BMP Siting Tool

Step-by-Step Guide

ArcGIS 10.1 Service Pack 1 (Build 3143)

Prepared by:

Tetra Tech, Inc.
10306 Eaton Place, Suite 340
Fairfax, VA 22030

January 2013

Contents

Tables

Figures

1 Getting Started

This section describes the steps required to install and activate BMP Siting Tool for the first time. The next time, you can simply launch ArcMap and add data to your GIS project to use the Siting Tool.

1.1 Install the Software

To install the required software:

- Install **ArcGIS** (version 10.1) with **Service Pack 1** (Build 3143) and **Spatial Analyst** extension on a Windows 7 (32-bit or 64-bit) machine. To do this, follow the instructions come with your ArcGIS software.
- Install the **BMP Siting Tool** using the setup package (***BMPSitingTool_Setup.zip***). To do this, follow the instructions in the *BMPSitingTool_InstallationGuide.pdf* file. The setup package contains four files, i.e., *BMPSitingTool_Setup.msi*, *BMPSitingTool_Geodatabase.gdb*, *BMPSitingTool_InstallationGuide.pdf*, and *BMPSitingTool_UserGuide.pdf* (this document).

1.2 Activate the Siting Tool

To activate the Siting Tool:

- Open **ArcMap** by clicking **Start**, pointing to **All Programs** > **ArcGIS**, and clicking **ArcMap10.1**.
- On the **ArcMap**, click the ***Customize*** menu and then click ***Customize Mode***…. Select the check box next to BMP Siting Tool listed under the toolbars tab of the Customize dialog box (Figure 1-1).

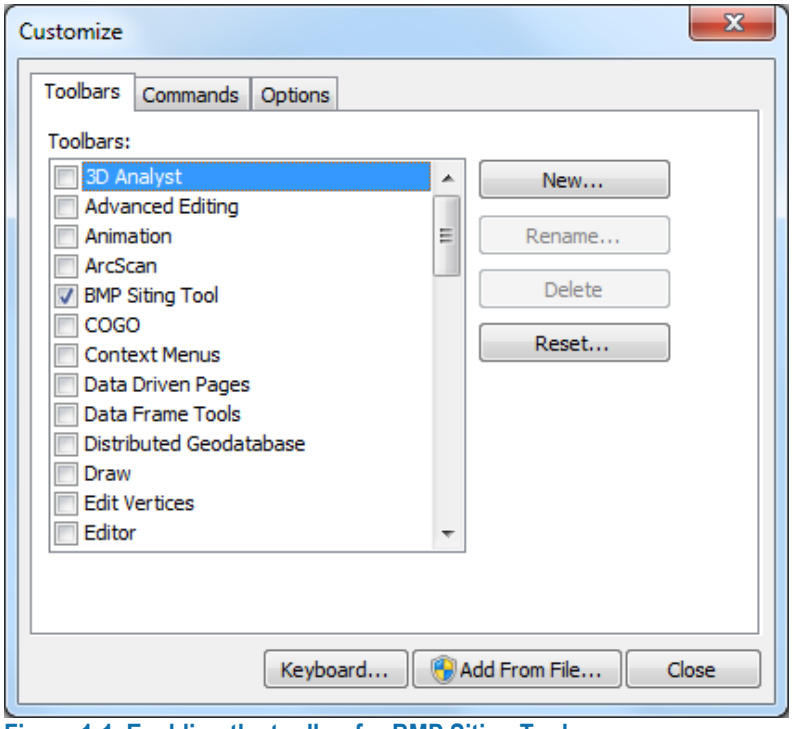

Figure 1-1. Enabling the toolbar for BMP Siting Tool.

- The *BMP Siting Tool* toolbar (Figure 1-2) is activated and displayed on the ArcMap.

Figure 1-2. BMP Siting Tool toolbar.

- To complete the BMP Siting Tool activation procedure, click **Close** on the Customize dialog box.
- To launch the user guide (this document) to learn more about the tool, click the **Help** button ( ) on the *BMP Siting Tool* toolbar.
- Close **ArcMap**.

2 BMP Siting Tool

The BMP Siting Tool was developed to help you select suitable locations for different types of low impact development (LID) techniques or conventional BMPs in *SUSTAIN* (Shoemaker et al. 2009). The Siting Tool provides guidance on where to place a selected BMP on the watershed, using the site suitability criteria. Figure 2-1 shows the flow chart for the BMP siting analyses.

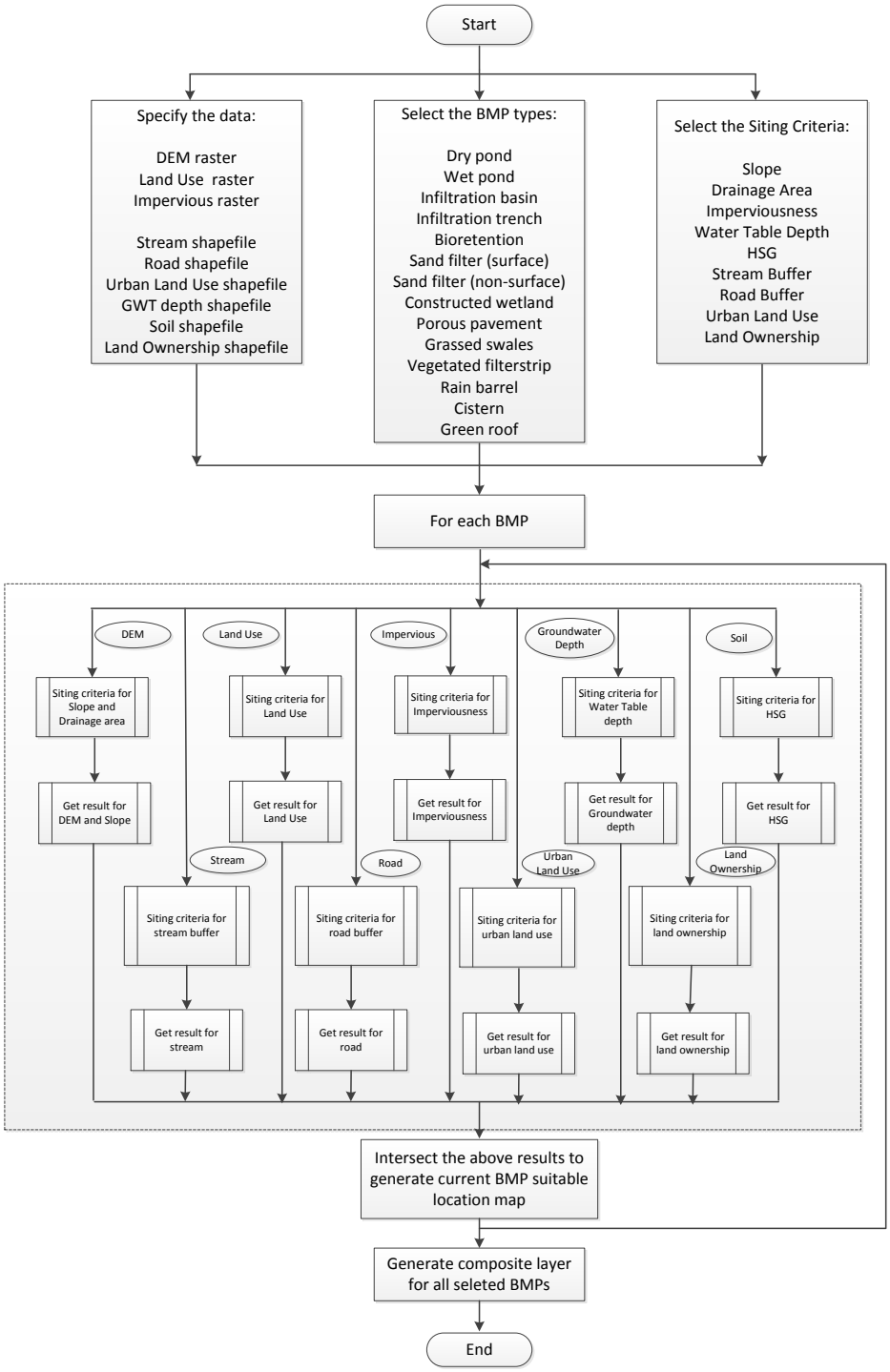

Figure 2-1. Flow chart for BMP siting analyses.

2.1 Data Requirements

Using GIS analysis and up to nine base data layers, the Siting Tool helps you identify suitable sites for placing structural BMPs according to suitability criteria including slope, soil type, urban land use, land ownership, roads, water table depth, stream location, and drainage area. Table 2-1 describes these nine GIS data layers that are used as the base input data for the tool.

Table 2-1. GIS data requirement for BMP suitability analysis

GIS layer	Format	Description
DEM	Raster file	The DEM is used to calculate the drainage slope and drainage areas that are used to identify the suitable locations for BMPs.
Land Use	Raster file	The land use grid (e.g., NLCD land cover) is used to eliminate the unsuitable areas for BMPs.
Percent Impervious	Raster file	The percent impervious grid is used to identify the suitable locations for BMPs for the given suitability criteria.
Soil	Shape file	The soil data contain the soil properties such as hydrological soil group, which are used to identify suitable locations for BMPs.
Urban Land Use	Shape file	The urban land use data contain the boundaries for the buildings and the impervious areas needed to identify suitable locations for LID elements.
Road	Shape file	The road layer is used to identify suitable locations for some BMPs that must be placed in a specific road buffer area.
Stream	Shape file	The stream layer is used to define a buffer so that certain BMP types can be placed outside the buffer to minimize the impact on streams.
Groundwater Table Depth	Shape file	The groundwater table depth layer is used to identify suitable locations for the infiltration BMPs; derived from monitoring data.
Land Ownership	Shape file	A parcel layer is used to identify the locations on the public or private land.

Table 2-2 shows the GIS data format required for the Siting Tool. GIS layers with different coordinate systems will cause errors during the spatial analysis. It is important to project all GIS data into the preferred coordinate system of the study area before starting the project. To project the GIS data from one coordinate system to another, use the Project utility under Data Management Tools of ArcToolbox.

Table 2-2. GIS data format requirement for BMP suitability analysis

GIS layer	Data type	Field name	Field type	Field value/description
DEM	Raster file	VALUE	Floating	ESRI grid
Land Use	Raster file	VALUE	Integer	ESRI grid
Land Use Lookup	Table	LUCODE	Integer	Should be same as in the VALUE field in Land Use raster layer
		LUNAME	String	Description about the land use type
		SUITABLE	Short	1 or 0 (1 = suitable; 0 = unsuitable)
Percent Impervious	Raster file	VALUE	Integer	0 – 100
Soil	Shape file	MUKEY	String	Hydrological soil classification (STATSGO or SSURGO or local dataset)
Soil Lookup	Table	MUKEY	String	Should be same as in the MUKEY field
		HYDGRP	String	A or B or C or D
Urban Land Use	Shape file	LU_DESC	String	Buildings (for Green Roof BMP type and

GIS layer	Data type	Field name	Field type	Field value/description
				defining the buffer around the buildings) or Roadways or ParkingLots (for Porous Pavement BMP type)
Road	Shape file	N/A	N/A	N/A
Stream	Shape file	N/A	N/A	N/A
Groundwater Table Depth	Shape file	GWDEP_FT	Double	Depth to groundwater table
Land Ownership	Shape file	OWNERSHIP	String	Public or Private

You can perform the analysis with at least one GIS data layer and the corresponding siting criteria. By increasing the number of input data layers (adding more constraints for the suitable locations), you will certainly increase the resolution of the suitable location map. Note that it is a tool, and the output is vastly correlated to the accuracy and resolution of the input data.

2.2 BMP Options

To conceptualize the physical function of BMPs with regard to their associated landscape, four categories (or types) of BMPs are presented in the Siting Tool: (1) point LID, (2) point BMP, (3) linear BMP, and (4) area BMP. Point BMPs and LID include practices that capture upstream drainage at a specific location and can use a combination of detention, infiltration, evaporation, settling, and transformation to manage flow and remove pollutants. Linear BMPs are narrow, linear shapes adjacent to stream channels that provide filtration of runoff; nutrient uptake; and ancillary benefits of stream shading, wildlife habitat, and aesthetic value. Area BMPs are land-based management practices that affect impervious area, land cover, and pollutant inputs (e.g., fertilizer, pet waste). Table 2-3 shows the structural BMP options available in BMP Siting Tool.

Table 2-3. Structural BMP options available in BMP Siting Tool

BMP option	BMP type
Bioretention	Point LID
Cistern	Point LID
Constructed Wetland	Point BMP
Dry Pond	Point BMP
Grassed Swale	Linear BMP
Green Roof	Area BMP
Infiltration Basin	Point BMP
Infiltration Trench	Linear BMP
Porous Pavement	Area BMP
Rain Barrel	Point LID
Sand Filter (non-surface)	Linear BMP
Sand Filter (surface)	Point BMP
Vegetated Filterstrip	Linear BMP
Wet Pond	Point BMP

2.3 Site Suitability Criteria

Table 2-4 shows a site suitability criteria matrix and is populated with default criteria that you can change to your preference or local knowledge. The default criteria in the tool are derived from two EPA reports (USEPA 2004a, 2004b). You can modify these criteria using the Siting Tool interface.

Table 2-4. Default criteria for BMP suitable locations used in BMP Siting Tool

BMP type	Drainage area (acre)	Drainage slope (%)	Impervious (%)	Hydrologic soil group	Water table depth (ft)	Road buffer (ft)	Stream buffer (ft)	Building buffer (ft)
Bioretention	< 2	< 5%	> 0%	A–D	> 2	< 100	> 100	--
Cistern	--	--	--	--	--	--	--	< 30
Constructed Wetland	> 25	< 15%	> 0%	A–D	> 4	--	> 100	--
Dry Pond	> 10	< 15%	> 0%	A–D	> 4	--	> 100	--
Grassed Swale	< 5	< 4%	> 0%	A–D	> 2	< 100	--	--
Green Roof	--	--	--	--	--	--	--	--
Infiltration Basin	< 10	< 15%	> 0%	A–B	> 4	--	> 100	--
Infiltration Trench	< 5	< 15%	> 0%	A–B	> 4	--	> 100	--
Porous Pavement	< 3	< 1%	> 0%	A–B	> 2	--	--	--
Rain Barrel	--	--	--	--	--	--	--	< 30
Sand Filter (non-surface)	< 2	< 10%	> 0%	A–D	> 2	--	> 100	--
Sand Filter (surface)	< 10	< 10%	> 0%	A–D	> 2	--	> 100	--
Vegetated Filterstrip	--	< 10%	> 0%	A–D	> 2	< 100	--	--
Wet Pond	> 25	< 15%	> 0%	A–D	> 4	--	> 100	--

2.4 Run-Time Sensitivity Analysis

The Siting Tool uses memory-intensive GIS operations especially related to the raster data set. It is important to use a reasonable resolution of raster data set depending on the study area. For a site-scale BMP analysis, the high-resolution data set can be used. But for a watershed-scale BMP analysis, a courser resolution is recommended. A runtime sensitivity analysis for the Siting Tool was performed on a Windows 7 machine (8 GB RAM and 2.8 GHz CPU) using different resolutions of the data set, ranging from 1-m to 1-km cell size, and the optimal raster size was found to have one million cells (rows multiplied by columns). The runtime exponentially increases as the number of cells in the raster data set increases by one million (Figure 2-2). For improved performance, it is highly recommended that you clip the raster data set to the spatial extent of interest or, alternatively, increase the cell size to reduce the raster data size.

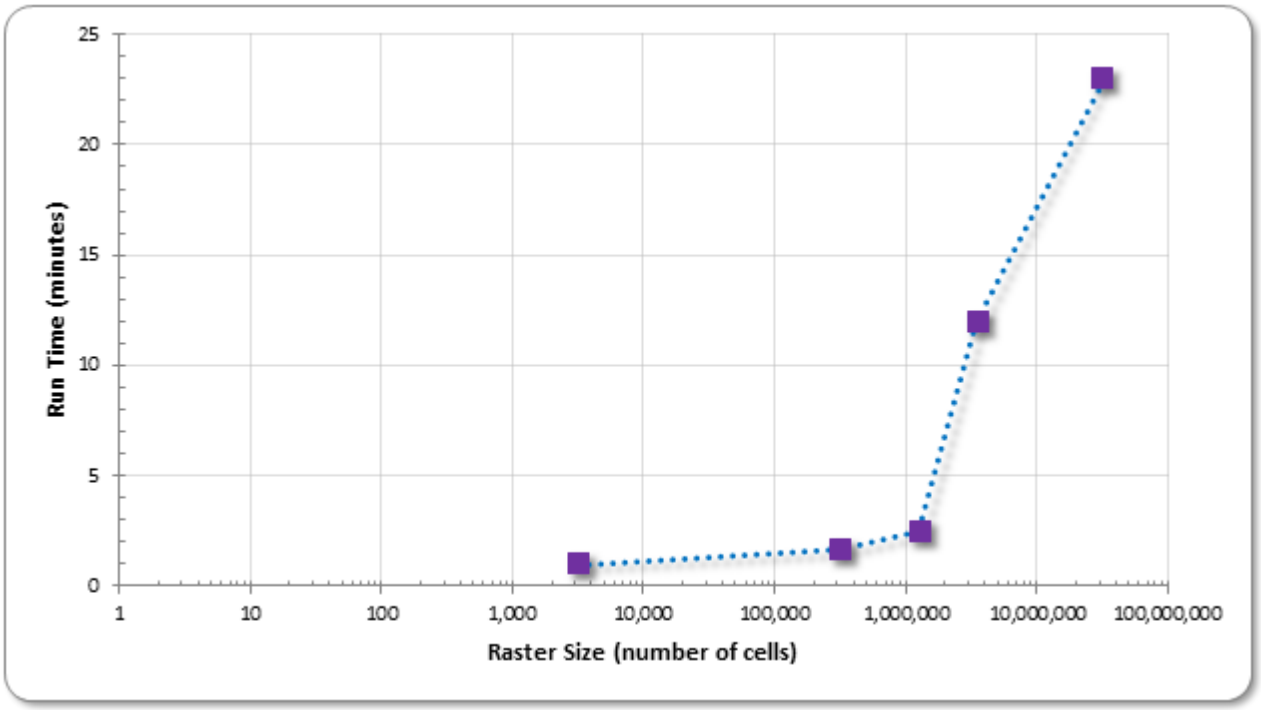

Figure 2-2. BMP Siting Tool run-time comparison for different raster data sizes.

2.5 Results

The output of the BMP Siting Tool analysis is a spatial map that highlights the areas that meet the selected default or user-specified site criteria for placement of the selected BMPs. You can use the BMP suitability map as a backdrop when placing BMPs for a *SUSTAIN* project. Multiple spatial maps can be created for project areas on the basis of the various criteria you selected. To further rank the suitable locations showing which are most suitable or less suitable based on the suitability criteria, you can specify the weighting factor for slope and soil criteria.

The Siting Tool is for guidance purpose only because it is a highly data-driven tool. It requires site visit in addition to the GIS exercise to validate the suitable locations before using them for BMP placement in *SUSTAIN*.

3 Tutorial Exercise

This section provides step-by-step instructions for identifying suitable BMP sites/areas using the BMP Siting Tool.

3.1 Create ArcMap Project

To create an ArcMap project for the Siting Tool:

- Open **ArcMap** by clicking **Start**, then pointing to **All Programs** > **ArcGIS**, and clicking **ArcMap10.1**.
- Create a **Project** folder (.*Project*) on your local drive.
- Give a name **BMPSitingTool.mxd** to your project by clicking **File** > **Save As**… on the *ArcMap* menu bar and then navigate to the **Project** folder and save your project.
- Add a GIS data set to your project by clicking the ArcMap *Add Data* tool ( ), navigate to *BMPSitingTool_Geodatabase.gdb* file on your local drive, select all the data files, and add them to the ArcMap project.
- Save your ArcMap project (Figure 3-1) by clicking **Save** ( ).

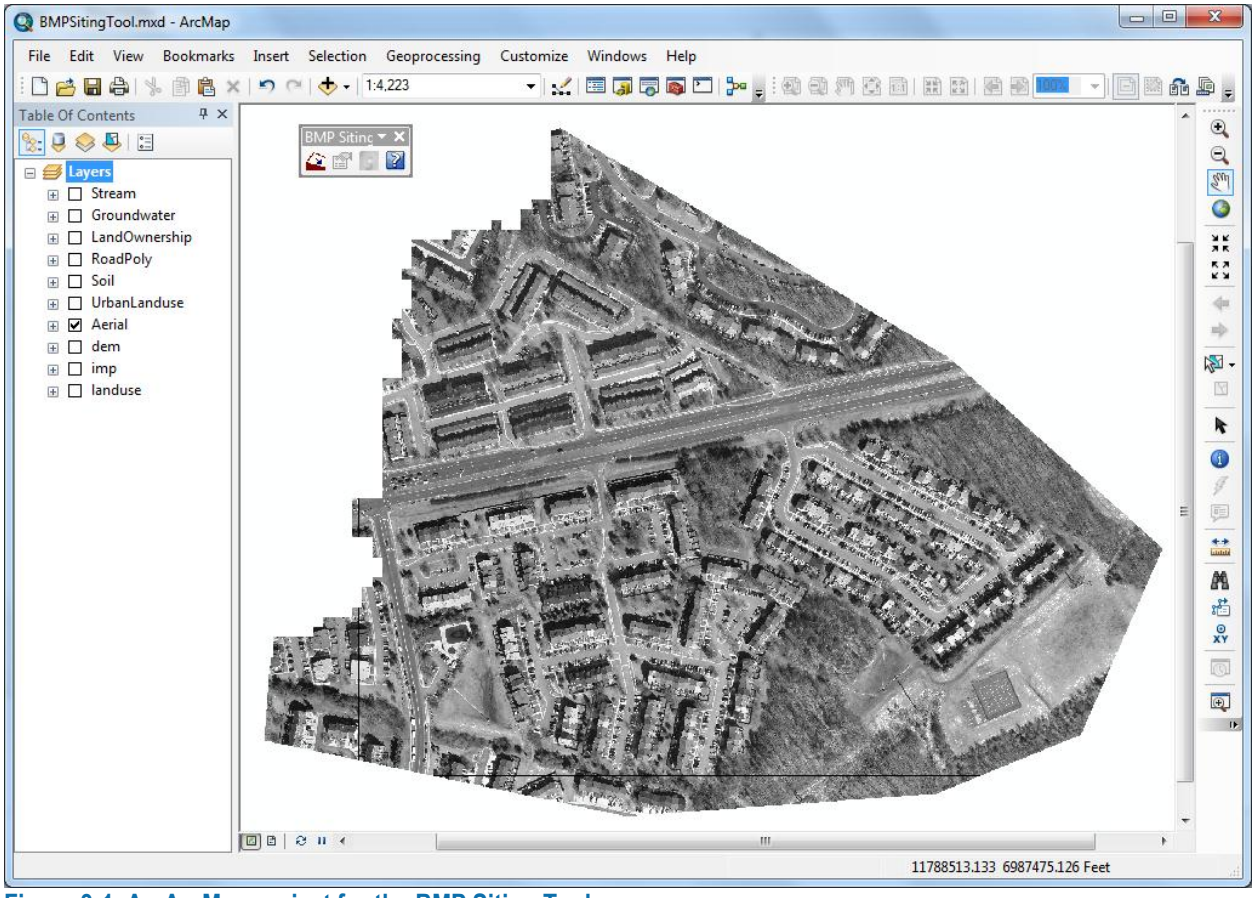

Figure 3-1. An ArcMap project for the BMP Siting Tool.

3.2 Define GIS Dataset

To define required GIS dataset in your ArcMap project for the Siting Tool:

- To activate the BMP Siting Tool, if you have not already done so, follow the steps in section 1.2.
- Click the **Data Management** button ( ) on the BMP Siting Tool toolbar ( ) that opens the Data Management window shown in Figure 3-2.
- Define each data layer by selecting the appropriate one from the drop-down list. Note that the drop-down list is populated from the ArcMap and shows only the data type required for the selected data layer. If you do not see the desired layer in the list, click the **Browse** button ( ) next to the data layer name and select the data from your local drive.
- To save and close the Data Management window, click the **Save** button. Note that the data information is saved in an xml file (*SitingToolConfig.xml*) under the same path where you saved your ArcMap project (*BMPSitingTool.mxd*). A log file (*SitingToolLog_DATE.log*) is created to report the informational and error messages.

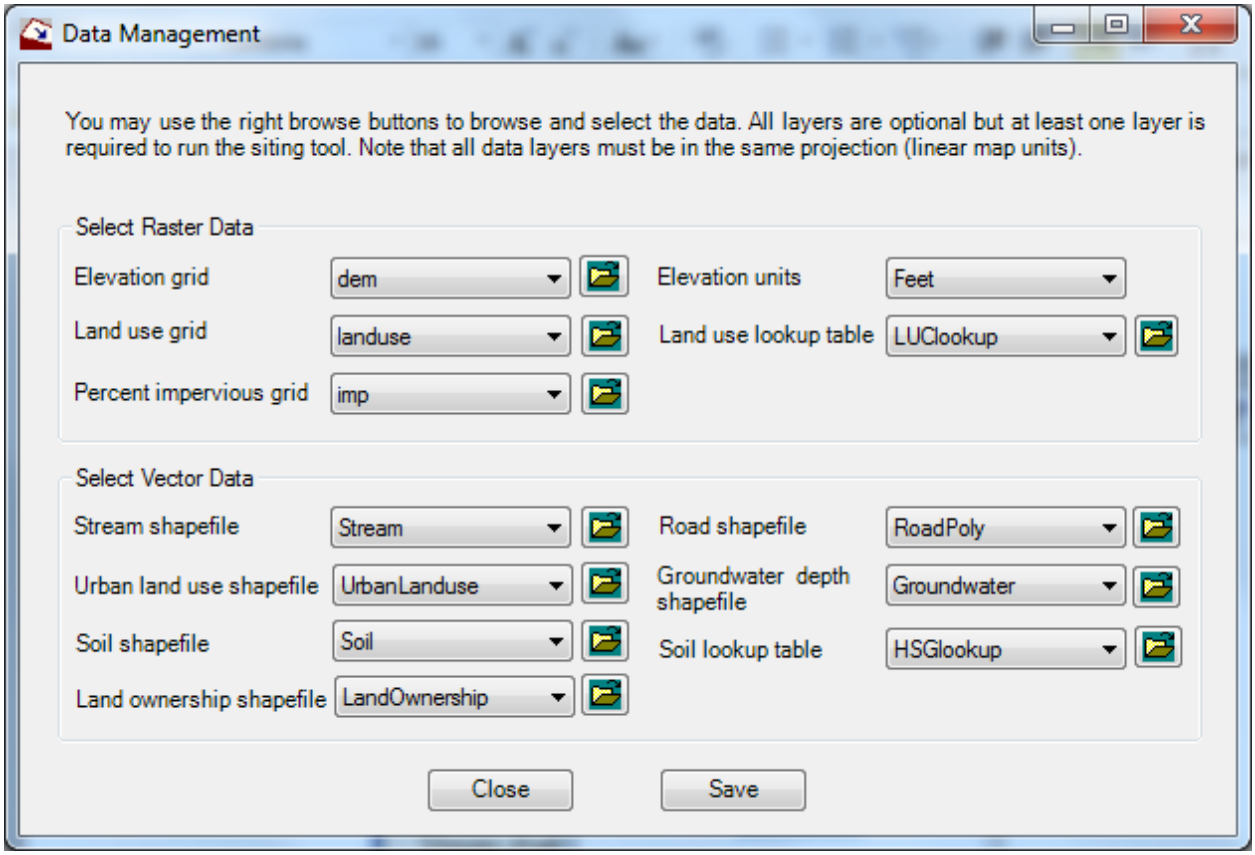

Figure 3-2. The Data Management window for the BMP Siting Tool.

SitingToolConfig.xml

This file stores the GIS project path and the data layers names defined in the Data Management window. The next time you open the Data Management window, the default selection of GIS layers are populated using the information saved in this file. If you move your ArcMap project to a different location on your computer, make sure to move this file along with the ArcMap document and make necessary edits to the GIS project path.

3.3 Select BMP Types

To select BMP types for site suitability analysis:

- If you have not already done so, click the **Select BMP Types** ( ), complete the steps in section 3.2.
- Click the **Select BMP Types** button on the *BMP Siting Tool* toolbar ( ) to launch the Select BMP Type window shown in Figure 3-3.
- Select **Bioretention** BMP type from the list of available BMP types (hold the Control key for multiple BMP selections) and click **Add** to move it to the list of selected BMP types (Figure 3-3). Select a BMP from the selected BMP Types and click **Remove** to remove it from the selected list and move it back to the list of available BMP types.
- To save and close the Select BMP Types window, click **Save**. Note that the data information is saved in an xml file (*Siting_Selected_BMP.xml*) under the same path where you saved your ArcMap project (*BMPSitingTool.mxd*).

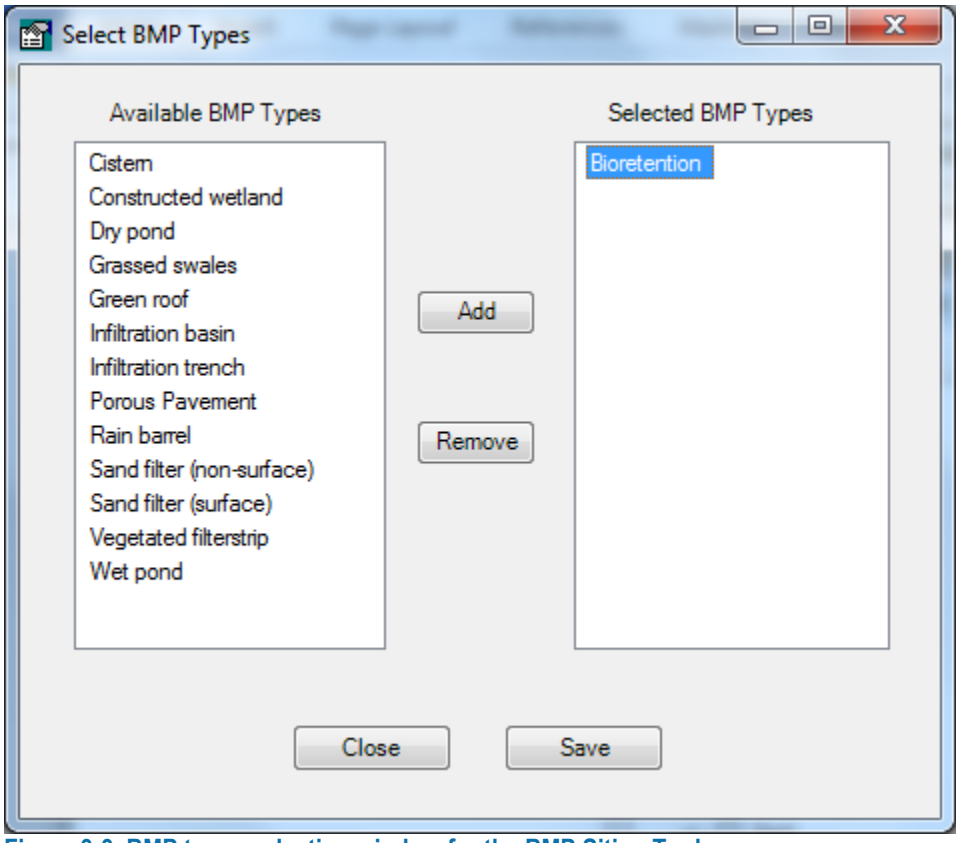

Figure 3-3. BMP types selection window for the BMP Siting Tool.

Siting_Selected_BMP.xml

This file stores the selected BMP types defined on the Select BMP Types window. Then next time you open the Select BMP Types window, the default values of BMP types are populated using the information saved in this file. If you move your ArcMap project to a different location on your computer, make sure to move this file along with the ArcMap document.

3.4 Select Suitability Criteria

To define the site suitability criteria for the selected BMP types:

- Click the **BMP Siting Criteria** button ( ), if you have not already done so, and complete the steps in section 3.3
- Click **BMP Siting Criteria** on the *BMP Siting Tool* toolbar ( ) to launch the BMP Siting Criteria window.
- From the list of selected BMP types, select **Bioretention** BMP type and review the default criteria populated on the right side of the window.
- Change the default criteria for Bioretention BMP type to the values shown in Figure 3-4 for this exercise. Note that you can unselect the checkbox next to a criterion to exclude it.
- To save the siting criteria for the selected BMP types, click **Save**. Note that the siting criteria information is saved in an xml file (*Siting_BMP_Criteria.xml*) under the same path where you saved your ArcMap project (*BMPSitingTool.mxd*).

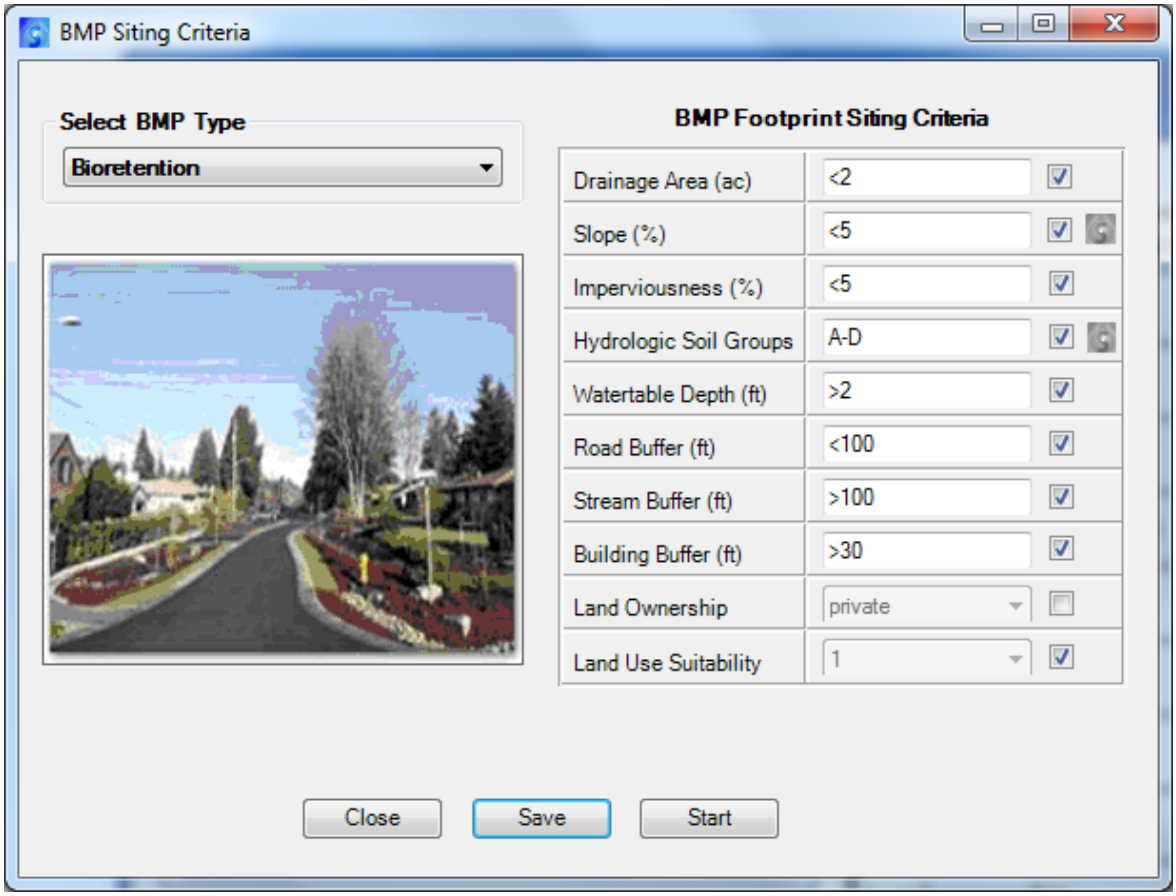

Figure 3-4. BMP siting criteria for Bioretention BMP type.

Siting_BMP_Criteria.xml

This file stores the siting criteria for the selected BMP types defined on the BMP Siting Criteria window. The next time you open the BMP Siting Criteria window, the siting criteria are populated using the information saved in this file. If you move your ArcMap project to a different location on your computer, make sure to move this file along with the ArcMap document. To select the system default siting criteria delete this file.

3.5 Process and View Results

To run the site suitability analyses for each selected BMP types and to view the resulting layers:

- To run the Siting Tool for *Bioretention*, click **Start**. The tool runs for each selected BMP type to find the locations that meet the site suitability criteria. The siting analyses creates a suitable GIS layer for each criterion of the selected BMP type and overlays the suitable GIS layers to identify the common locations among all suitable GIS layers for the selected BMP type.
- After the data processing is complete, the result layer (*Bioretention1*) showing the suitable locations that meet the specified criteria appears in the ArcMap project (Figure 3-5). Note that the result layer is saved in the **Result1** folder under the same path where you saved your ArcMap project (*BMPSitingTool.mxd*). The system also creates a **Cache** folder to store the intermediate data layers created during the siting analyses at the same location.

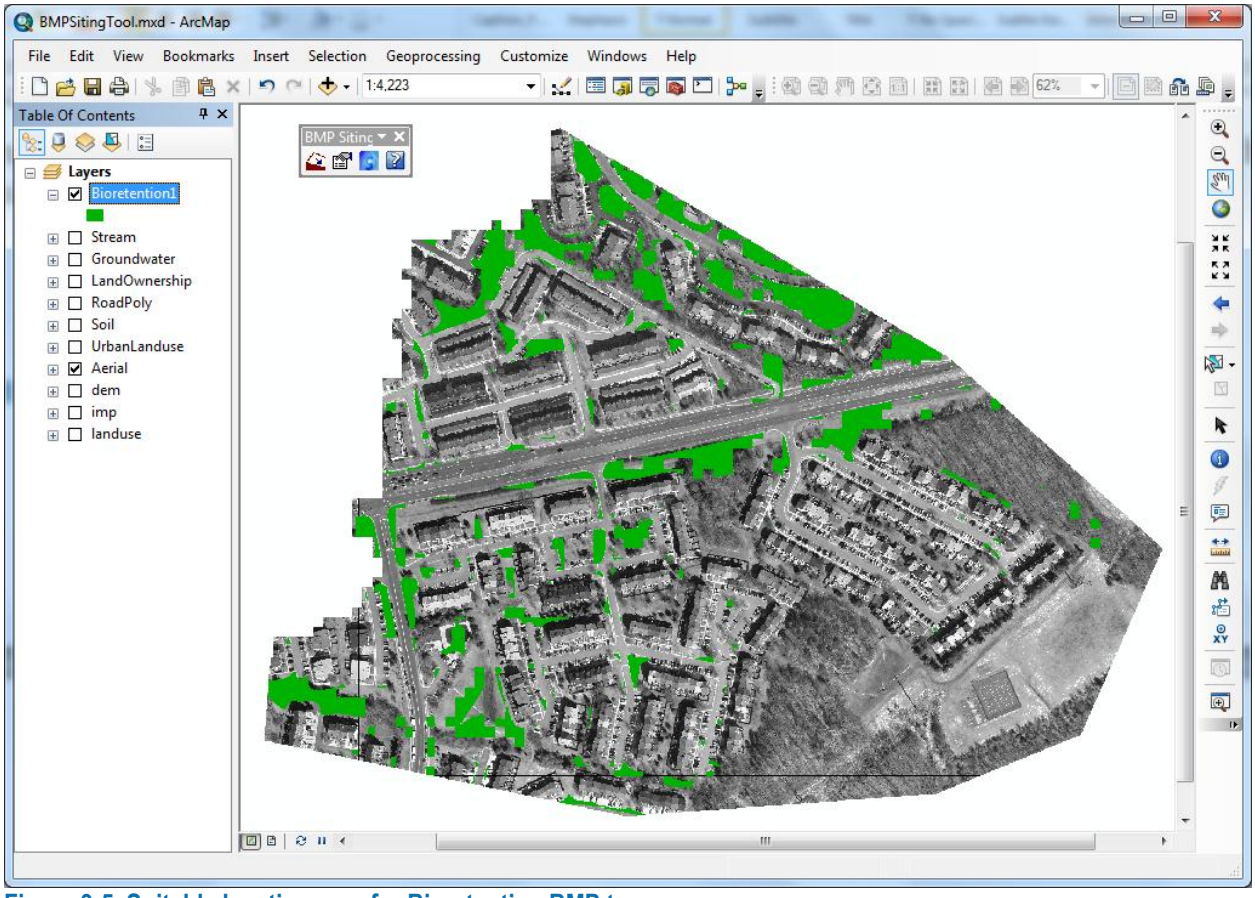

Figure 3-5. Suitable location map for Bioretention BMP type.

> **Cache Folder**
>
> This folder stores the intermediate data created during the siting analyses. The next time you run the Siting Tool, some of the data sets in this folder might be reused (repeated process) to save the run time. To save hard disk space, you may delete this folder after you are finished with the project.

- To run the Siting Tool for more than one BMP type, repeat the steps in section 3.3 and add **Dry Pond** to the selected BMP types (Figure 3-6).

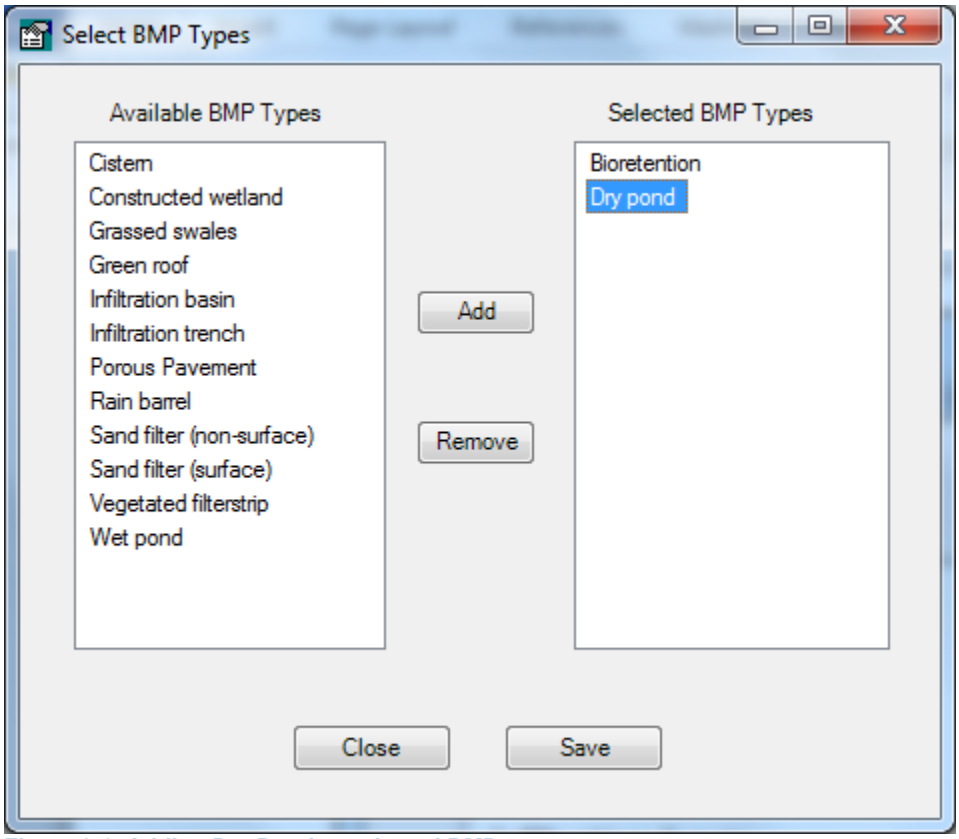

Figure 3-6. Adding Dry Pond to selected BMP types.

- To review and edit the siting criteria for **Dry Pond**, repeat the steps in section 3.4 and change the default criteria to those as shown in Figure 3-7.
- To run the Siting Tool for the *Bioretention* and *Dry Pond* BMP types, click **Start**. The tool runs for each selected BMP type to find the locations that meet the site suitability criteria. The siting analyses creates a suitable GIS layer for each criterion of the selected BMP type and overlays the suitable GIS layers to identify the common locations among all suitable GIS layers for the selected BMP type.
- After the data processing is complete, the result layers (*Bioretention2*, *Dry_pond2*, and *Composite2*) showing the suitable locations that meet the specified criteria appear in the ArcMap project (Figure 3-8). Note that the result layers are saved in the **Result1** folder under the same path where you saved your ArcMap project (*BMPSitingTool.mxd*).

Result Layers

The first time you run the Siting Tool, the system saves the result layers with the BMP type name and adding 1 to the end of each BMP type name. The next time you run the Siting Tool, the resulting layers are named with an increment to the previously saved name. In this example, the first run created a **Bioretention1** layer and the second run created **Bioretention2** layer. Because two BMPs were selected for the second run, two additional layers are created (**Dry_pond2** and **Composite2**). A composite layer is a collection of all suitable locations for all the selected BMPs.

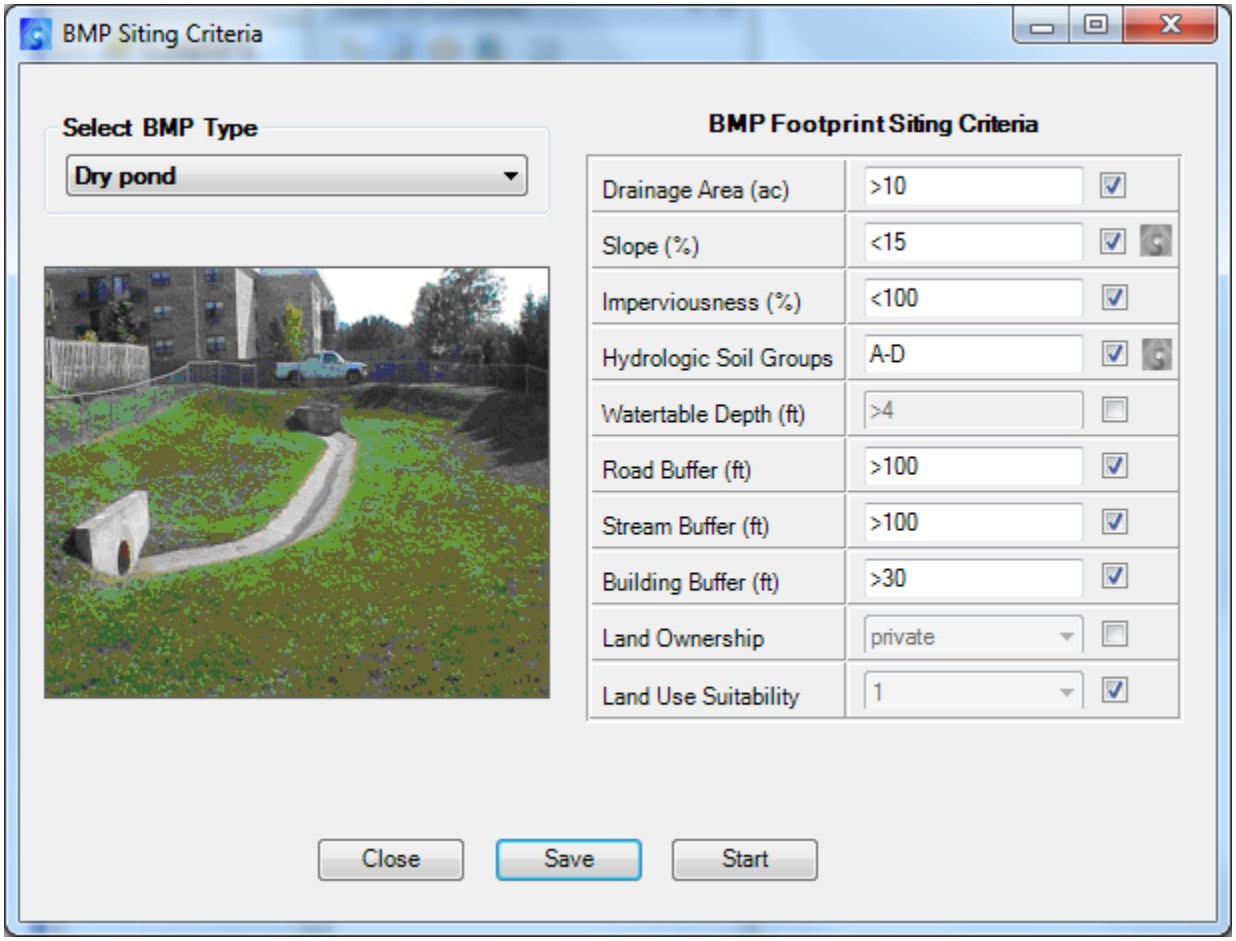

Figure 3-7. BMP siting criteria for Dry Pond BMP type.

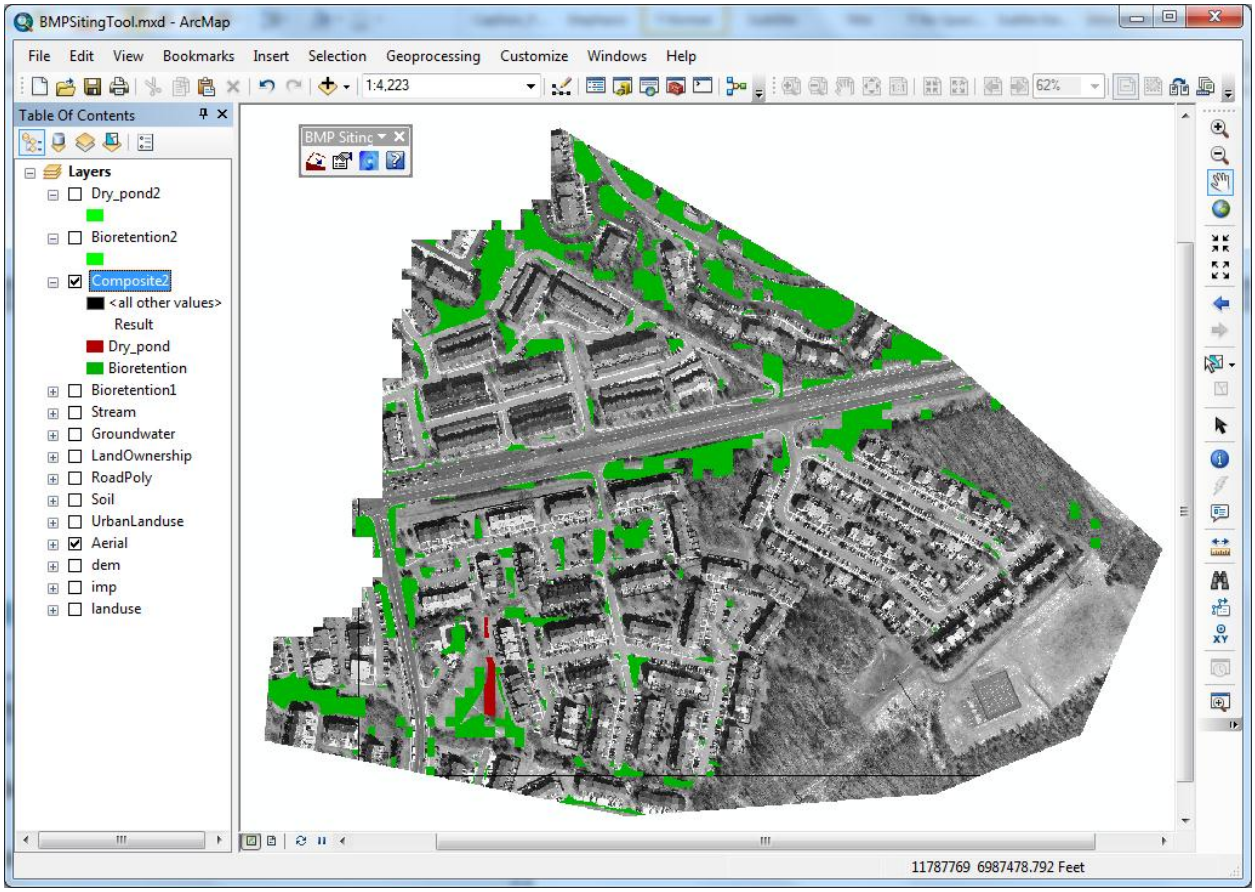

Figure 3-8. Suitable location map for Bioretention and Dry Pond BMP types.

- To rank the suitable locations for **Bioretention**, open the BMP Siting Criteria window by clicking **BMP Siting Criteria** ( ), then click the grey icon next to Hydrologic Soil Group criterion (Figure 3-4). A separate dialog box opens (Figure 3-9). Define the weighting factors for each hydrologic soil group and select the *Consider As Criteria* check box as shown in Figure 3-9. The icon next to the Hydrologic Soil Group criterion turns blue indicating that the weighting factors are defined for this criterion (Figure 3-10).
- To run the Siting Tool for the *Bioretention* and *Dry Pond* BMP types, click **Start**. The tool runs for each selected BMP type to find the locations that meet the site suitability criteria. The siting analyses creates a suitable GIS layer for each criterion of the selected BMP type and overlays the suitable GIS layers to identify the common locations among all suitable GIS layers for the selected BMP type.
- After the data processing is complete, the result layers (*Bioretention3*, *Dry_pond3*, and *Composite3*) showing the suitable locations that meet the specified criteria appear in the ArcMap project. Note that the result layers are saved in the **Result1** folder under the same path where you saved your ArcMap project (*BMPSitingTool.mxd*).

Ranking Suitability Criteria

The Siting Tool allows ranking the suitability locations on the basis of Hydrologic Soil Group and Slope criteria. For example, a Bioretention basin is best suited in areas with Hydrologic Soil Group A as compared to D and on low slope areas as BMP footprints. The higher sum weight number shows high ranking among suitable areas.

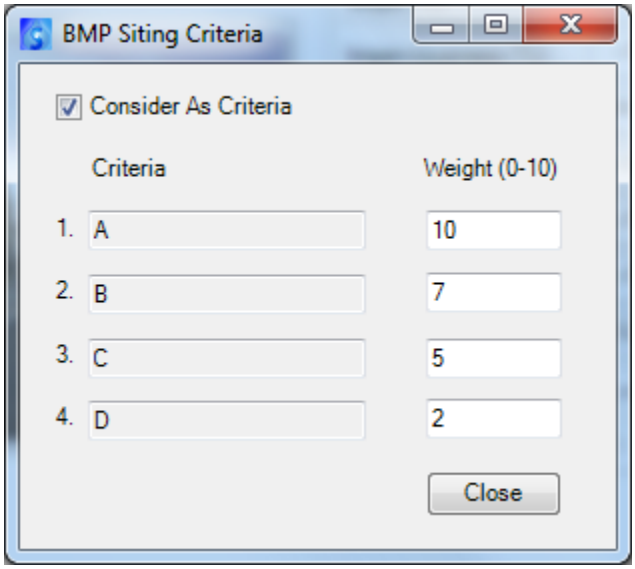

Figure 3-9. Weighting factors of hydrologic soil groups for Bioretention BMP type.

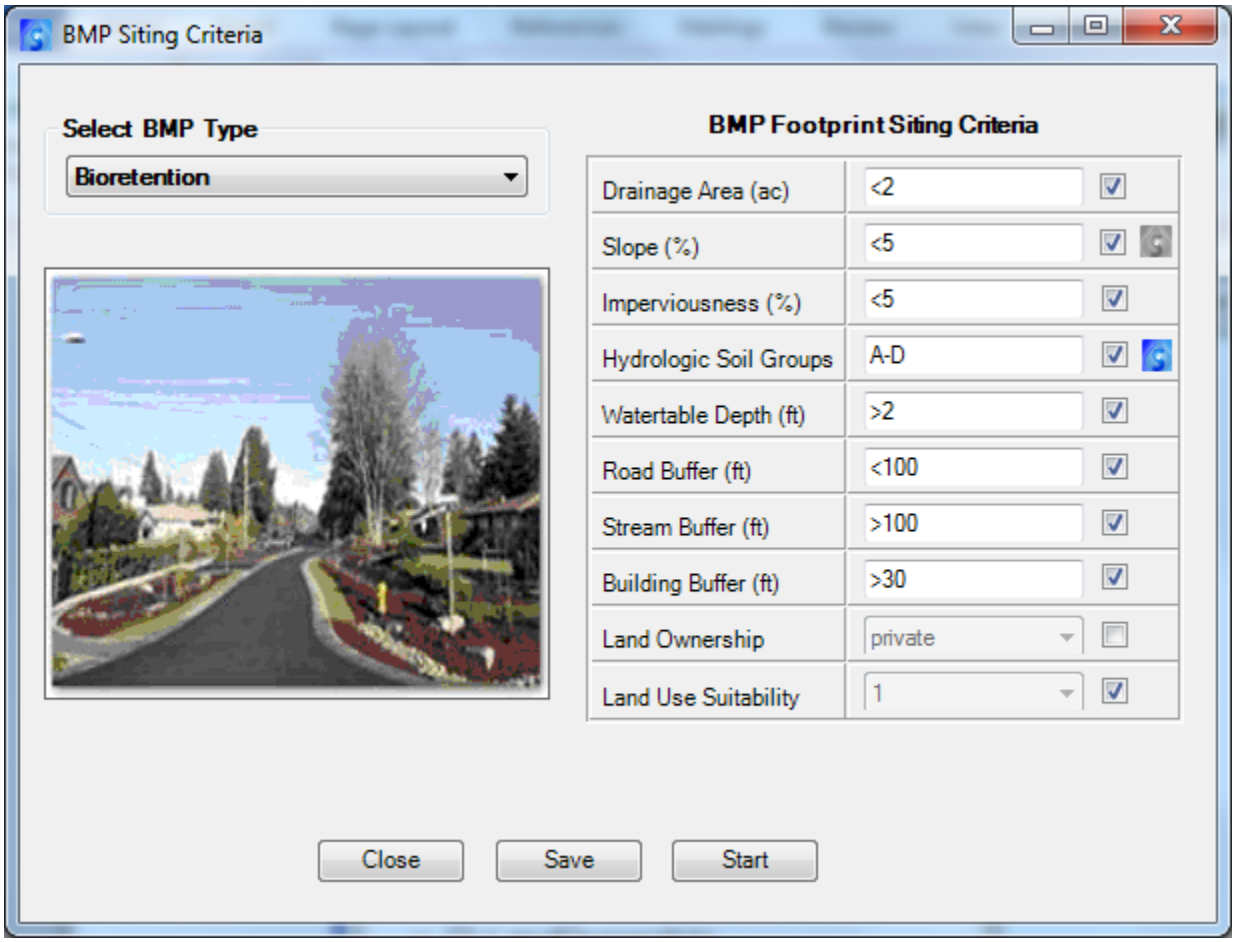

Figure 3-10. BMP Siting Criteria window after defining the weighting factors for Bioretention BMP type.

- To visualize the ranking of the *Bioretention* suitable locations, select the **Bioretention3** layer on the map. To display the properties of the selected layer, click mouse right button on the layer name and select **Properties…**. A separate dialog box opens (Figure 3-11). Select the *Unique values* under **Categories** and select *sumWeight* Value Field as shown in Figure 3-11. Click **Add All Values** and select desired color scheme from the available Color Ramp in ArcGIS or click individual color *Symbol* and select the desired color for each *Value*. Click OK and the selected symbology is displayed on the map (Figure 3-12). Note that you may want to label the sumWeight *Value* as High, Medium, and Low rank as you see appropriate.

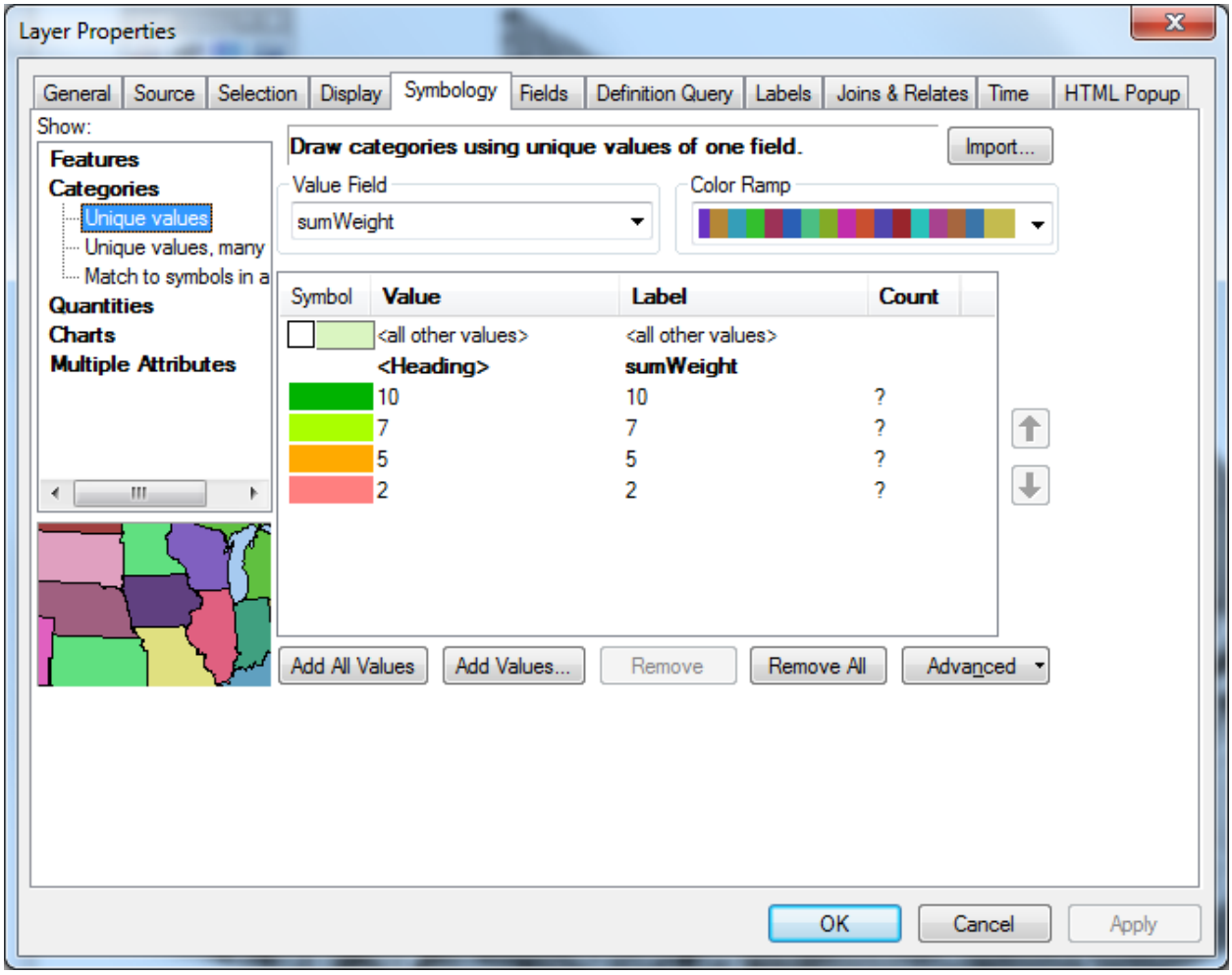

Figure 3-11. Layer Properties window for selecting symbology for Bioretention BMP type.

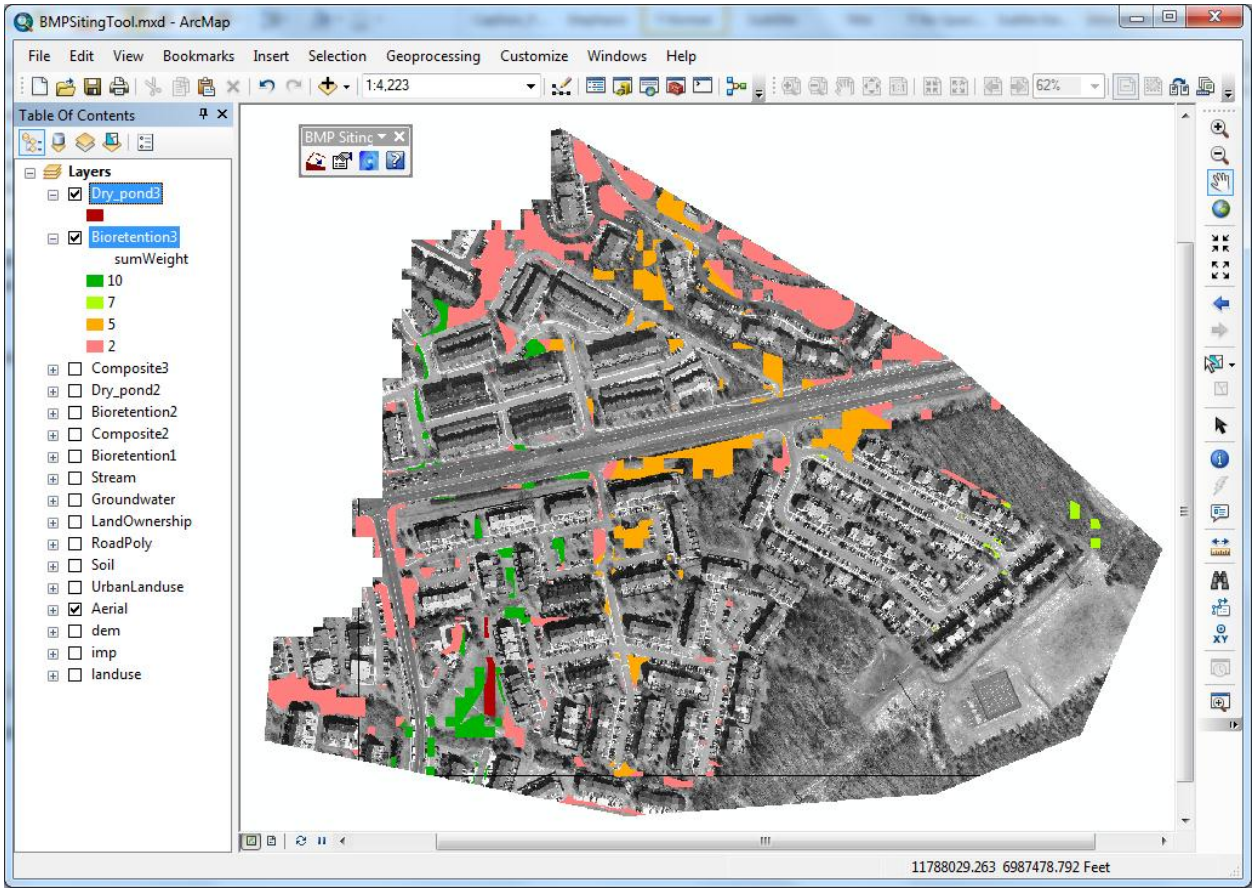

Figure 3-12. Suitable location map for Bioretention and Dry Pond BMP types.

Result Folder

This folder stores the result layers for each BMP types selected in your project. The first time you run the Siting Tool, the system creates a folder named **Result1** and saves the resulting layers there. If you close and reopen the ArcMap project and run the Siting Tool, a new result folder is created with an increment to the previously created folder name. For example if the previously created folder was Result1, it creates a new folder, **Result2**, and saves the result layers for next runs there.

4 References

Shoemaker, L., J. Riverson, K. Alvi, J.X. Zhen, S. Paul, and T. Rafi. 2009. *SUSTAIN—A Framework for Placement of Best Management Practices in Urban Watersheds to Protect Water Quality*. EPA/600/R-09/095. U.S. Environmental Protection Agency, Water Supply and Water Resources Division, National Risk Management Research Laboratory, Cincinnati, OH. <http://nepis.epa.gov/Exe/ZyPURL.cgi?Dockey=P1005IFG.txt >. Accessed Dec 12, 2012.

USEPA (U.S. Environmental Protection Agency). 2004a. *Stormwater Best Management Practice Design Guide*. EPA/600/R-04/121. U.S. Environmental Protection Agency, Office of Research and Development, Washington, DC.

USEPA (U.S. Environmental Protection Agency). 2004b. *The Use of Best Management Practices (BMPs) in Urban Watersheds*. EPA/600/R-04/184. U.S. Environmental Protection Agency, Office of Research and Development, Washington, DC.