up the element input screen**.

   The underdrain input section provides calculated values of total flow, flow through the underdrain, and percent of total flow passing through the underdrain.
3. **Evaluate the "Percent through Underdrain" value to confirm that at least 91 percent of runoff is passing through the facility**.

In the event the facility exceeds the required 91 percent, the designer could route additional area to the Splash Boxx until the facility just meets the requirement or, if the designer has specified multiple facilities in series, the user can confirm that all Splash Boxx BMPs are required to meet the treatment requirement (i.e., filter 91 percent of the runoff volume).

Flow Control Performance: Per the 2012 SWMMWW, sites triggering Minimum Requirement #7 (Flow Control) are required to match pre-developed stormwater discharge durations for the range of pre-developed discharge rates from 50 percent of the 2-year peak flow up to the full 50-year peak flow. Note the target pre-developed land cover is typically forested; however, the 2012 SWMMWW outlines criteria for matching alternate "pre-project" conditions.

Compliance with the flow control standard at the outlet of the Splash Boxx is not proof of overall site compliance. The designer must demonstrate that all surfaces on the site triggering flow control per the 2012 SWMMWW meet the standard at the designated point of compliance.

The user can assess the performance of Splash Boxx BMPs relative to Ecology requirements through the "Analysis" dialog box, as follows.

1. **Run both the pre-developed and mitigated scenarios in the schematic editor**:

   Define the pre-developed basin land cover per the 2012 SWMMWW and per site conditions (e.g., moderately sloped forest, on till soils).

2. **Select the desired point of compliance from the tabs in the bottom left portion of the "Analysis" dialog box (e.g., "POC 1")**

3. **Select the "Stream Protection Duration" standard from the tabs below the analysis screen**:

   WWHM 2012 will plot the duration curves for the pre-developed and mitigated scenarios and report whether or not the facility meets (or "passes") the requirement. In most instances, the Splash Boxx alone will not meet this requirement, but the user can move the point of compliance downstream to the next facility in the treatment train (e.g., infiltrating facility) to evaluate the net impact of both facilities in series.

In addition to the data summary provided in the "Analysis" dialog box, the user can view the project report file through the "Reports" dialog box. This report contains information such as pre-developed and mitigated flow frequencies, maximum water surface elevations within facilities, and other information to assist the user in evaluation of the Splash Boxx relative other common performance standards.

LID Performance: Per the 2012 SWMMWW, sites triggering Minimum Requirement #5 (On-site Stormwater Management) are required to either meet the LID Performance Standard or implement BMPs from Ecology's prescribed Lists 1 and 2 for each surface type (see "Using Splash Boxx for Compliance with Minimum Requirements" above for additional information on the LID performance standard).

Compliance with the LID standard at the outlet of the Splash Boxx is not proof of overall site compliance. The designer must demonstrate that all surfaces on the site triggering on-site stormwater management per the 2012 SWMMWW meet the standard at the designated point of compliance or demonstrate that they have satisfied the requirements for the site per Ecology's prescribed lists.

The user can assess the performance of Splash Boxx BMPs relative to the LID Performance Standard as explained for flow control (using the "LID Duration" tab in the "Analysis" dialog box).