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Stormwater

**FINAL  
REPORT**

# User's Guide to the BMP SELECT Model Version 1.0.1

SW1R06a

# USER'S GUIDE TO THE BMP SELECT MODEL

*Version 1.0.1*

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*2009*



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ACR, Colorado State University, University of Utah

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This manual was prepared by Christine A. Pomeroy (University of Utah) and A. Charles Rowney (ACR, LLC), with input from many sources. Larry A. Roesner (Colorado State University) and Jeff Moeller (WERF) reviewed early drafts and provided guidance on the overall content and structure. The larger project team helped shape the thinking that gave rise to the SELECT model. The Issue Area Team brought together by WERF reviewed early drafts of the manual and provided comments. We also wish to acknowledge the feedback from about 100 beta testers who patiently worked through the first draft of the model and this manual.

The SELECT model itself was written by A. Charles Rowney, with support from Christine A. Pomeroy as a reviewer, source of parameters and chief bug-catcher, and with coding support from Christopher M. Rowney (ACR, LLC).

## Introduction

### Purpose of this Manual

This manual is intended to document the nature and use of the BMP SELECT (System Effectiveness and Life-cycle Evaluation of Costs Tool) model version 1.0.1. It is expected that users are personally proficient in the theory and practice involved in solving the problems which the software can be used to assess. In keeping with this expectation, this manual is limited to providing basic definitions and details on running the model. It should not be used as a reference or authoritative source of information otherwise.

### About the Theory

The technical capabilities of this software were designed by Colorado State University and the University of Utah, with support from other members of the project team. Form, technology and function advice was provided by the WERF Issue Area Team that guided the project under which this tool was developed. The methods used were chosen because they represent an effective simple representation of the runoff process and BMP performance which is suitable for estimation on a watershed basis in many circumstances. The cost estimation model, derived from the WERF Whole Life Cost Model, is similarly a simple method suitable for watershed level estimation. None of these technologies represents the current most advanced state of the art or practice, and no method can be guaranteed to be useful in all circumstances.

It is therefore up to the user to determine whether or not the underlying methods embodied in this code are suitable for their purposes. It is not intended that this software be used by someone without the ability to judge the suitability of this software for their purposes. It is up to the user to determine whether or not this software will do the job they want done.

The available documentation can help a user make this determination, but the code itself is the only truly comprehensive documentation of the model, so users should review the code if they have questions about the details of the model technology and capability. Questions on application of the model in any particular set of circumstances will not be answered by WERF or its agents.

### About the Software

This software was developed on behalf of WERF by a team including ACR, LLC, the University of Utah, and Colorado State University, with support from other members of the project team and with form, technology and function advice provided by the WERF Issue Area Team that guided the project under which this tool was developed.

The choice of Microsoft Excel and VBA running on Microsoft Windows XP as a platform for development should not be construed as a recommendation or endorsement of those products, but simply a reflection of the wide availability of Excel to WERF subscribers.

The programming techniques used in this tool represent recommendations from the WERF Issue Area Team and the Project Team that it be internally accessible to a wide range of users, able to solve the technical problems that were specified, and amenable to future expansion. Sophisticated software techniques that might enhance speed or other internal behavior were avoided where they had the potential to make the result inaccessible to the average user.

Depending on user feedback and needs, future versions may depart from some of the methods used in this first version of SELECT, or may extend it and take further advantage of the technical options that can increase speed and computational efficiency. Comments and questions regarding the software itself should be directed to Jeff Moeller at WERF: [jmoeller@werf.org](mailto:jmoeller@werf.org).

### About WERF

This software was developed by WERF in response to WERF Subscriber needs. Subscribers desired a simple tool that could be readily applied to evaluate the relative performance and cost implications of various BMP control options. This tool, SELECT, was the result.

In this first version, SELECT has the capability to evaluate runoff and BMPs, and applies the WERF whole life cost model to enable estimates of system performance. It is likely that in response to continued feedback and support from subscribers, the SELECT model will continue to grow. In the mean time, interested users can obtain information directly from WERF at [www.werf.org/select](http://www.werf.org/select).

### Minimum Knowledge Base for Users

In the initial stages of development of the BMP SELECT profile, a user survey was conducted to indentify candidates that would most likely use the software.

The profile that emerged is of users that:

- ◆ might work for municipalities or potentially regulatory agencies, or might be consultants working for municipalities,
- ◆ would likely be mid-level, perhaps managers or project staff,
- ◆ would tend to be planners rather than designers,
- ◆ are making basic decisions on alternatives, rather than developing design information,
- ◆ were probably working by themselves,
- ◆ would have a background in and some fundamental knowledge of hydrology and water quality management scientists/engineers/planners, but would not necessarily be dedicated to this knowledge area or be expert in it,
- ◆ might have access to sophisticated staff or technical resources, but are not inclined to use them (don't have time/budget; under pressure for quick decisions).

The reasons the user might be using the SELECT model came out of these discussions, and included the following scenarios thought to be typical:

- ◆ They are evaluating alternative approaches to BMP placement, and are looking at multiple scenarios.
- ◆ They have limited information available, but not enough to drive a sophisticated model, and need an answer based on what they have in hand.
- ◆ They are making decisions/recommendations on layout and type of BMP (generating a report of recommendations), and need an approximation.
- ◆ They are checking results from a bigger/more sophisticated model, or are planning the development of such a model.
- ◆ They are estimating costs or program elements for budget workups or similar purposes.

In short, the user of this software is expected to be personally knowledgeable in this technical area, and focused on developing quick solutions based on best available data in situations where a simple model is all that is needed. It is anticipated that they will prefer something quick and simple to apply, which is largely intuitive to use, and which does not require a major investment in learning data formats and model operating requirements.

### **Computer Requirements**

The model requires a Microsoft Windows XP operating system and an installed copy of Microsoft Excel 2003 which has macros enabled. The model will work on any hardware configuration that is effective for this purpose. Disc storage for the software itself is about 3mb, but this may increase as users add content to the spreadsheets that accompany the software. Disc storage space needed for the data files accompanying the software will typically be a few megabytes, but may be larger if users assemble a large library of alternative rainfall data sets.

### **BMPs and Water Quality Parameters**

The stormwater BMPs that can be simulated in the SELECT model Version 1.0.1 include:

- ◆ Extended detention
- ◆ Bioretention
- ◆ Wetlands
- ◆ Swales
- ◆ Permeable pavement
- ◆ Filters

The water quality parameters that can be simulated include:

- ◆ TSS
- ◆ Total nitrogen
- ◆ Total phosphorus
- ◆ Total zinc

As time and funds permit, additional BMP and low impact development (LID) practices will be added to the model. If you would like to help expand the current set of BMPs or water quality parameters in the model, please contact Jeff Moeller at WERF ([jmoeller@werf.org](mailto:jmoeller@werf.org)).



## Model Theory

The BMP SELECT Model is a “planning-level” tool with a focus on limiting the extent and/or complexity of input data necessary to generate results. Since this is a planning tool, it is anticipated that the user will have limited data about the watershed being evaluated and little or no data on the size of BMPs to be implemented within the watershed. As a result, the model was developed in such a manner as to avoid the need for the user to determine and input the size and number of BMPs based on detailed data. Instead, the model uses a number of standards, methods and simplifying assumptions, along with limited user-input data, to perform calculations implicitly. This section summarizes the model methods and assumptions for runoff calculations, treatment of runoff by BMPs, pollutant load estimates, and cost calculations.

### Watershed Runoff Calculations

Watershed runoff is calculated using a runoff coefficient, hourly continuous precipitation data from a historical rainfall record and a computed depression storage value based upon user defined maximum depression storage for each hourly time step. The depression storage must be satisfied in order for runoff to occur.

Incremental depression storage and the recovery of depression storage through evaporation is calculated as:

$$f = f_0 + ND * k, f \leq f_{max} \quad \text{between events} \quad \text{Equation 1}$$

$$f = f_0 - P, 0 \leq f \quad \text{during events} \quad \text{Equation 2}$$

where

$f$  = available (instantaneous) depression storage (inches)

$f_0$  = depression storage from previous time step (inches)

$ND$  = # of days of dry weather

$k$  = pan evaporation rate (inches/day)

$f_{max}$  = user defined maximum depression storage (inches)

$P$  = accumulated event rainfall

Available depression storage therefore decreases during events, and increases between events, and is always bounded by zero and some maximum. Model default maximum depression storage values for residential, commercial and undeveloped land use categories are given in Table 1.

**Table 1. Default Land Use Characteristics.**

| Land Use    | Imperviousness (%) | Runoff Coefficient | Maximum Depression Storage (inches) |
|-------------|--------------------|--------------------|-------------------------------------|
| Residential | 31                 | 0.23               | 0.10                                |
| Commercial  | 72                 | 0.51               | 0.05                                |
| Undeveloped | 4                  | 0.07               | 0.20                                |

Watershed runoff depth is calculated as:

$$R = (P - f) * C, (P - f) \geq 0 \quad \text{Equation 3}$$

where

$R$  = runoff depth (inches)

$P$  = instantaneous precipitation (inches).

The runoff volume (cubic feet) is calculated by converting the runoff depth calculated by Equation 2 to feet and then multiplying the value by the subwatershed area.

The runoff coefficient ( $C$ ) is directly entered by the model user, or is calculated by the model as

$$C = 0.858i^3 - 0.78i^2 + 0.774i + 0.04 \quad \text{Equation 4}$$

where

$i$  = percent impervious (total impervious area).

Default imperviousness values for residential, commercial and undeveloped land use categories are given in Table 1. Note that this equation uses total impervious area rather than directly connected impervious area (WEF/ASCE 1998). Table 1 also lists the runoff coefficient values calculated using Equation 3.

### BMP Quantity Calculations

Treatment of watershed runoff by BMPs is computed using two methods: 1) treatment of a storage volume with outflow at a specified drawdown rate and 2) treatment of storage volume as a secondary initial abstraction with regeneration occurring via evaporation. Extended detention, wetland, bioretention, media filter and swale BMPs are modeled using the storage volume/drawdown rate method and pervious pavement is modeled using the secondary initial abstraction method. The following sections describe how the BMP SELECT Model performs these calculations.

Flow frequency exceedance curves are generated for combined (treated and untreated) discharge from each subwatershed by the model by calculating the percent of time each incremental flow rate is equaled or exceeded during the full simulation period.

#### Treatment of a storage volume with outflow at a specified drawdown rate

In this method, runoff from the area of the watershed that contributes to the BMP is routed to the specified BMP for treatment with outflow from the BMP occurring at a specified drawdown rate. When the storage volume of the BMP is exceeded, excess runoff bypasses the BMP and is not treated, as is shown in Figure 1. This method is applied to extended detention, wetland, bioretention, media filter and swale BMPs.

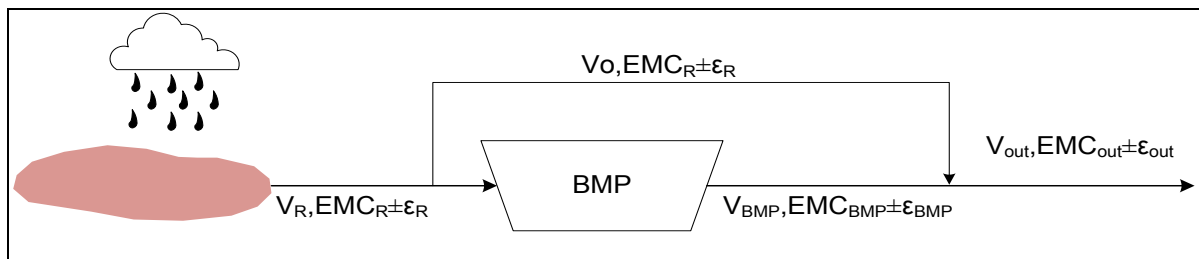


Figure 1. Treatment of Storage Volume with Outflow at a Specified Draw Down Rate.

The storage volume is user specified or estimated by the model as a water quality capture volume (WQCV) using the methods described in the WEF Manual of Practice #23 (WEF/ASCE 1998). Storage volume in watershed inches is calculated using:

$$P_0 = (a * C) * P_6 \quad \text{Equation 5}$$

where

$P_0$  = storage volume (inches)

$a$  = regression constant

$C$  = watershed runoff coefficient

$P_6$  = mean storm precipitation computed from continuous rainfall data (inches)

The regression constant is dependent on the drawdown time, the time specified by the user to completely drain the basin. Default regression constants are given in Table 2. If an intermediate drawdown time is entered by the user, the model interpolates between these values.

**Table 2. WQCV Regression Constants.**

| Draw Down Time<br>(hours) | $a$   |
|---------------------------|-------|
| 12                        | 1.316 |
| 24                        | 1.582 |
| 48                        | 1.963 |

Source: WEF/ASCE, 1998

For each hourly time step, the runoff volume from the area of the watershed that contributes to the BMP is compared to the available storage volume. Available basin volume is tracked for each time step by accounting for inflow and outflow. The treated volume (outflow) rate is constant and is calculated by dividing the WQCV by the drawdown time unless the inflow rate is less than the WQCV/drawdown time. An annual percent mass loss value is used to account for infiltration/evapotranspiration from the BMP. This loss is modeled by reducing the outflow from the BMP by a set percentage; this loss is not applied to runoff that bypasses the BMP. Bypass flow occurs when the runoff volume is greater than the available basin volume.

### **Treatment of storage volume as a secondary initial abstraction**

Pervious pavement is modeled using the secondary initial abstraction method. The holding space of the pavement is modeled as an initial abstraction, similar to depression storage. Only the surface area of the pervious pavement is treated by the pavement. Runoff from the portion of the watershed not covered in permeable pavement is not treated and is modeled as bypass flow. Rainfall that falls on the user specified contributing area is infiltrated into the pavement until the holding capacity is filled. Once the holding capacity is filled, excess precipitation is converted to runoff using

$$Q_{PP} = P * C \quad \text{Equation 6}$$

where

$Q_{PP}$  = runoff from the permeable pavement (inches).

Incremental pavement storage capacity and the recovery of the pavement storage capacity through evaporation is calculated as:

$$HS = HS_0 + ND * k, HS \leq HS_{max} \quad \text{Equation 7}$$

where

$HS$  = available (instantaneous) pavement storage capacity (inches)

$HS_0$  = pavement storage capacity from previous time step (inches)

$HS_{max}$  = user defined maximum pavement storage capacity (inches).

### Pollutant Load Calculations

Pollutant loads are estimated as the product of event mean concentration values and the volume of water. Pollutant loads from watersheds that have extended detention, wetland, bioretention, media filter and swale BMPs, or from watersheds that do not have BMPs are calculated as:

$$Load = EMC_{WS} * Q_B + EMC_{BMP} * Q_{BMP} \quad \text{Equation 8}$$

where

$Load$  = total pollutant load discharged to receiving water (lbs)

$EMC_{WS}$  = event mean concentration for watershed land use (mg/L)

$Q_B$  = runoff that bypasses BMP and is not treated by the BMP (inches)

$EMC_{BMP}$  = event mean concentration for the BMP effluent (mg/L)

$Q_{BMP}$  = runoff treated by the BMP (inches)

Mean default even mean concentration (EMC) and standard deviation values are given for residential, commercial and undeveloped land use types in Table 3. Table 4 summarizes effluent EMCs for extended detention, wetland, bioretention, media filter, swales and permeable pavement.

Pollutant loads from watersheds that have permeable pavement are calculated as:

$$Load = EMC_{WS} * Q_{WS} + EMC_{BMP} * Q_{PP} \quad \text{Equation 9}$$

where

$Q_{WS}$  = runoff from the portion of the watershed not covered in permeable pavement (inches)

Pollutant load exceedance curves are generated for combined (treated and untreated) discharge from each subwatershed by the model by calculating the percent of time each incremental pollutant load value is equaled or exceeded during the full simulation period. An uncertainty band is provided on the water quality exceedance curves, representing values above and below the calculated exceedance curves. These plus and minus curves are determined based on the reported standard deviations of EMC observations in the literature. The basic curve is calculated using the average EMC value, and the plus and minus curves are based on the reported standard deviations of the EMC values about the average.

**Table 3. Default Event Mean Concentration Values for Default Land Uses.**

| Land Use    | TSS (mg/L) |     | Total Phosphorus (mg/L) |      | Total Nitrogen (mg/L) |      | Total Zinc (mg/L) |      |
|-------------|------------|-----|-------------------------|------|-----------------------|------|-------------------|------|
|             | MED        | STD | MED                     | STD  | MED                   | STD  | MED               | STD  |
| Residential | 101        | 21  | 0.383                   | 0.10 | 0.736                 | 0.12 | 0.135             | 0.05 |
| Commercial  | 69         | 5   | 0.201                   | 0.02 | 0.572                 | 0.10 | 0.226             | 0.05 |
| Undeveloped | 70         | 3   | 0.121                   | 0.05 | 0.543                 | 0.10 | 0.195             | 0.02 |

MED = Median, STD = Standard Deviation

Source: U.S. EPA, 1983.

**Table 4. Default Effluent Even Mean Concentrations for BMPs.**

| BMP                             | TSS (mg/L) |     | Total Phosphorus (mg/L) |      | Total Nitrogen (mg/L) |      | Total Zinc (mg/L) |       |
|---------------------------------|------------|-----|-------------------------|------|-----------------------|------|-------------------|-------|
|                                 | MED        | STD | MED                     | STD  | MED                   | STD  | MED               | STD   |
| Extended Detention <sup>1</sup> | 31         | 2   | 0.19                    | 0.04 | 2.72                  | 0.50 | 0.0602            | 0.003 |
| Wetland Basins <sup>1</sup>     | 18         | 1   | 0.14                    | 0.02 | 1.15                  | 0.20 | 0.0307            | 0.002 |
| Bioretention <sup>1</sup>       | 24         | 2   | 0.34                    | 0.06 | 0.78                  | 0.10 | 0.0400            | 0.001 |
| Swales <sup>2</sup>             | 13         | 1   | 0.22                    | 0.05 | 2.72                  | 0.40 | 0.0215            | 0.001 |
| Media Filters <sup>1</sup>      | 16         | 1   | 0.14                    | 0.03 | 0.76                  | 0.10 | 0.0585            | 0.002 |
| Permeable Pavement <sup>1</sup> | 18         | 1   | 0.14                    | 0.03 | 1.15                  | 0.15 | 0.0307            | 0.002 |

MED = Median, STD = Standard Deviation

Source: <sup>1</sup>Geosyntec Engineers and Wright Water Consultants, 2008; <sup>2</sup>Barrett et al, 1998.

### Cost Calculations

Cost calculations are based on the WERF Whole Life Cost Models (Project numbers SW2R08 and 01CTS21TA). Parametric equations based on the total area of acres treated by each BMP are used to calculate capital cost, and an adjustment factor for small projects is allowed by the model. Operation and maintenance costs are computed as a percentage of the capital cost, as are replacement costs. Total costs are based on capital, operation and maintenance, and replacement costs, accounting for design life and the application of a discount rate. Complete documentation for the Whole Life Cost methodology is given in Lampe et al. (2005) and Pomeroy and Houdeshel (2009). Default cost data included in the model are summarized in Table 5.

**Table 5. Default Cost Parameters.**

| BMP                               | Base Cost<br>(\$/acre<br>treated) | Adjustment | O&M<br>(%) | Discount Rate<br>(%) | Replacement<br>(%) | Design<br>Life (yrs) |
|-----------------------------------|-----------------------------------|------------|------------|----------------------|--------------------|----------------------|
| Extended Detention <sup>1,3</sup> | 3,750                             | 2          | 2.7        | 5.5                  | 80                 | 25                   |
| Wetland Basins <sup>1,3</sup>     | 3,750                             | 1.42       | 1.4        | 5.5                  | 80                 | 25                   |
| Bioretention <sup>2,3</sup>       | 53,000                            | 1          | 3.5        | 5.5                  | 80                 | 25                   |
| Swales <sup>1,3</sup>             | 3,750                             | 2.2        | 5.4        | 5.5                  | 80                 | 25                   |
| Media Filters                     | N.A.                              | N.A.       | N.A.       | N.A.                 | N.A.               | N.A.                 |
| Permeable Pavement <sup>1,4</sup> | 374,000                           | 1          | 2.3        | 5.5                  | 80                 | 25                   |

N.A. = Not available.

Source: <sup>1</sup>Lampe et al, 2005, <sup>2</sup>Pomeroy and Houdeshel, 2009.

<sup>3</sup>Base cost includes engineering & planning. Medium maintenance.

<sup>4</sup>Assumes concrete, includes engineering & planning, contingency. Medium maintenance.

## Using the Model

The first thing to know about using SELECT is that although most of its data and results are accessible through ordinary spreadsheets of the type you are used to using in Microsoft Excel, you won't normally be working with spreadsheets directly. Generally, you'll work with Forms that enable you to control the model, enter data and view results. The actual spreadsheets are used for many kinds of data storage and outputs, including charts, so they are still valuable even if they aren't the main working interface. This provides a combination that greatly reduces the learning curve for the software but still lets users customize things like the graphics and reports using tools that they are used to in Excel.

When you first load the model, it will display the About SELECT screen shown below in Figure 2. This form provides the version number that you have loaded. Links on the available tabs provide information about the model, and can guide you to some on-line resources. If you are not using Excel 2003, the standard to which this software was developed, a warning message will also show up letting you know you aren't using the preferred version of Excel and that there may be issues as a result of this.

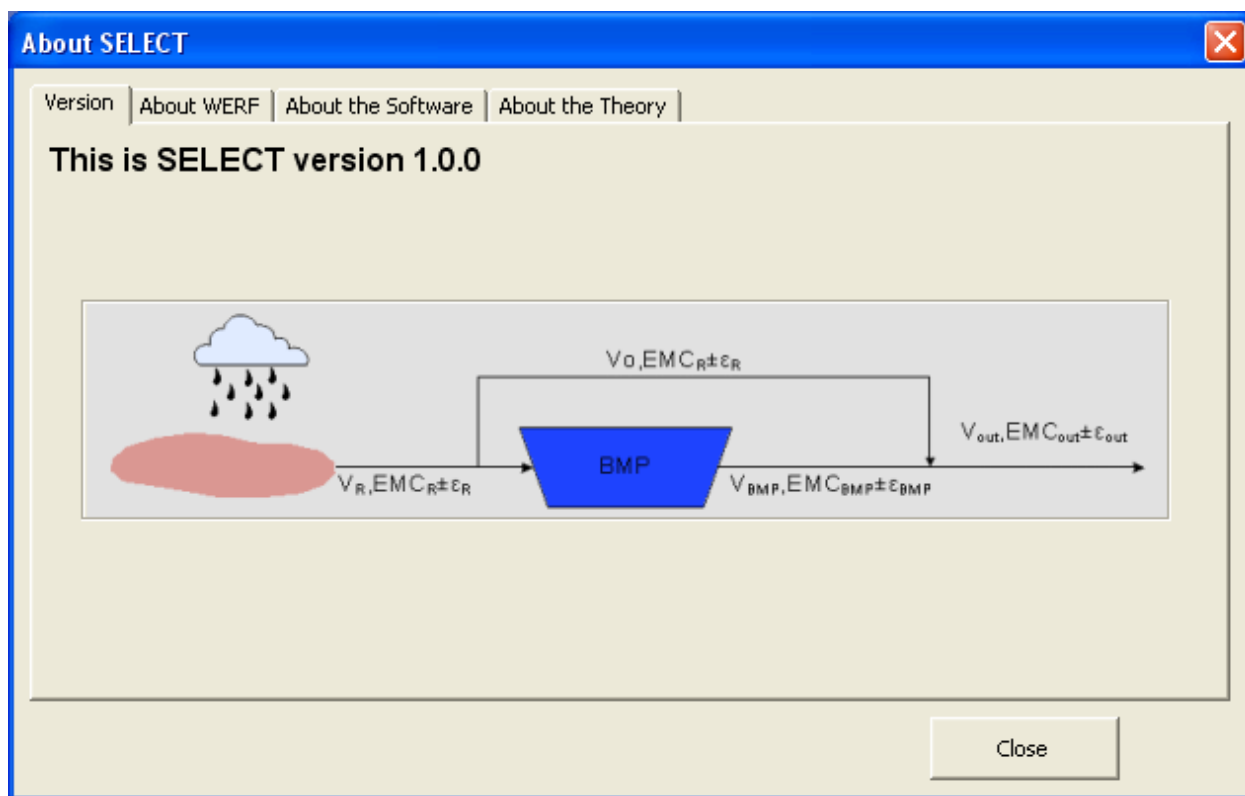


Figure 2. The About SELECT Form.

If you don't want to explore this form, just hit the Close button, and proceed to the model itself. (Note: If you want, you can always bring up the About SELECT panel at any time by clicking the button at the bottom of the Start page.)

The Start page of the model allows the user to set up and evaluate BMP options, set user information and modify default values. Each of these activities is achieved by clicking on the respective buttons shown in Figure 3. The following sections describe the activities that can be performed under each button.

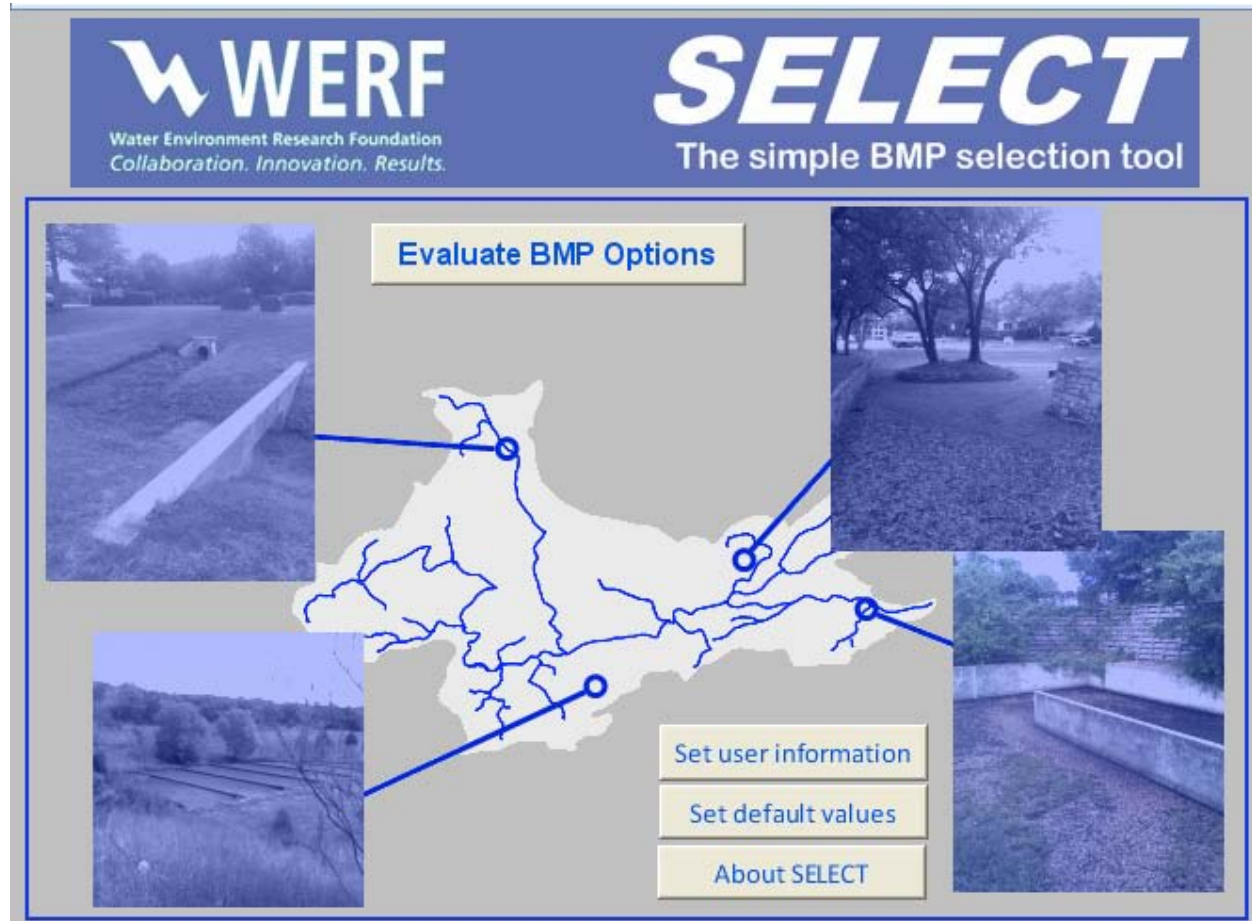


Figure 3. Start Page of BMP SELECT Model.

### Evaluate BMP Options

This portion of the model is used to create alternative BMP scenarios, modify existing scenarios, perform water quality, water quantity and cost computations and generate output. Figure 4 summarizes the activities that are available under each of the tabs accessible through the evaluate BMP options button.

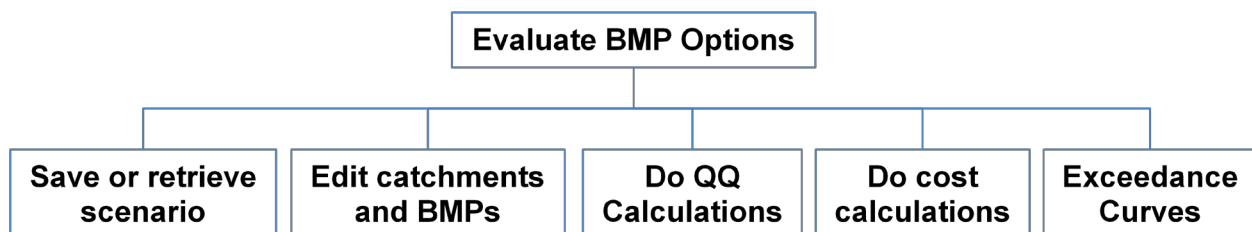


Figure 4. Evaluate BMP Options Menu Structure.



### Evaluate BMP Options>Save or Retrieve Scenario

The BMP SELECT model can store multiple scenarios for evaluation of various BMP alternatives. These can be retrieved under the save or retrieve scenarios tab shown in Figure 5. When multiple scenarios are created by a user, they are saved and retrieved under this tab by selecting the desired scenario from the pull down menu and clicking the appropriate button. Note that if only one scenario is evaluated by the model, a scenario name is not indicated until the user gives it a name. Scenarios are created or deleted by clicking the manage scenarios button and are added, changed, or deleted in the form shown in Figure 6. Scenario information is edited in the form shown in Figure 7, and includes the scenario title, author, the name of the scenario file and the location where the file is stored. Scenario data are stored as separate Microsoft Excel files. It should be noted that the scenario management feature of the BMP SELECT model does not work in Microsoft Excel 2007.

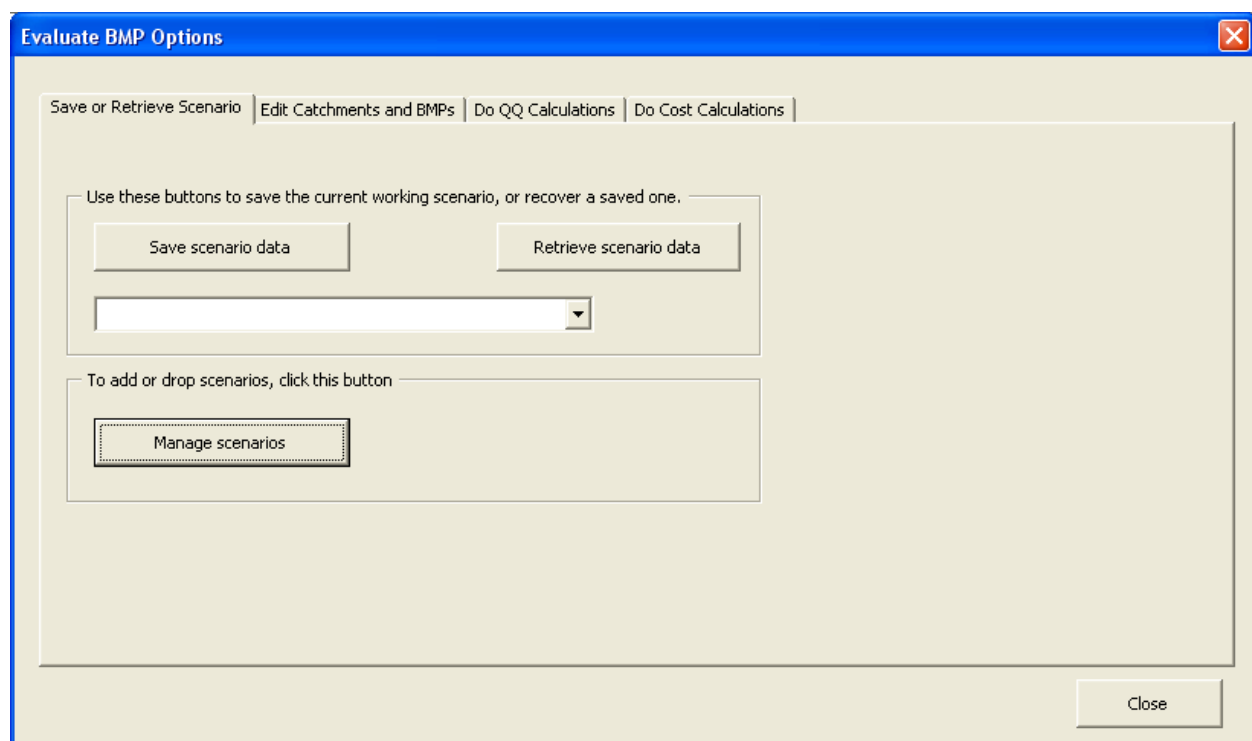


Figure 5. Save or Retrieve Scenario.

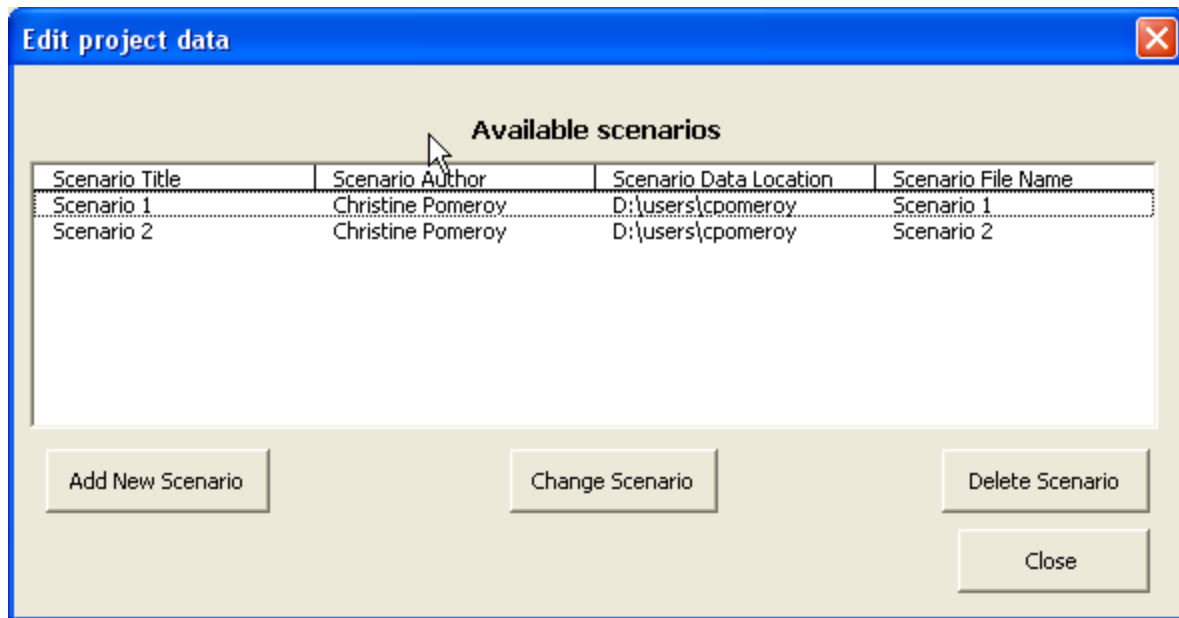


Figure 6. Edit Project Data.

Scenario Title: Example 1

Scenario Author: Christine Pomeroy

Location of scenario file: D:\users\cpomeroy

Name of scenario file: Example 1

Figure 7. Scenario Information.

### Evaluate BMP Options>Edit catchments and BMPs

Subcatchments and their respective BMPs are created and modified under the edit catchments and BMPs tab shown in Figure 8; a summary table of the data for each catchment is shown under this tab. The total watershed area is summarized, along with a summary of the total area treated by BMPs. Existing subcatchments may be deleted or modified by highlighting the subcatchment of interest and clicking the delete button or the change subcatchment button. When a subcatchment is modified, or a new one is added, the form shown in Figure 9 is displayed. Several categories of data are entered in this form. Basic watershed characteristics, such as land use and subwatershed area are entered. Default quantity parameters (runoff coefficient and depression storage) are automatically populated in the form based on the default data specified

for that land use type. The user may overwrite these defaults with subwatershed specific data, if desired. The BMP applied to the subwatershed is specified in this form from the pull down menu, and the area contributing to the BMP is identified. For extended detention, wetland basin, filter, swale and bioretention BMPs the user specifies the water quality capture volume (WQCV), the drawdown time for the BMP and the percent losses; the user specifies the storage capacity for permeable pavement BMPs. As an alternative to entering a value for the WQCV, the BMP SELECT model will calculate the WQCV upon request. The WQCV may be calculated for each subcatchment by clicking the estimate WQCV button. The user specifies the rainfall data set used for this estimation in the form shown in Figure 10.

**Evaluate BMP Options**

Save or Retrieve Scenario | **Edit Catchments and BMPs** | Do QQ Calculations | Do Cost Calculations

**Available Subcatchments**

| Name           | Area (acres) | Land Use    | Cv  | DS (inch) | BMP                | Treated Area (acres) | WQCV (inch) | Drawdown (hrs) |
|----------------|--------------|-------------|-----|-----------|--------------------|----------------------|-------------|----------------|
| Subcatchment a | 100          | Commercial  | 0.5 | 0.05      | Extended Detention | 25                   | 0.57        | 12             |
| Subcatchment 5 | 22           | Residential | 0.2 | 0.1       | Extended Detention | 12                   | 0.15        | 12             |
| Subcatchment 3 | 4            | Residential | 0.2 | 0.1       | Bioretention       | 2                    | 0.57        | 12             |
| Subcatchment 4 | 22           | Residential | 0.2 | 0.1       | Wetland Basin      | 2                    | 0.22        | 12             |

148 Total area (acres) 41 Treated area (acres)

Add New Subcatchment Change Subcatchment Delete Subcatchment

Close

**Figure 8. Edit Catchments and BMPs.**

Edit subcatchment data

Update information for subcatchment

Name

Subcatchment a

Basic characteristics

Land use

Commercial

Area (acres)

100

Quantity Parameters

Runoff coefficient

0.9

Depression storage (inches)

0.1

BMP Parameters

BMP type

Extended Detention

Contributing area (acres)

25

Drawdown time (hrs)

24

WQCV (ins)

12

Estimate WQCV

Percent losses

0

Base cost / acre (\$)

3750

Engineering & Planning costs (\$)

50000

Small facility base cost adjustment ratio

2

Land costs (\$)

250000

O&M cost as % of capital cost

2.7

Other costs (\$)

0

Replacement cost as % of capital cost

80

Life span (years)

25

Discount rate

5.5

Cancel

Save

Figure 9. Editing Subcatchment Data.

Generate an Estimated WQCV

1) Select the applicable rainfall.

Rainfall file 2
Rainfall

2) Click 'Calculate'

Calculate

Values used in calculating WQCV

304.65999

Total rainfall over period (inches)

635

# of events in period

0.4797795

average event volume (inches)

Runoff coefficient for this Sub Catchment: 0.51

3) Click the case (12, 24 or 48 hr) you prefer.

Estimated WQCV for different drawdown times

12 hr

24 hr

48 hr

0.32

0.39

0.48

Use 12hr

Use 24hr

Use 48hr

Cancel

Figure 10. Estimate WQCV.

Table 6 provides a description of each of the subcatchment and BMP parameters, including BMP cost data; further details on how these parameters are used for computations are provided in the model theory section of this documentation.

**Table 6. Summary of Watershed and BMP Input Parameters.**

| <b>Category</b>                                          | <b>Input Parameter</b>                     | <b>Description</b>                                                                                                               |
|----------------------------------------------------------|--------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------|
| Basic Characteristics                                    | Land Use                                   | Land use in subcatchment                                                                                                         |
|                                                          | Area (acres)                               | Area of subcatchment                                                                                                             |
| Quantity Parameters                                      | Runoff coefficient*                        | Portion of precipitation that is converted to runoff after initial abstraction                                                   |
|                                                          | Depression storage* (inches)               | Watershed storage modeled as an initial abstraction                                                                              |
| BMP Parameters (variable depending on BMP type selected) | Contributing area (acres)                  | Area of watershed that contributes runoff to the BMP                                                                             |
|                                                          | WQCV (inches)                              | Water Quality Capture Volume; input by user or calculated by the model upon user request                                         |
|                                                          | Drawdown time (hours)                      | The desired emptying time for the BMP                                                                                            |
|                                                          | Percent losses (%)*                        | Used to account for infiltration/evapotranspiration from the BMP; outflow from the BMP is reduced by this amount                 |
|                                                          | Holding capacity (inches)                  | Storage volume of permeable pavement                                                                                             |
| Cost Parameters                                          | Base cost / acre (\$)*                     | The cost of the facility per acre of watershed treated                                                                           |
|                                                          | Small facility cost adjustment ratio*      | Larger facilities generally provide economies of scale for capital cost; this option allows for an increase to the base cost     |
|                                                          | O&M cost as % of capital cost (%)*         | Operation and maintenance (O&M) costs are entered as percentage of capital cost                                                  |
|                                                          | Discount rate (%)*                         | Used to calculate the present value of long-term operational costs; does not fluctuate over time; does not account for inflation |
|                                                          | Replacement cost as % of capital cost (%)* | Replacement cost is entered as percentage of capital cost                                                                        |
|                                                          | Engineering & planning cost (\$)           | Cost of additional engineering and planning; added to capital cost                                                               |
|                                                          | Land cost (\$)                             | Cost of land; added to capital cost                                                                                              |
|                                                          | Other costs (\$)                           | Any other costs applied towards capital cost                                                                                     |
|                                                          | Life span (years)*                         | Anticipated lifespan of the facility                                                                                             |

\*Defaults established in the set default values section of the BMP SELECT model; may be modified on a subcatchment-by-subcatchment basis.

### **Evaluate BMP Options>Do quantity and quality (QQ) calculations**

The model is run from the Do QQ Calculations tab, as shown in Figure 11. The user has the option to select the desired rainfall record set for model computation. After the model is run, a summary of the water quantity and quality results are displayed in tabular format for each subcatchment, as shown in Figure 12. After the model is run, the user has the option to generate reports, and a new tab appears allowing computation of flow and pollutant load frequency exceedance curves. Detailed, standard, and short reports are available and are generated as new user-named worksheets in the Excel file upon request. A summary of the information provided in each report is given in Table 7.

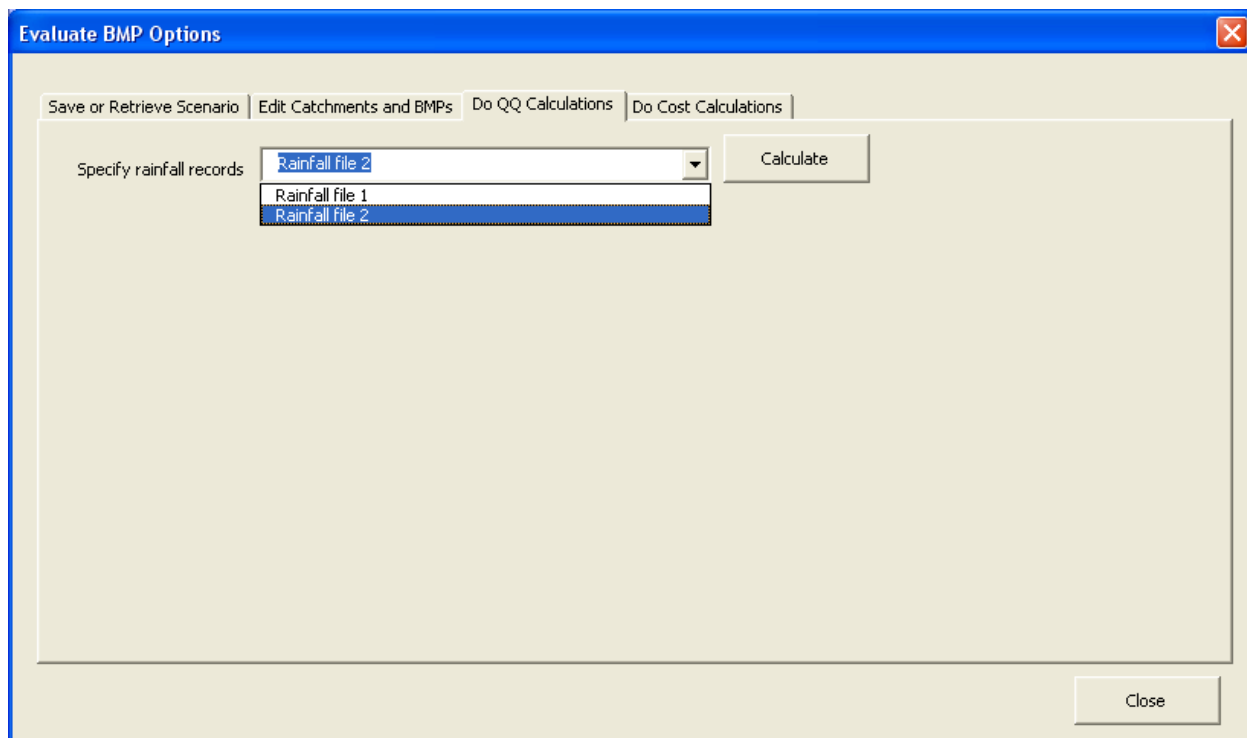


Figure 11. Do QQ Calculations.

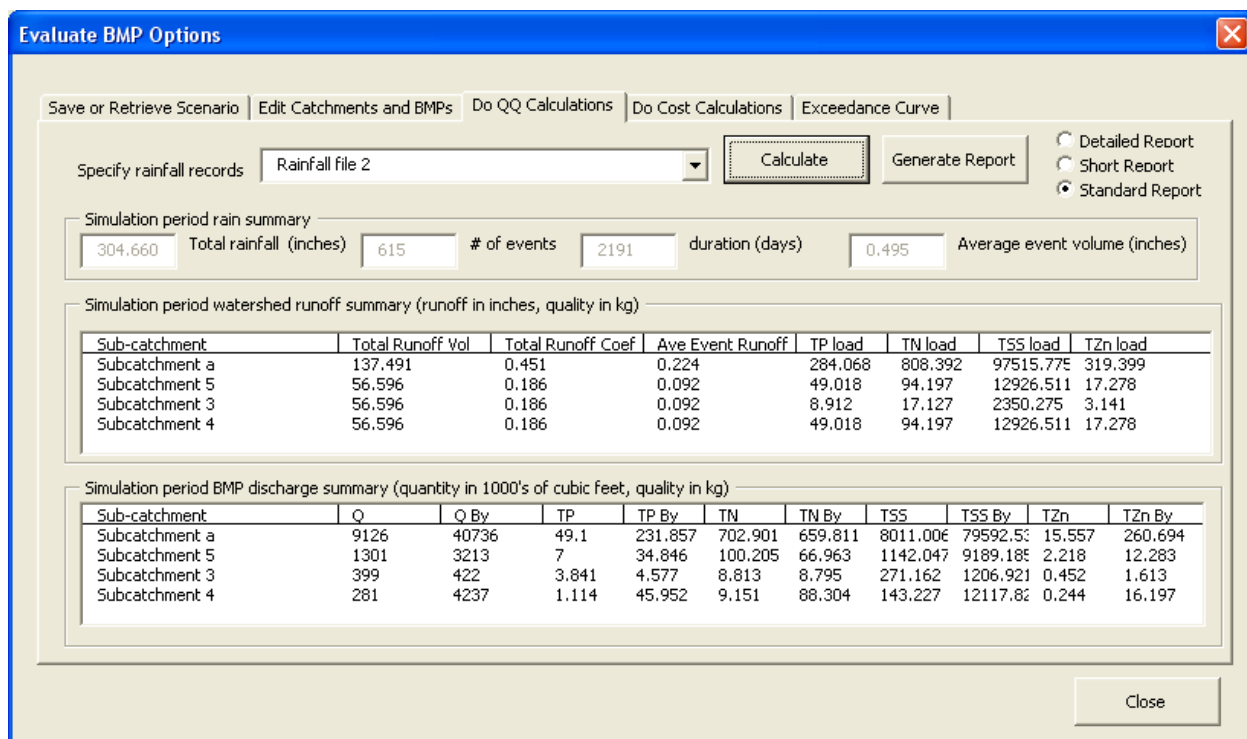


Figure 12. Summary of QQ Calculations.



Table 7. Data Provided in Detailed, Standard, and Short Reports.

| Information                                         | Detailed | Standard | Short |
|-----------------------------------------------------|----------|----------|-------|
| User Name                                           | X        | X        | X     |
| User organization                                   | X        | X        | X     |
| Report Date                                         | X        | X        | X     |
| Report Time                                         | X        | X        | X     |
| <b>Scenario Data</b>                                |          |          |       |
| Subwatershed Name                                   | X        | X        | X     |
| Area (acres)                                        | X        | X        | X     |
| Land Use                                            | X        | X        | X     |
| Cv                                                  | X        | X        | X     |
| DS (inches)                                         | X        | X        | X     |
| BMP                                                 | X        | X        | X     |
| Treated Area (acres)                                | X        | X        | X     |
| WQCV (inches)                                       | X        | X        | X     |
| Drawdown (hrs)                                      | X        | X        | X     |
| % Loss                                              | X        | X        | X     |
| PPV (inches)                                        | X        | X        | X     |
| <b>Scenario BMP Quality Data</b>                    |          |          |       |
| Subwatershed Name                                   | X        |          |       |
| BMP Type                                            | X        | X        |       |
| % Loss                                              | X        | X        |       |
| Effluent EMC (mg/l) TP, TN, TSS, TZn                | X        | X        |       |
| <b>Scenario Land Use Quality Data</b>               |          |          |       |
| Subwatershed Name                                   | X        |          |       |
| Land Use Name                                       | X        | X        |       |
| EMC (mg/l) TP, TN, TSS, TZn                         | X        | X        |       |
| <b>Rainfall Data</b>                                |          |          |       |
| File name                                           | X        | X        | X     |
| To and From dates                                   | X        | X        | X     |
| Duration (days)                                     | X        | X        | X     |
| Number of events (ins)                              | X        | X        | X     |
| Total rain (ins)                                    | X        | X        | X     |
| Event average rainfall (ins)                        | X        | X        | X     |
| Annual average rainfall (Ins)                       | X        | X        | X     |
| <b>Runoff (quantity, TP, TN, TSS, Zn, )</b>         |          |          |       |
| Total Over Period (cu.ft., kg.)                     | X        | X        | X     |
| Annual Average (cu.ft., kg.)                        | X        | X        | X     |
| <b>BMPs (quantity, TP, TN, TSS, Zn, )</b>           |          |          |       |
| Annual Treated Discharge (cu.ft., kg.)              | X        | X        | X     |
| Annual Bypassed Discharge (cu.ft., kg.)             | X        | X        | X     |
| Annual Total Discharge (cu.ft., kg.)                | X        | X        | X     |
| Annual Total Percent Removed (cu.ft., kg.)          | X        | X        | X     |
| <b>Average Concentration (mg/l) TP, TN, TSS, Zn</b> | X        | X        | X     |

### Evaluate BMP Options>Do cost calculations

Costs are calculated under the cost calculations tab and a summary table is generated after the calculations are complete, as shown in Figure 13. A cost report can be generated by clicking the generate report button, the report is displayed in a new Excel worksheet labeled Cost Report. The report summarizes capital cost data for each subcatchment including the contributing BMP area, the base cost per acre, the adjustment for small projects, engineering and planning costs, and other costs. Operation and maintenance costs are also summarized, and the total net present value is provided for each subcatchment, along with a grand total of combined costs for all of the subcatchments evaluated in the scenario.

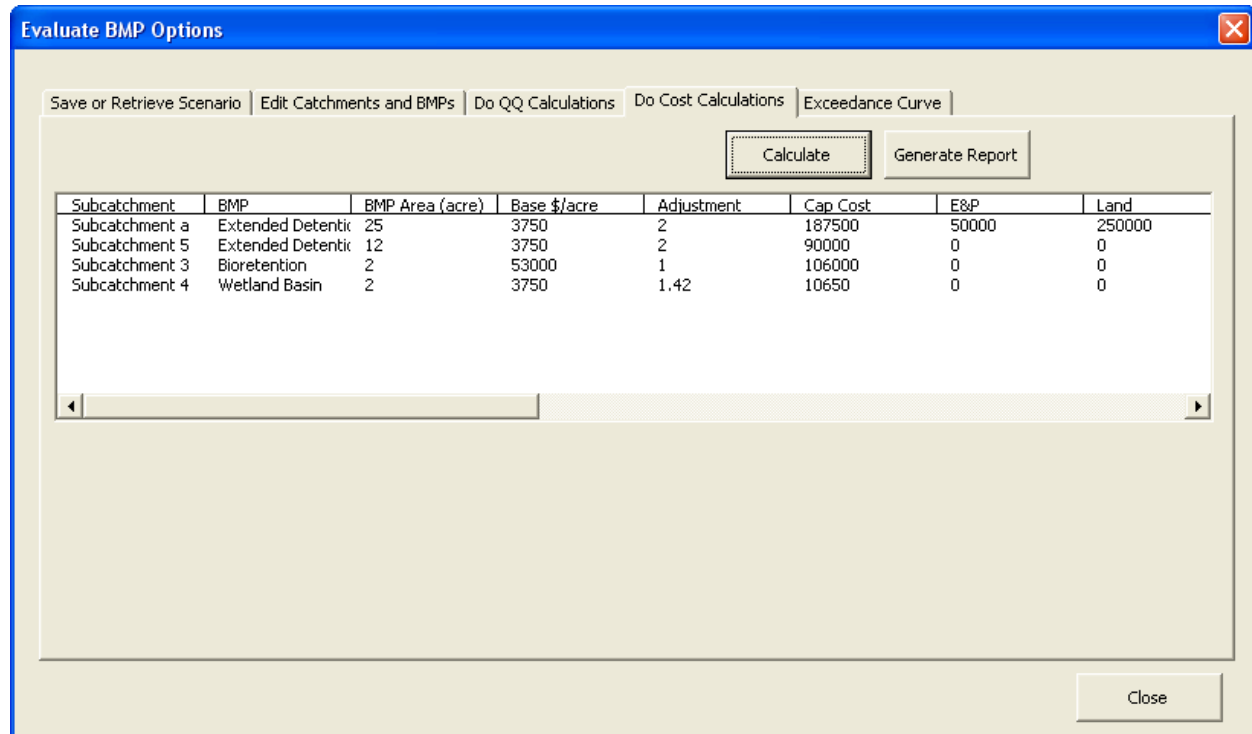


Figure 13. Do Cost Calculations.

### Evaluate BMP Options>Exceedance Curve

Data for flow and pollutant load frequency exceedance curves are calculated separately for each subcatchment when the user selects the subcatchment and initiates generation of the data by clicking the calculate exceedance button shown in Figure 14. Note that this button appears only after running the model under the Do QQ Calculations tab. Exceedance curves are graphed for each subcatchment individually for flow or the water quality parameters. Each exceedance curve is displayed in a new Excel worksheet. It should be noted that exceedance curve plots can only be generated for one subcatchment at a time.

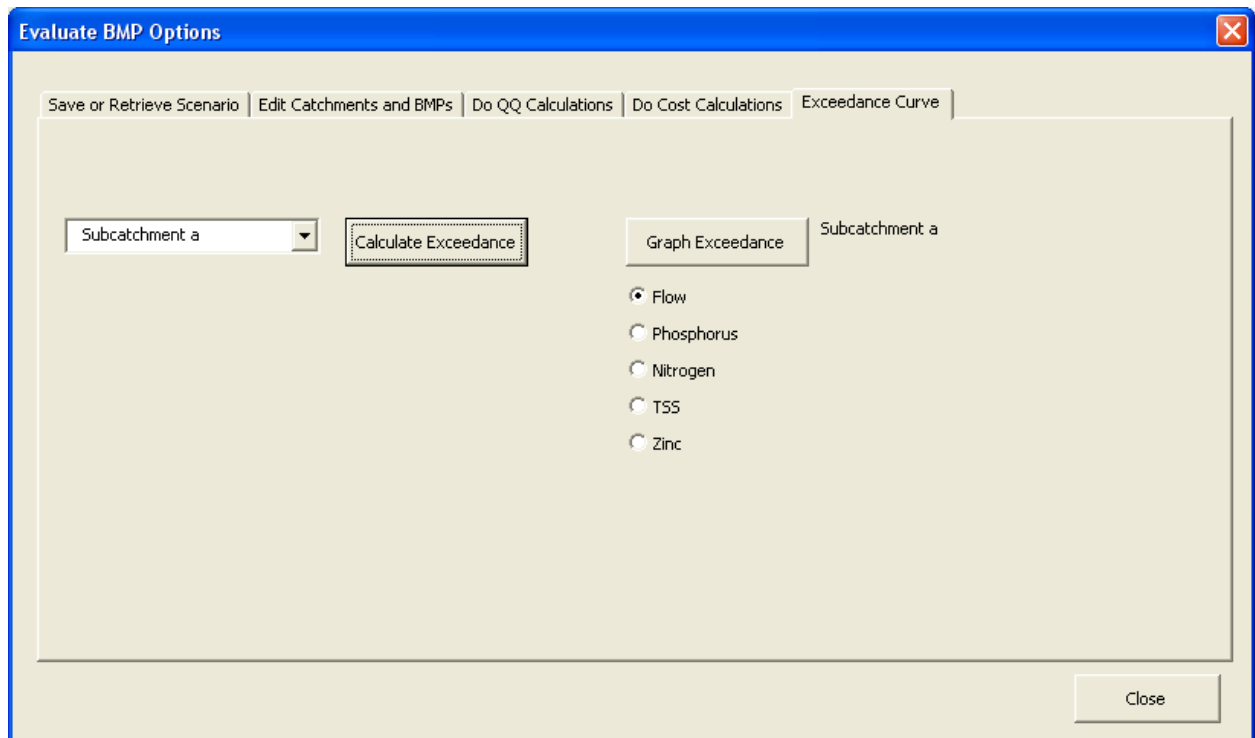
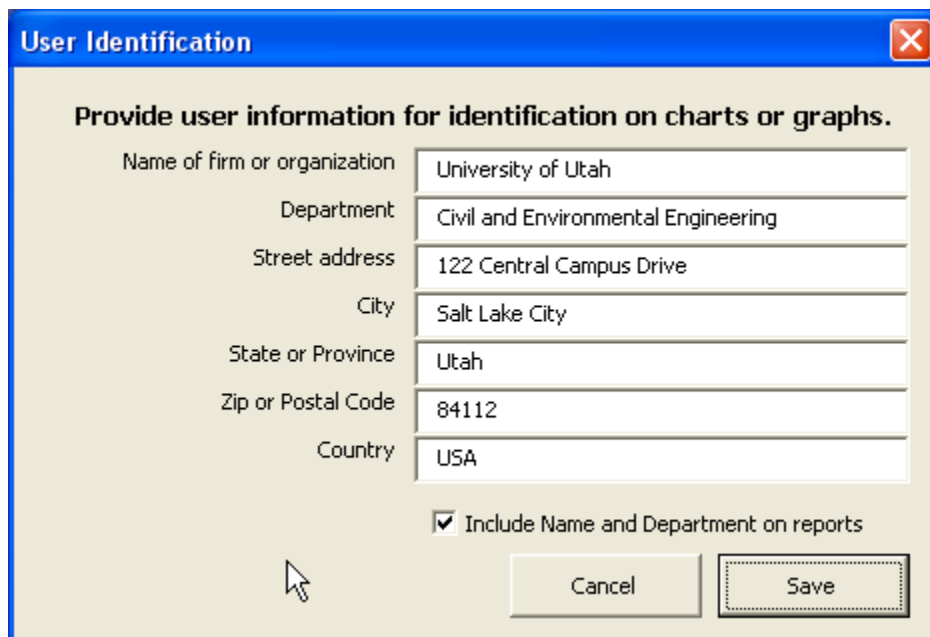


Figure 14. Exceedance Curves.

## Set User Information

A model user may enter information relevant to their organization by clicking on the set user information button on the start page of the model. This information is optional, but if it is provided it is displayed on summary reports generated by the model. Figure 15 shows the requested information, which includes the name and address of the firm or organization. A user can opt to not include this information on reports by unchecking the check box at the bottom of the form.



The image shows a 'User Identification' dialog box with a blue title bar and a close button. The main text reads 'Provide user information for identification on charts or graphs.' Below this, there are several text input fields with labels to their left: 'Name of firm or organization' (University of Utah), 'Department' (Civil and Environmental Engineering), 'Street address' (122 Central Campus Drive), 'City' (Salt Lake City), 'State or Province' (Utah), 'Zip or Postal Code' (84112), and 'Country' (USA). At the bottom, there is a checked checkbox labeled 'Include Name and Department on reports'. To the right of the checkbox are 'Cancel' and 'Save' buttons. A mouse cursor is pointing at the bottom left of the dialog box.

Figure 15. User identification.

## Set Default Values

Default parameters are modified under the set default values button. Watershed parameters, BMP parameters and meteorological data are modified in this section of the model. The menu structure of this portion of the model is shown in Figure 16. Parameters under each button are described in this section.

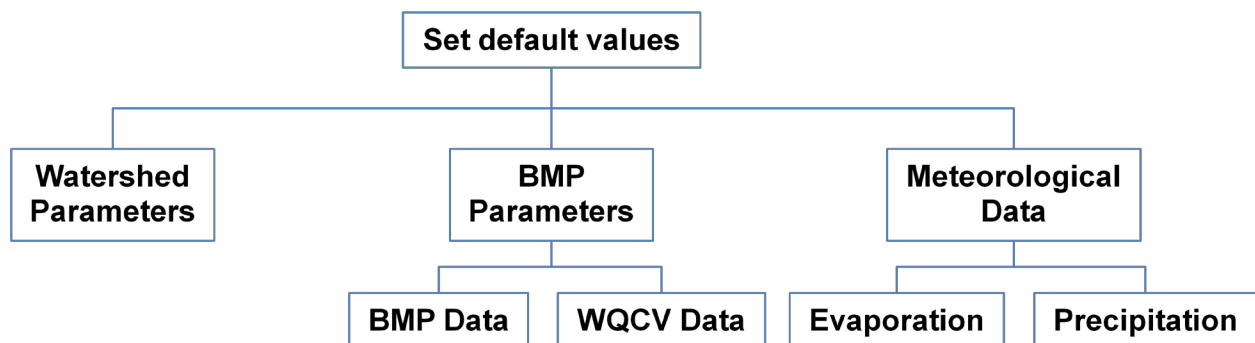


Figure 16. Default Values Menu Structure.

## Set Default Values>Watershed Parameters

Default watershed parameters are modified under the tab shown in Figure 17. The user can create new land uses, change existing land uses or delete land uses on this page. Figure 18 displays the variables that may be modified for each land use type, each of which is explained in Table 8.

Default land use parameters and their sources for residential, commercial, and undeveloped lands were given in Table 1 and Table 3 in the Model Theory section of this user's manual.

Set Default Values

Change default parameters and import rainfall files here

Watershed Parameters | BMP Parameters | Meteorological Data

Available characteristic land use parameters

| Watershed Type | % Imp. | Cv    | DS (inches) | TP ave (mg/l) | TP sdev (mg/l) | TN ave (mg/l) | TN  |
|----------------|--------|-------|-------------|---------------|----------------|---------------|-----|
| Residential    | 31     | 0.23  | 0.1         | 0.383         | 0.1            | 0.736         | 0.1 |
| Commercial     | 72     | 0.513 | 0.05        | 0.201         | 0.02           | 0.572         | 0.1 |
| Undeveloped    | 4      | 0.07  | 0.2         | 0.121         | 0.05           | 0.543         | 0.1 |

Add New Land Use Change Land Use Delete Land Use Close

Figure 17. Watershed Parameters.

**Edit land use data**

**Change information for land use type 1**

Land use name: Residential

**Quantity Parameters**

Percent imperviousness: 31

Runoff coefficient: 0.23

Depression storage (inches): 0.1

**Quality Parameters**

|                               | mean  | std. dev. |
|-------------------------------|-------|-----------|
| Total Phosphorus (mg/l)       | 0.383 | 0.1       |
| Total Nitrogen (mg/l)         | 0.736 | 0.12      |
| Total Suspended Solids (mg/l) | 101   | 21        |
| Total Zinc (mg/l)             | 0.135 | 0.05      |

Buttons: Cancel, Save

Figure 18. Edit Land Use Data.

Table 8. Land Use Input Parameters.

| Category            | Input Parameter             | Description                                                                                                 |
|---------------------|-----------------------------|-------------------------------------------------------------------------------------------------------------|
| Quantity Parameters | Percent imperviousness (%)  | The portion of the subwatershed that is covered by impervious surfaces (i.e. roads, roofs and parking lots) |
|                     | Runoff coefficient          | Calculated by model using Equation 4 or manually entered by user                                            |
|                     | Depression storage (inches) | Watershed storage modeled as an initial abstraction                                                         |
| Quality Parameters  | Mean (mg/L)                 | Event mean concentration (EMC) for each water quality parameter                                             |
|                     | Std. Dev. (mg/L)            | Standard deviation of EMC for each water quality parameter                                                  |

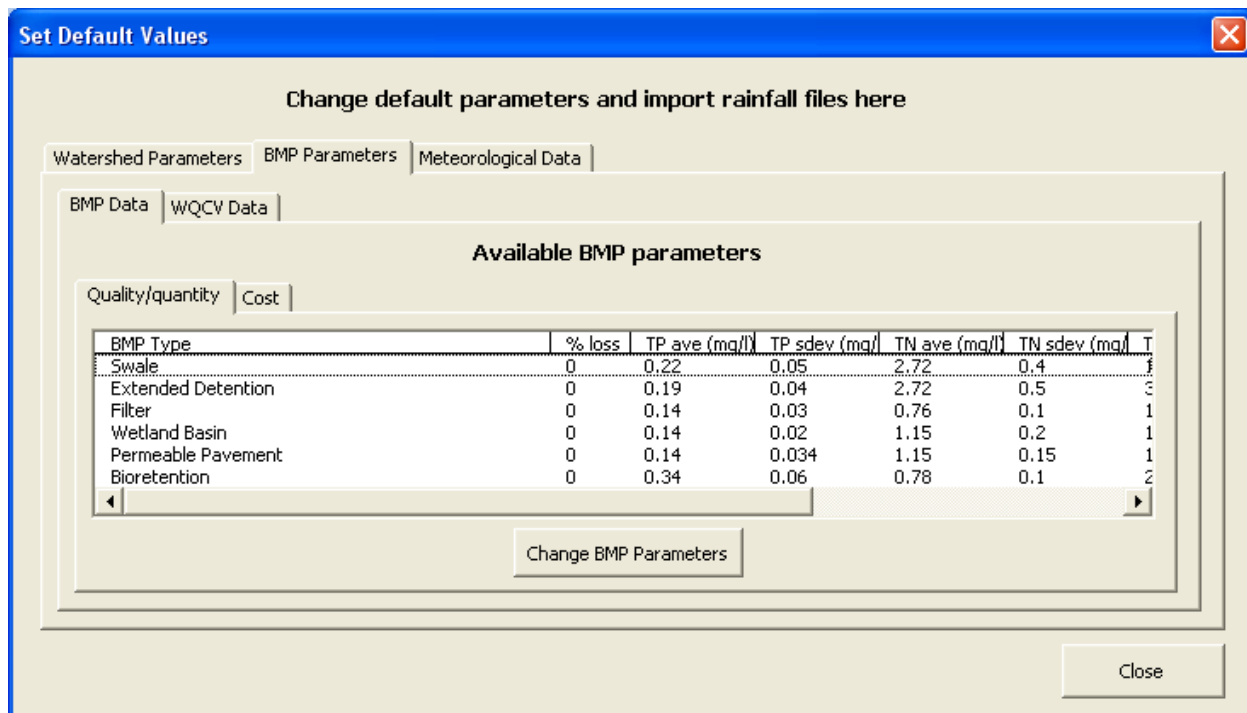
### Set Default Values>BMP Parameters

The BMP SELECT model currently has the ability to model swales, extended detention, filters, wetland basins, permeable pavement and bioretention. Default parameters for each of these BMPs are modified under the BMP parameters tab; input parameters are described in this section.

### Set Default Values>BMP Parameters>BMP Data

Quality/quantity and cost data for each BMP type are summarized in tables under tabs shown respectively in Figure 19 and Figure 20. Default quality, quantity and cost data for each BMP type can be modified as shown in Figure 21; each of the variables is explained in Table 9. Default event mean concentrations and standard deviations for each BMP type were summarized

in Table 4 in the Model Theory section of this user's manual. Default cost data for each BMP type were given in the Model Theory section of this user's manual. Note that users may override all default data with local data applicable to their own project.



**Set Default Values**

Change default parameters and import rainfall files here

Watershed Parameters | **BMP Parameters** | Meteorological Data

BMP Data | WQCV Data

**Available BMP parameters**

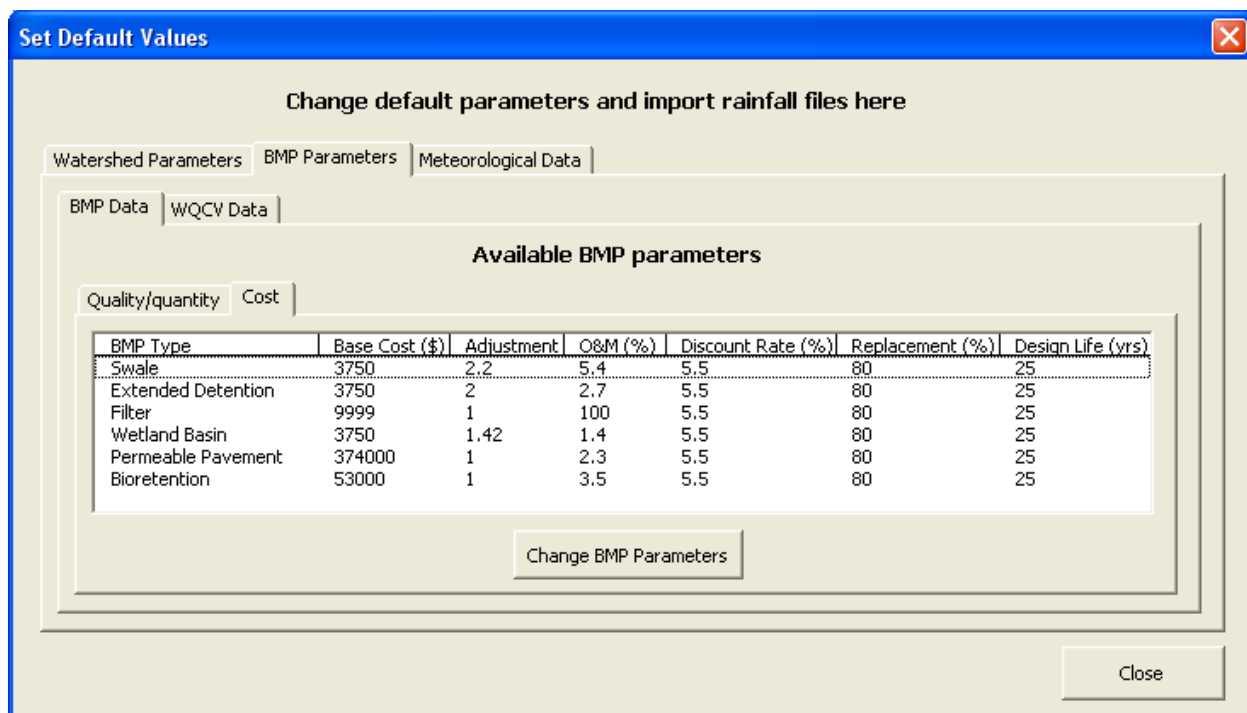
Quality/quantity | Cost

| BMP Type           | % loss | TP ave (mg/l) | TP sdev (mg/l) | TN ave (mg/l) | TN sdev (mg/l) | T |
|--------------------|--------|---------------|----------------|---------------|----------------|---|
| Swale              | 0      | 0.22          | 0.05           | 2.72          | 0.4            | 1 |
| Extended Detention | 0      | 0.19          | 0.04           | 2.72          | 0.5            | 3 |
| Filter             | 0      | 0.14          | 0.03           | 0.76          | 0.1            | 1 |
| Wetland Basin      | 0      | 0.14          | 0.02           | 1.15          | 0.2            | 1 |
| Permeable Pavement | 0      | 0.14          | 0.034          | 1.15          | 0.15           | 1 |
| Bioretention       | 0      | 0.34          | 0.06           | 0.78          | 0.1            | 2 |

Change BMP Parameters

Close

Figure 19. Summary of Default Quality/Quantity Data.



**Set Default Values**

Change default parameters and import rainfall files here

Watershed Parameters | **BMP Parameters** | Meteorological Data

BMP Data | WQCV Data

**Available BMP parameters**

Quality/quantity | Cost

| BMP Type           | Base Cost (\$) | Adjustment | O&M (%) | Discount Rate (%) | Replacement (%) | Design Life (yrs) |
|--------------------|----------------|------------|---------|-------------------|-----------------|-------------------|
| Swale              | 3750           | 2.2        | 5.4     | 5.5               | 80              | 25                |
| Extended Detention | 3750           | 2          | 2.7     | 5.5               | 80              | 25                |
| Filter             | 9999           | 1          | 100     | 5.5               | 80              | 25                |
| Wetland Basin      | 3750           | 1.42       | 1.4     | 5.5               | 80              | 25                |
| Permeable Pavement | 374000         | 1          | 2.3     | 5.5               | 80              | 25                |
| Bioretention       | 53000          | 1          | 3.5     | 5.5               | 80              | 25                |

Change BMP Parameters

Close

Figure 20. Summary of Default Cost Data.

**Edit BMP Data**

**Change information for BMP type 2**

BMP name:

**Quantity Parameters**

Annual percent mass loss:

**Quality Parameters**

|                               | mean                                | std.dev.                           |
|-------------------------------|-------------------------------------|------------------------------------|
| Total Phosphorus (mg/l)       | <input type="text" value="0.19"/>   | <input type="text" value="0.04"/>  |
| Total Nitrogen (mg/l)         | <input type="text" value="2.72"/>   | <input type="text" value="0.5"/>   |
| Total Suspended Solids (mg/l) | <input type="text" value="31"/>     | <input type="text" value="2"/>     |
| Total Zinc (mg/l)             | <input type="text" value="0.0602"/> | <input type="text" value="0.003"/> |

**Cost Parameters**

|                                       |                                   |
|---------------------------------------|-----------------------------------|
| Base cost / acre (\$)                 | <input type="text" value="3750"/> |
| Small facility cost adjustment ratio  | <input type="text" value="2"/>    |
| O&M cost as % of capital cost         | <input type="text" value="2.7"/>  |
| Discount rate                         | <input type="text" value="5.5"/>  |
| Replacement cost as % of capital cost | <input type="text" value="80"/>   |
| Life span (years)                     | <input type="text" value="25"/>   |

Figure 21. Editing BMP Data.

Table 9. BMP Input Parameters.

| Category           | Input Parameter                           | Description                                                                                                                      |
|--------------------|-------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------|
| Quantity Parameter | Annual percent mass loss (%)              | Used to account for infiltration/evapotranspiration from the BMP; outflow from the BMP is reduced by this amount                 |
| Quality Parameters | Mean (mg/L)                               | Event mean concentration (EMC) of effluent from each BMP type                                                                    |
|                    | Std. Dev. (mg/L)                          | Standard deviation of EMC effluent for each BMP type                                                                             |
| Cost Parameters    | Base cost / acre (\$/acre)                | The cost of the facility per acre of watershed treated                                                                           |
|                    | Small facility cost adjustment ratio      | Larger facilities generally provide economies of scale for capital cost; this option allows for an increase to the base cost     |
|                    | O&M cost as % of capital cost (%)         | Operation and maintenance (O&M) costs are entered as percentage of capital cost                                                  |
|                    | Discount rate (%)                         | Used to calculate the present value of long-term operational costs; does not fluctuate over time; does not account for inflation |
|                    | Replacement cost as % of capital cost (%) | Replacement cost is entered as percentage of capital cost                                                                        |
|                    | Life span (years)                         | Anticipated lifespan of the facility                                                                                             |



### ***Set Default Values>BMP Parameters>WQCV Data***

The regression constants used to calculate the water quality capture volume (WQCV) may be adjusted, as shown in Figure 22. Default values come from WEF/ASCE (1998).

Set Default Values

Change default parameters and import rainfall files here

Watershed Parameters | **BMP Parameters** | Meteorological Data

BMP Data | **WQCV Data**

Temporarily adjust water quality capture volume coefficients here

|                                  |       |
|----------------------------------|-------|
| coefficient for 12 hour drawdown | 1.316 |
| coefficient for 24 hour drawdown | 1.582 |
| coefficient for 48 hour drawdown | 1.963 |

Close

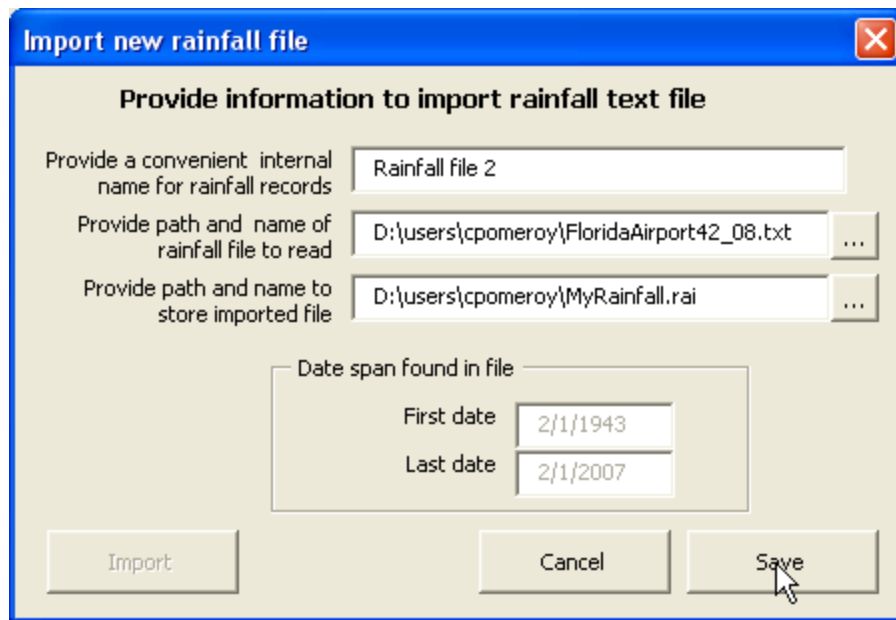
Figure 22. Default WQCV Coefficients.

### **Set Default Values>Meteorological Data**

The model uses hourly precipitation data and monthly average evaporation rates to compute watershed runoff. These data are accessed under the Meteorological Data tab.

#### **Set Default Values>Meteorological Data>Precipitation Data**

The model has been designed to use National Climatic Data Center (NCDC) data with a one hour incremental precipitation (<http://www.ncdc.noaa.gov/oa/ncdc.html>). NCDC formatted data are imported into the model and stored outside of the model as a separate \*.rai file with a path and file name that is specified by the user, as is shown in Figure 23. Note that the file must be saved in order to retain the rainfall record for use by the model. Multiple rainfall record sets may be recognized by the model, as is shown in Figure 24.



**Import new rainfall file**

**Provide information to import rainfall text file**

Provide a convenient internal name for rainfall records: Rainfall file 2

Provide path and name of rainfall file to read: D:\users\cpomeroy\FloridaAirport42\_08.txt

Provide path and name to store imported file: D:\users\cpomeroy\MyRainfall.ra

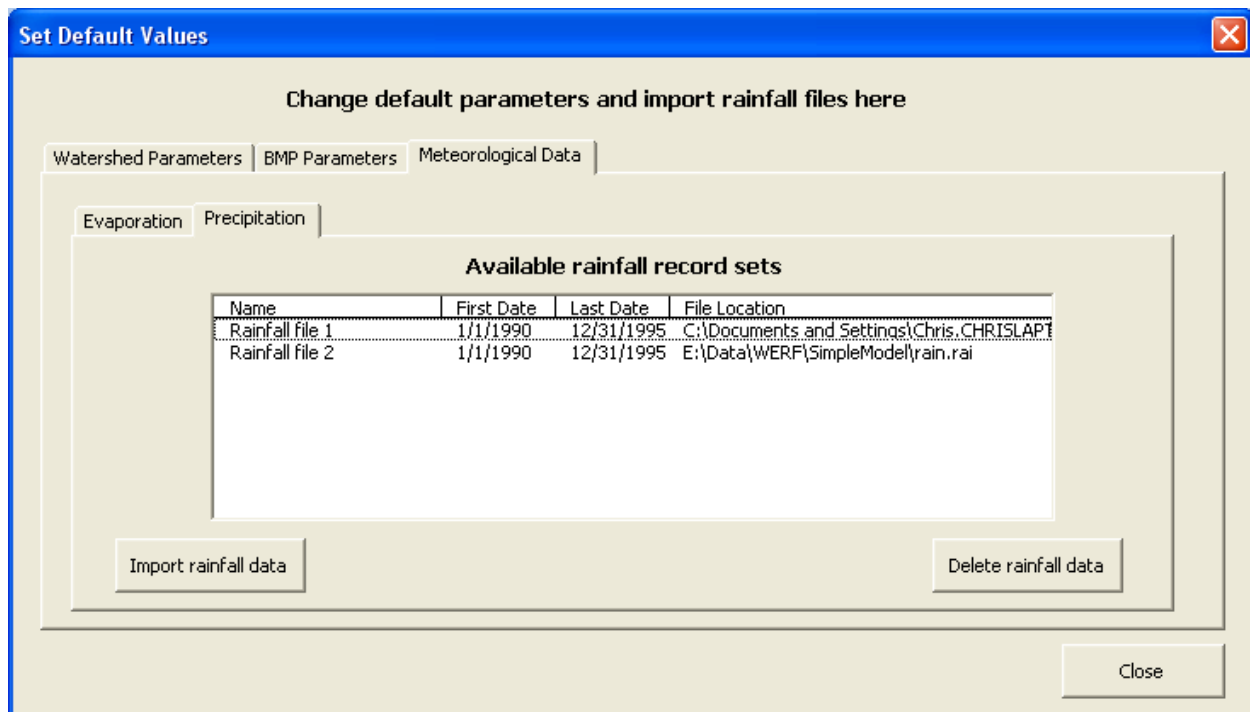
Date span found in file

First date: 2/1/1943

Last date: 2/1/2007

Buttons: Import, Cancel, Save

Figure 23. Importing New Rainfall Data.



**Set Default Values**

**Change default parameters and import rainfall files here**

Watershed Parameters | BMP Parameters | **Meteorological Data**

Evaporation | **Precipitation**

**Available rainfall record sets**

| Name            | First Date | Last Date  | File Location                              |
|-----------------|------------|------------|--------------------------------------------|
| Rainfall file 1 | 1/1/1990   | 12/31/1995 | C:\Documents and Settings\Chris.CHRI\AP... |
| Rainfall file 2 | 1/1/1990   | 12/31/1995 | E:\Data\WERF\SimpleModel\rain.ra           |

Buttons: Import rainfall data, Delete rainfall data, Close

Figure 24. Rainfall Record Sets.

### ***Set Default Values>Meteorological Data>Evaporation Data***

Monthly evaporation rates are used to regenerate depression storage and the storage capacity of permeable pavement. These rates are provided in inches per month, as shown in Figure 25. Default values are given for Orlando, Florida and must be modified to values appropriate for their project location.

**Set Default Values**

Change default parameters and import rainfall files here

Watershed Parameters | **BMP Parameters** | Meteorological Data

Evaporation | Precipitation

**Adjust monthly evaporation rates (inches/month) here**

|          |     |        |     |           |     |
|----------|-----|--------|-----|-----------|-----|
| January  | 2.9 | May    | 7.6 | September | 6.3 |
| February | 3.6 | June   | 8.3 | October   | 5.1 |
| March    | 5.4 | July   | 8.4 | November  | 3.4 |
| April    | 6.3 | August | 7.7 | December  | 2.7 |

Cancel Save

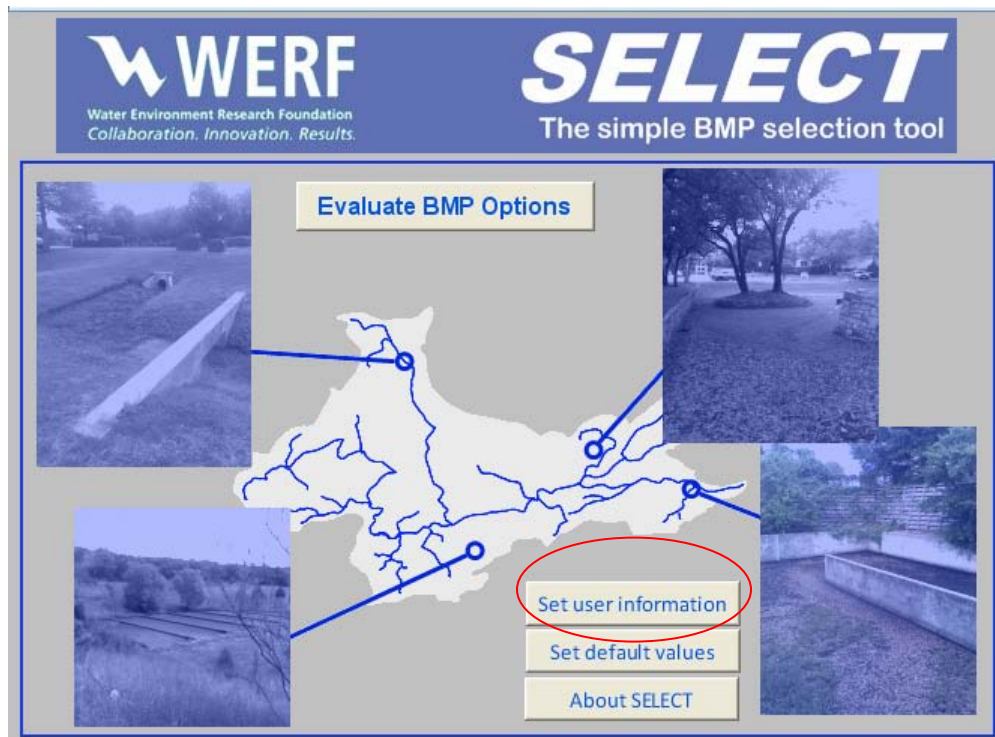
Close

Figure 25. Evaporation Data.

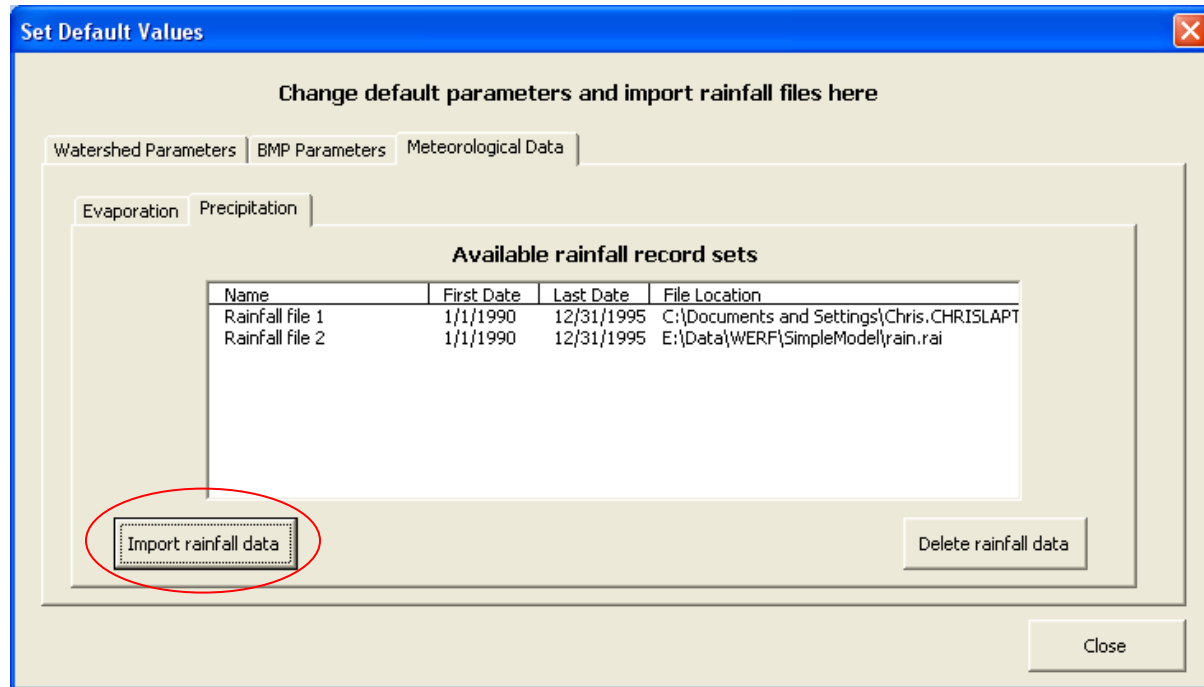
## Quick Start Tutorial

This tutorial provides user instructions to run the model with the default watershed and BMP scenarios embedded in Version 1 of the model. Instructions on how to view model outputs are also provided. To make the model run, a user needs to import rainfall data. Instructions for how to import a rainfall data file and do a test run follow.

1. Download the files and store them somewhere convenient. One file is the spreadsheet, the other is a rainfall file.
2. Double click on the spreadsheet or open Excel and then open the downloaded file. When it asks, allow Excel to Enable Macros.
3. Click on the 'Set Default Values' button



4. Find the Meteorological data panel and then the Precipitation panel, and click on the 'Import Rainfall data' button.



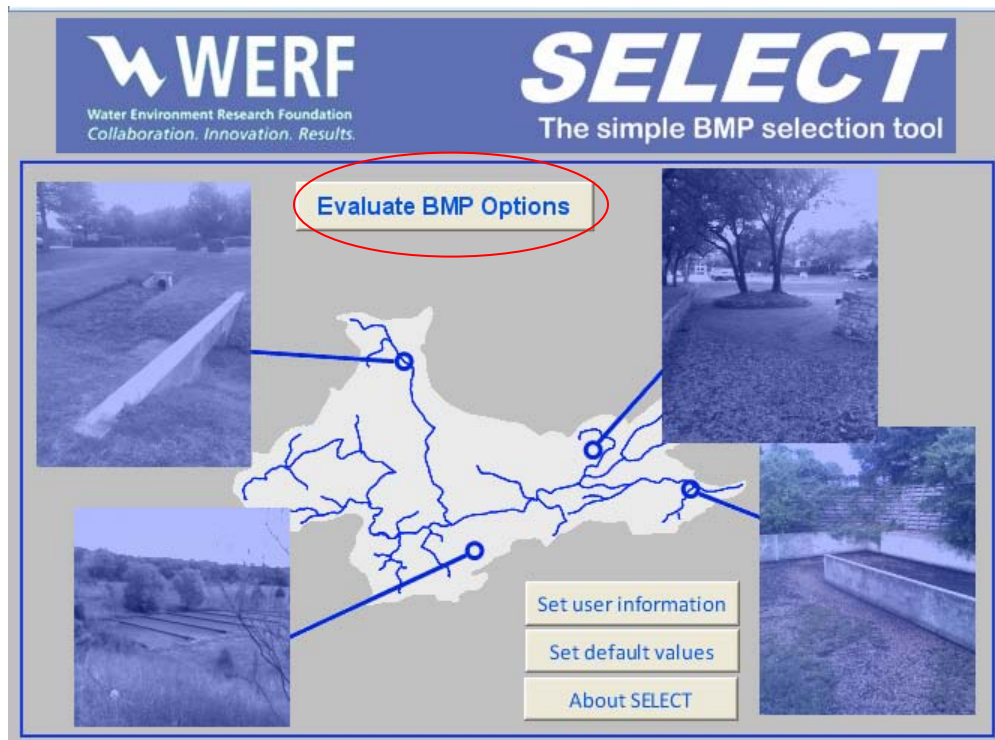
5. When the import form comes up,

- ◆ Click the first button and navigate to where you put the rainfall file, then click on the second button and find the location you would like to store the imported rainfall file.

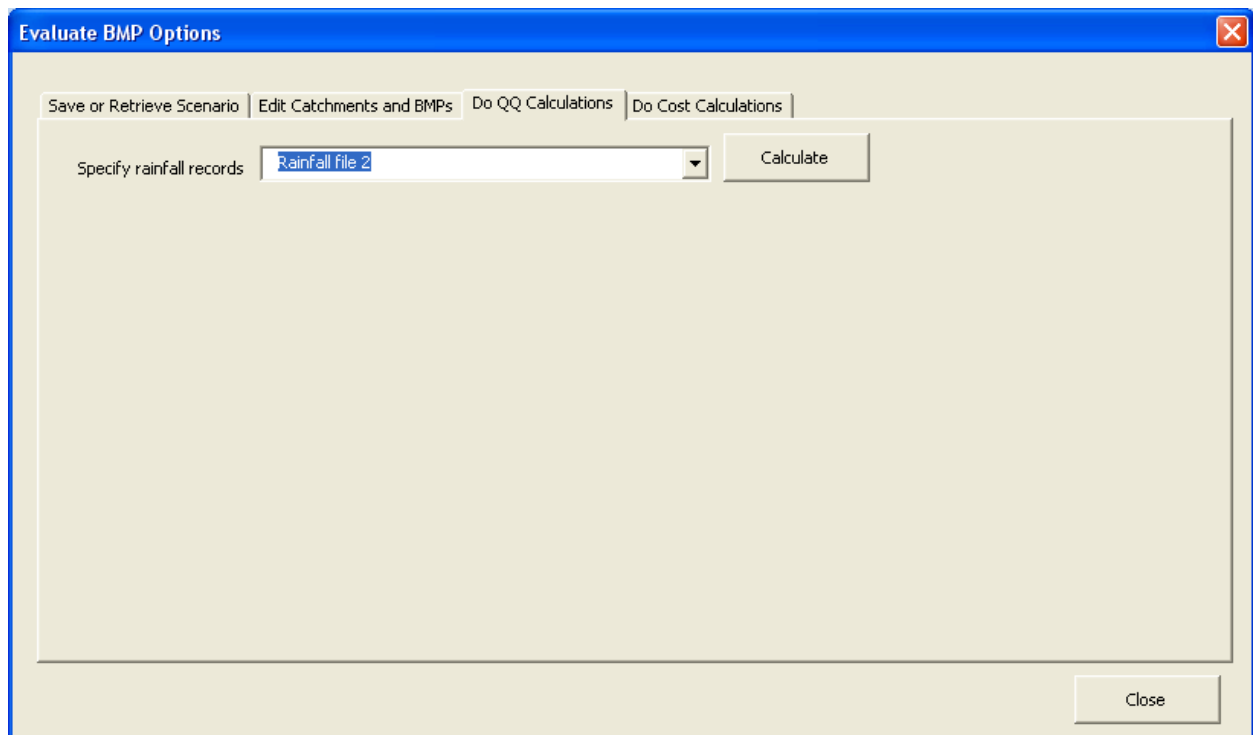


6. When the import is finished, a popup will tell you the import worked. Click 'OK'. Then save the rainfall file location data by clicking the 'Save' button.

7. Close the open form, and then click the 'Evaluate BMP Options' button.



8. A new form will pop up. Find the 'Do QQ Calculations' tab, and click it. Specify the rainfall record imported in Steps 4-6 and click calculate to run the model.



9. After the model runs the window will fill with Quantity and Quality (QQ) calculations. Additionally a new button 'Generate Reports' will appear as well as three selectable report options: 'Detailed Report', 'Short Report' and 'Standard Report'.

The 'Evaluate BMP Options' window displays simulation results and report options. It includes tabs for 'Save or Retrieve Scenario', 'Edit Catchments and BMPs', 'Do QQ Calculations', 'Do Cost Calculations', and 'Exceedance Curve'. The 'Do QQ Calculations' tab is active.

Specify rainfall records: Rainfall file 2

Simulation period rain summary:

|         |                         |     |             |      |                 |       |                               |
|---------|-------------------------|-----|-------------|------|-----------------|-------|-------------------------------|
| 304.660 | Total rainfall (inches) | 615 | # of events | 2191 | duration (days) | 0.495 | Average event volume (inches) |
|---------|-------------------------|-----|-------------|------|-----------------|-------|-------------------------------|

Simulation period watershed runoff summary (runoff in inches, quality in kg)

| Sub-catchment  | Total Runoff Vol | Total Runoff Coef | Ave Event Runoff | TP load | TN load | TSS load  | TZn load |
|----------------|------------------|-------------------|------------------|---------|---------|-----------|----------|
| Subcatchment a | 137.491          | 0.451             | 0.224            | 284.068 | 808.392 | 97515.775 | 319.399  |
| Subcatchment 5 | 56.596           | 0.186             | 0.092            | 49.018  | 94.197  | 12926.511 | 17.278   |
| Subcatchment 3 | 56.596           | 0.186             | 0.092            | 8.912   | 17.127  | 2350.275  | 3.141    |
| Subcatchment 4 | 56.596           | 0.186             | 0.092            | 49.018  | 94.197  | 12926.511 | 17.278   |

Simulation period BMP discharge summary (quantity in 1000's of cubic feet, quality in kg)

| Sub-catchment  | Q    | Q By  | TP    | TP By   | TN      | TN By   | TSS      | TSS By   | TZn    | TZn By  |
|----------------|------|-------|-------|---------|---------|---------|----------|----------|--------|---------|
| Subcatchment a | 9126 | 40736 | 49.1  | 231.857 | 702.901 | 659.811 | 8011.006 | 79592.53 | 15.557 | 260.694 |
| Subcatchment 5 | 1301 | 3213  | 7     | 34.846  | 100.205 | 66.963  | 1142.047 | 9189.185 | 2.218  | 12.283  |
| Subcatchment 3 | 399  | 422   | 3.841 | 4.577   | 8.813   | 8.795   | 271.162  | 1206.921 | 0.452  | 1.613   |
| Subcatchment 4 | 281  | 4237  | 1.114 | 45.952  | 9.151   | 88.304  | 143.227  | 12117.82 | 0.244  | 16.197  |

Buttons: Calculate, Generate Report, Detailed Report, Short Report, Standard Report, Close.

10. Choose the 'Standard Report' option. Now click 'Generate Report' a new window will appear asking for a title for the report. 'Watershed Report' is the default title but can be replaced with any title not already in use.

The 'Report Title' dialog box prompts the user to provide a report name. The default title 'Watershed Report' is entered in the text field. Buttons for 'OK' and 'Cancel' are at the bottom.

Report Title

Please provide report name:

Watershed Report

OK Cancel

11. Once you have selected a report name click the ‘OK’ button. The model will run and a new Excel worksheet will appear. To view the report close the ‘Do QQ Calculations’ window. You will notice a new tab at the bottom of the excel sheet appropriately titled with the report title. This tab will remain in the model unless deleted.

|    | A                              | B                                | C                | D               | E              | F                  | G                                               | H              | I                             | J                 | K                        | L          | M | N |
|----|--------------------------------|----------------------------------|------------------|-----------------|----------------|--------------------|-------------------------------------------------|----------------|-------------------------------|-------------------|--------------------------|------------|---|---|
| 1  | BMP Performance Report         |                                  |                  |                 |                |                    |                                                 |                |                               |                   | SELECT model version 1.0 |            |   |   |
| 2  |                                |                                  |                  |                 |                |                    |                                                 |                |                               |                   |                          |            |   |   |
| 3  | User Name                      | Name of firm or organization     |                  |                 |                |                    |                                                 |                |                               |                   | Report Date              | 11/19/2009 |   |   |
| 4  | User organization              | Name of department or work group |                  |                 |                |                    |                                                 |                |                               |                   | Report Time              | 7:00 PM    |   |   |
| 5  |                                |                                  |                  |                 |                |                    |                                                 |                |                               |                   |                          |            |   |   |
| 6  | Scenario Name                  | Scenario 2                       |                  |                 |                |                    |                                                 |                |                               |                   |                          |            |   |   |
| 7  |                                |                                  |                  |                 |                |                    |                                                 |                |                               |                   |                          |            |   |   |
| 8  | Scenario Data                  |                                  |                  |                 |                |                    |                                                 |                |                               |                   |                          |            |   |   |
| 9  | Subwatershed Name              | Area (acres)                     | Land Use         | Cv              | DS (inches)    | BMP                | Treated Area                                    | WQCV (inches)  | Drawdown                      | % Loss            | PPV (inches)             |            |   |   |
| 10 | Subcatchment 1                 | 100                              | Commercial       | 0.9             | 0.1            | Extended Detention | 25                                              | 12             | 24                            | 0                 |                          |            |   |   |
| 11 | Subcatchment 2                 | 32                               | Residential      | 0.23            | 0.1            | Filter             | 32                                              | 0.22           | 12                            | 0                 |                          |            |   |   |
| 12 | Subcatchment 3                 | 13                               | Residential      | 0.23            | 0.1            | Wetland Basin      | 13                                              | 0.17           | 24                            | 0                 |                          |            |   |   |
| 13 | Total Area                     | 145                              |                  |                 |                |                    | 70                                              |                |                               |                   |                          |            |   |   |
| 14 |                                |                                  |                  |                 |                |                    |                                                 |                |                               |                   |                          |            |   |   |
| 15 | Scenario BMP Quality Data      |                                  |                  |                 |                |                    |                                                 |                |                               |                   |                          |            |   |   |
| 16 | BMP Type                       | % Loss                           | TP (mg / l) Ave. | TP (mg / l) S.C | TN (mg/l) Ave. | TN (mg/l) S.D      | TSS (mg/l) Ave.                                 | TSS (mg/l) S.C | TZn (mg/l) Ave.               | TZn (mg/l) S.Dev. |                          |            |   |   |
| 17 | Extended Detention             | 0                                | 0.19             | 0.04            | 2.72           | 0.5                | 31                                              | 2              | 0.0602                        | 0.003             |                          |            |   |   |
| 18 | Filter                         | 0                                | 0.14             | 0.03            | 0.76           | 0.1                | 16                                              | 1              | 0.0585                        | 0.002             |                          |            |   |   |
| 19 | Wetland Basin                  | 0                                | 0.14             | 0.02            | 1.15           | 0.2                | 18                                              | 1              | 0.0307                        | 0.002             |                          |            |   |   |
| 20 |                                |                                  |                  |                 |                |                    |                                                 |                |                               |                   |                          |            |   |   |
| 21 |                                |                                  |                  |                 |                |                    |                                                 |                |                               |                   |                          |            |   |   |
| 22 | Scenario Land Use Quality Data |                                  |                  |                 |                |                    |                                                 |                |                               |                   |                          |            |   |   |
| 23 | Land Use Name                  |                                  | TP (mg / l) Ave. | TP (mg / l) S.C | TN (mg/l) Ave. | TN (mg/l) S.D      | TSS (mg/l) Ave.                                 | TSS (mg/l) S.C | TZn (mg/l) Ave.               | TZn (mg/l) S.Dev. |                          |            |   |   |
| 24 | Commercial                     |                                  | 0.201            | 0.02            | 0.572          | 0.1                | 69                                              | 5              | 0.226                         | 0.05              |                          |            |   |   |
| 25 | Residential                    |                                  | 0.383            | 0.1             | 0.736          | 0.12               | 101                                             | 21             | 0.135                         | 0.05              |                          |            |   |   |
| 26 |                                |                                  |                  |                 |                |                    |                                                 |                |                               |                   |                          |            |   |   |
| 27 |                                |                                  |                  |                 |                |                    |                                                 |                |                               |                   |                          |            |   |   |
| 28 | Rainfall                       | Name                             | Rainfall file 2  |                 |                |                    |                                                 |                |                               |                   |                          |            |   |   |
| 29 |                                | From                             | 02/01/43         |                 |                |                    |                                                 |                | To                            | 02/01/07          |                          |            |   |   |
| 30 |                                | Duration (days)                  | 23377            |                 |                |                    |                                                 |                | Total rain (ins)              | 55150.6           |                          |            |   |   |
| 31 |                                | Number of events (ins)           | 6051             |                 |                |                    |                                                 |                | Event average rainfall (ins)  | 9.114             |                          |            |   |   |
| 32 |                                |                                  |                  |                 |                |                    |                                                 |                | Annual average rainfall (Ins) | 858.74            |                          |            |   |   |
| 33 |                                |                                  |                  |                 |                |                    |                                                 |                |                               |                   |                          |            |   |   |
| 34 | Runoff                         | Quantity                         | TP               | TN              | TSS            | ZN                 |                                                 |                |                               |                   |                          |            |   |   |
| 35 | Total Over Period              | #####                            | #####            | 331511.19       | 40699279.15    | 121936.28          |                                                 |                |                               |                   |                          |            |   |   |
| 36 | Annual Average (l/s)           | 309537.63                        | 1926.32          | 5161.91         | 633722.79      | 1898.65            |                                                 |                |                               |                   |                          |            |   |   |
| 37 |                                |                                  |                  |                 |                |                    |                                                 |                |                               |                   |                          |            |   |   |
| 38 | BMPs                           | Quantity                         | TP               | TN              | TSS            | ZN                 |                                                 |                |                               |                   |                          |            |   |   |
| 39 | Annual Treated Discharge       | 4575.62                          | 23.36            | 304.63          | 3646.96        | 7.65               |                                                 |                |                               |                   |                          |            |   |   |
| 40 | Annual Bypassed Discharge      | 304961.79                        | 1895.70          | 5083.67         | 623976.70      | 1871.66            |                                                 |                |                               |                   |                          |            |   |   |
| 41 | Annual Total Discharge         | 309537.41                        | 1919.06          | 5388.30         | 627623.66      | 1879.31            |                                                 |                |                               |                   |                          |            |   |   |
| 42 | Annual Total Percent Remove    |                                  | 0.38             | -4.39           | 0.96           | 1.02               | *** Warning: The chosen EMCs cause an increase. |                |                               |                   |                          |            |   |   |
| 43 |                                |                                  |                  |                 |                |                    |                                                 |                |                               |                   |                          |            |   |   |

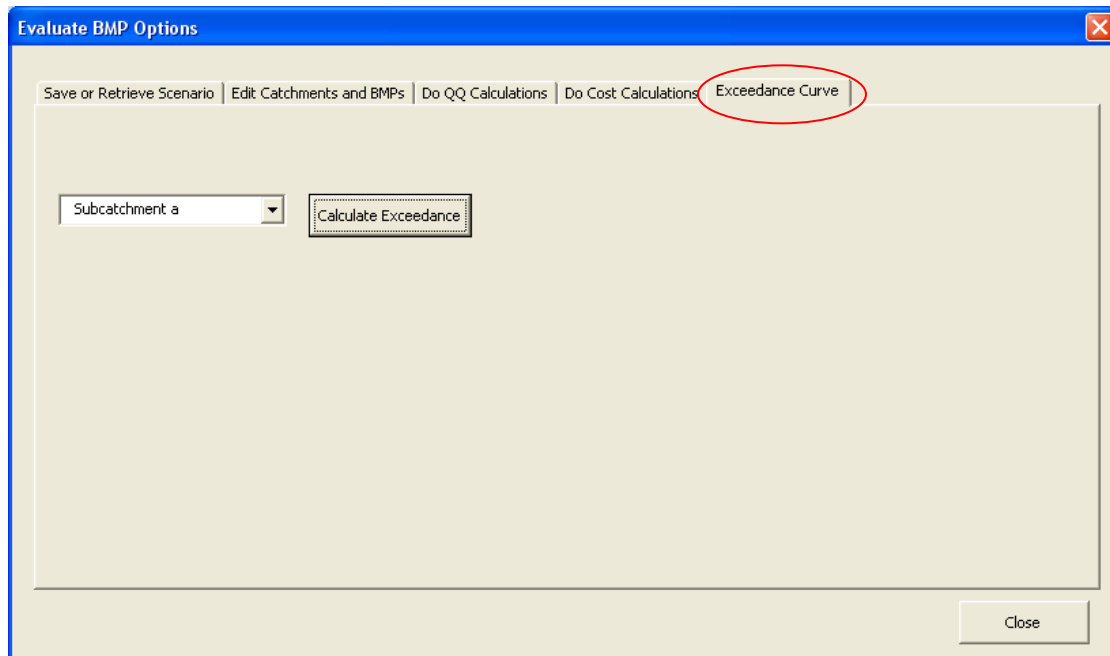
Watershed Report

Start

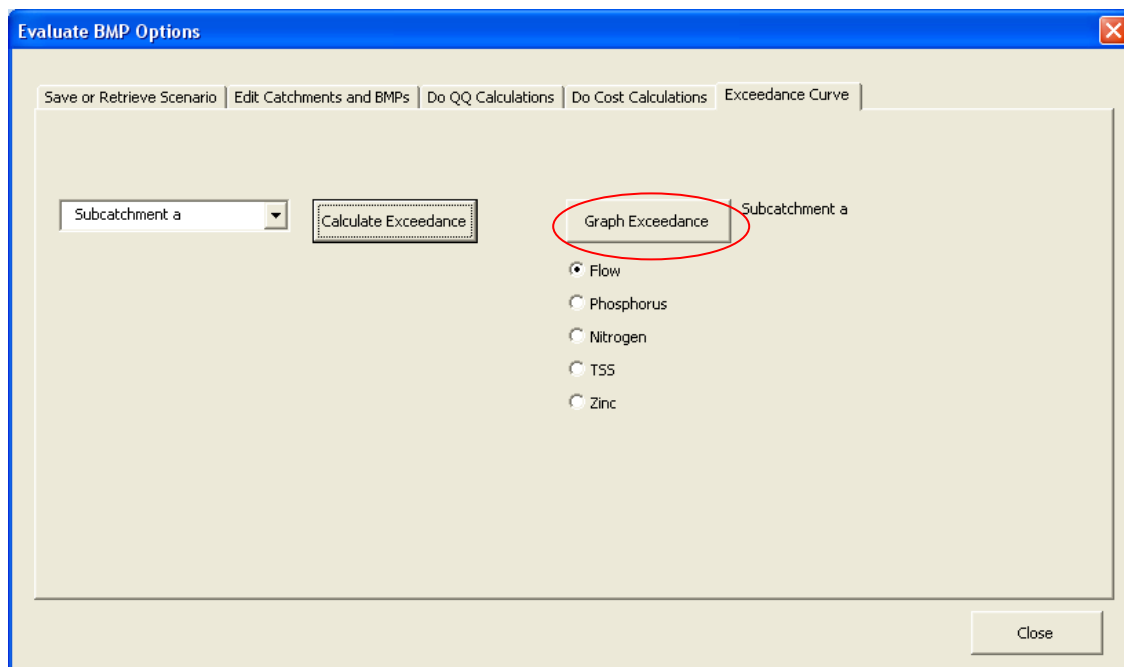
12. This process can be repeated for the other report types, ‘Detailed Report’ and ‘Short Report’ by clicking on the Start Tab and repeating Steps 7 through 11, selecting the desired report type.



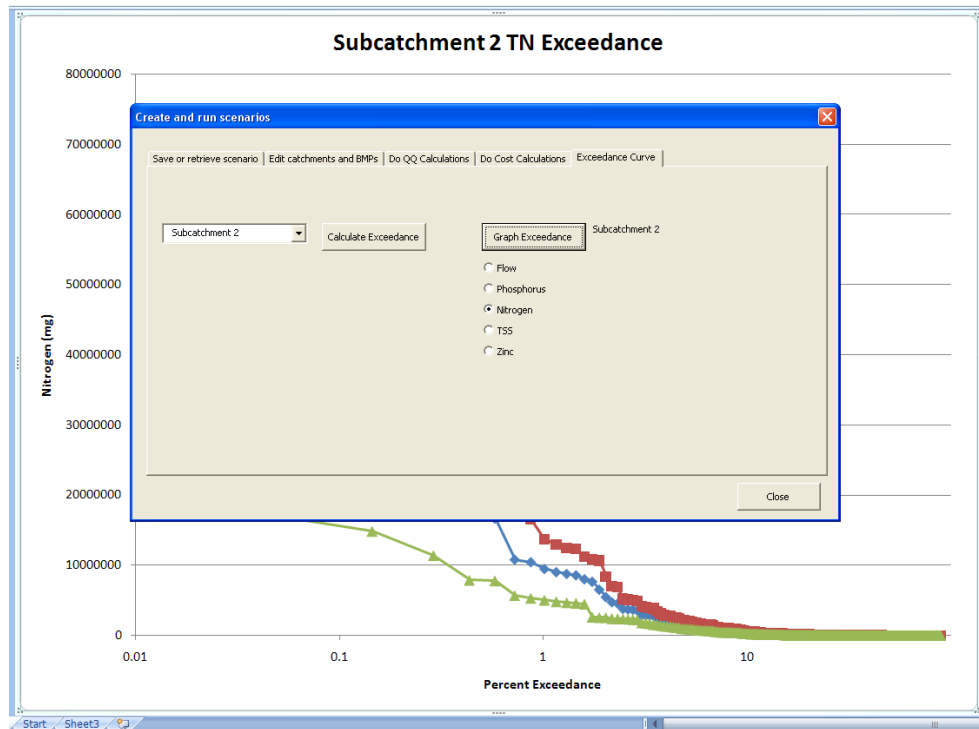
13. Run the model again by returning to the home screen and repeating steps 7-8. This time notice a new tab appears titled 'Exceedance Curve'. Select this tab.



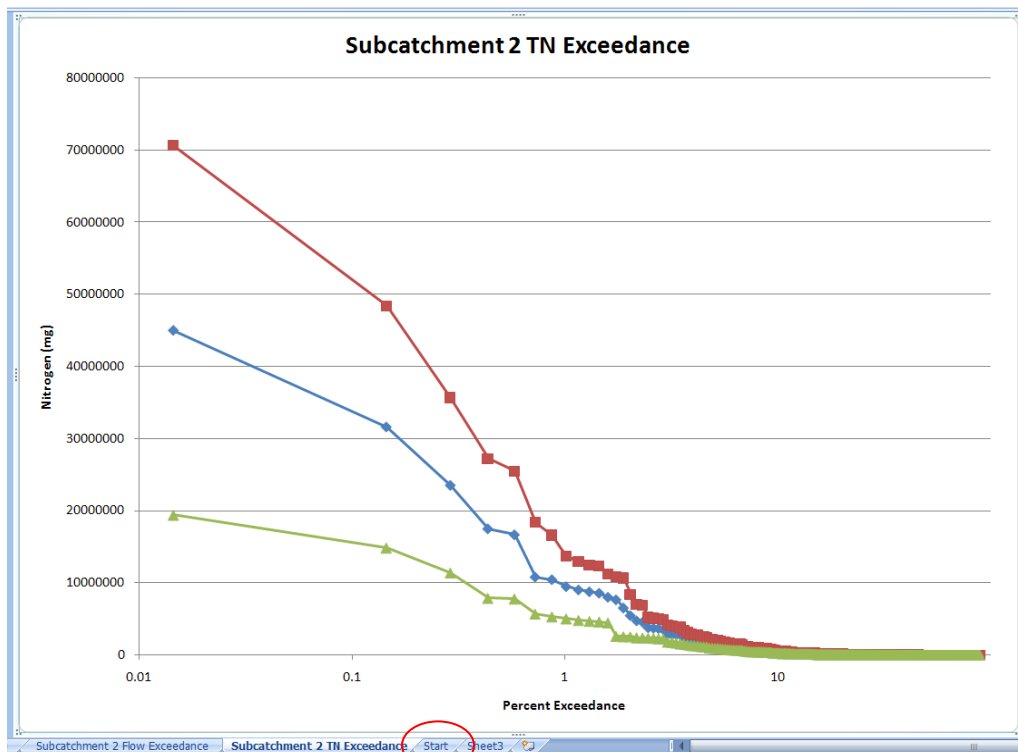
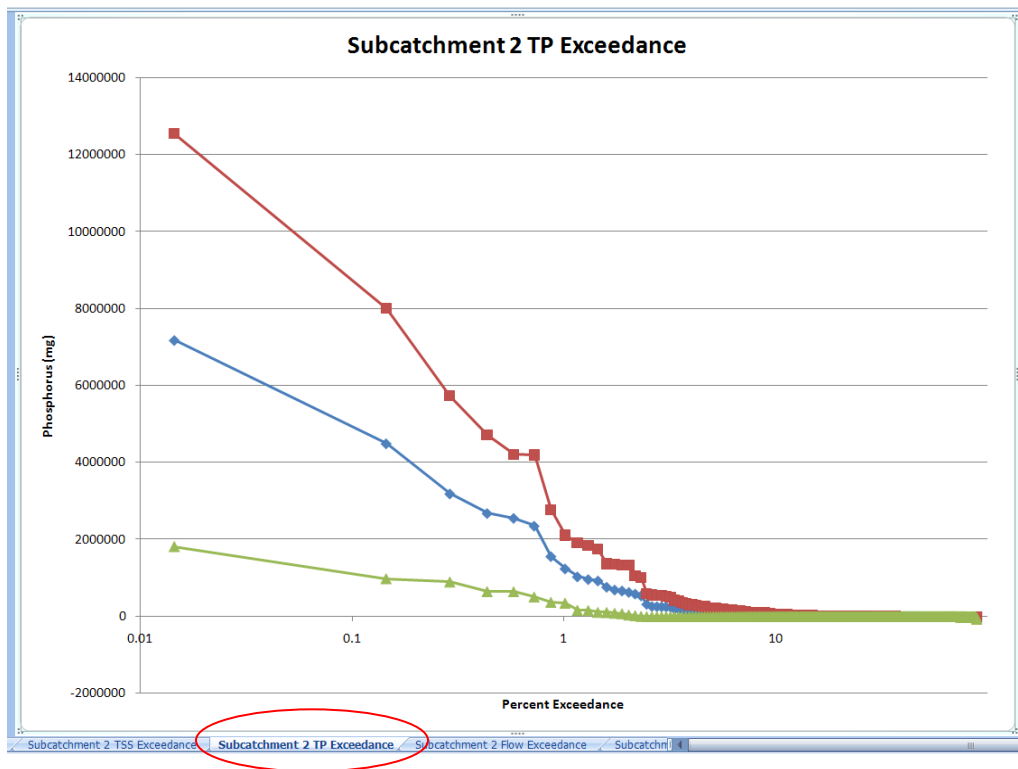
14. Choose a subcatchment from the drop down window then click the 'Calculate Exceedance' button. You will notice new options appeared in the window.



15. Select a model output parameter to graph (Flow, Phosphorus, Nitrogen, TSS or Zinc) then click the ‘Graph Exceedance’ button. A graph will appear behind the window. Close this window to fully see the graph, however if you want to generate other exceedance plots, do so before closing the window. If you close the window before generating additional plots you will need to repeat steps 7-8 and 14-15 before they can be generated.

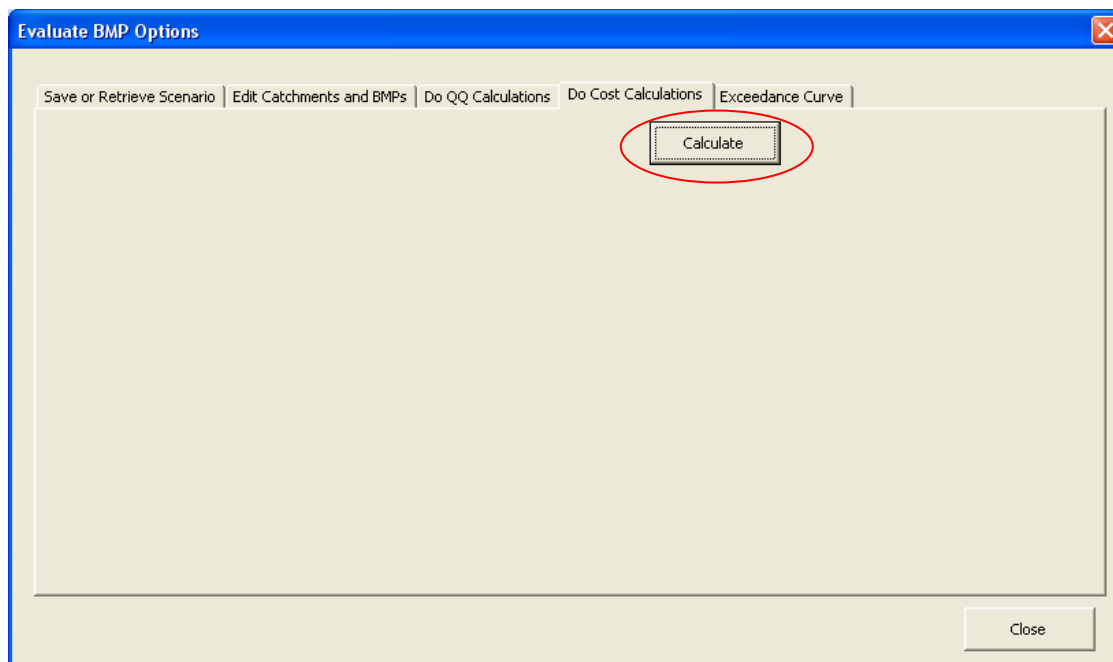


16. You can repeat step 15 for each subcatchment and each output parameter. In addition to creating a graph the model creates a new tab with an appropriate title at the bottom of the model.

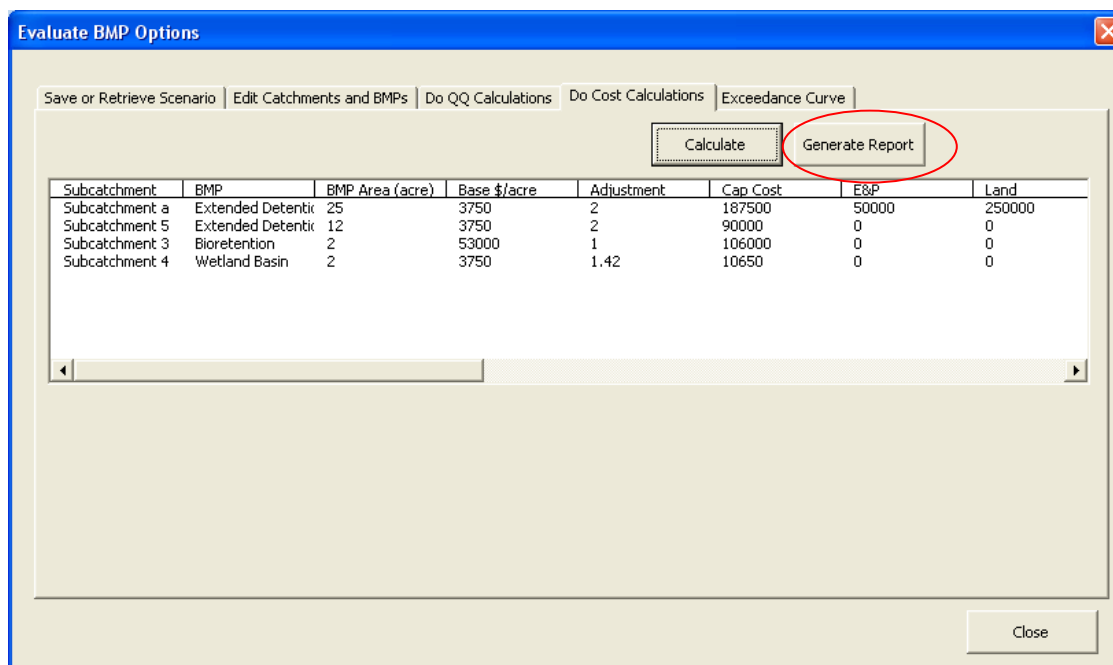


17. To run *Cost Calculations* return to the home screen, to do so click the 'Start' tab.

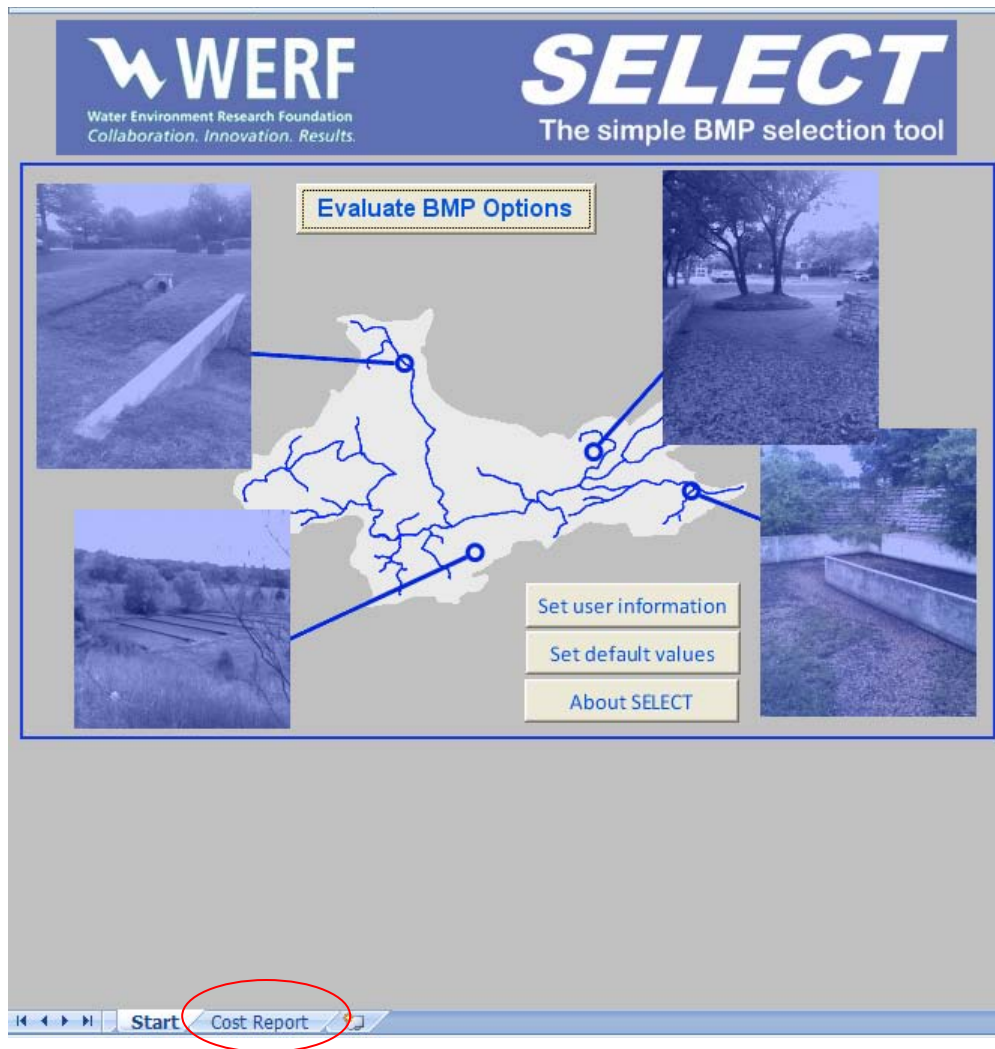
18. Now click on the 'Work' button and when the new window appears choose the 'Do Cost Calculations' tab.



19. Click the 'Calculate' button. The model will generate tabled data listing each BMP with the resulting cost relevant data. A new button will also appear to the right of the 'Calculate' button. This button is titled 'Generate Report'.



20. To view a detailed cost report, click the 'Generate Report'. Next click the 'Close' button on the bottom right portion of the window. At the bottom of the Excel document a new tab labeled Cost Report will appear.



21. Click on the newly generated ‘Cost Report’ tab. The ‘Cost Report’ tab shows all the calculated cost data in a familiar Excel format.

|    | A | B                                                  | C                                  | D            | E         | F         | G         | H             | I              | J                  | K                  | L                        |
|----|---|----------------------------------------------------|------------------------------------|--------------|-----------|-----------|-----------|---------------|----------------|--------------------|--------------------|--------------------------|
| 1  |   | <b>BMP Cost Report</b>                             |                                    |              |           |           |           |               |                |                    |                    | SELECT model version 1.0 |
| 2  |   |                                                    |                                    |              |           |           |           |               |                |                    |                    |                          |
| 3  |   | <b>User Name</b>                                   | Name of firm or organization       |              |           |           |           |               |                |                    | <b>Report Date</b> |                          |
| 4  |   | <b>User organization</b>                           | Name of department or work group   |              |           |           |           |               |                |                    | <b>Report Time</b> |                          |
| 5  |   |                                                    |                                    |              |           |           |           |               |                |                    |                    |                          |
| 6  |   | <b>Scenario Name</b>                               | No name assigned for this scenario |              |           |           |           |               |                |                    |                    |                          |
| 7  |   |                                                    |                                    |              |           |           |           |               |                |                    |                    |                          |
| 8  |   | <b>Scenario Data</b>                               |                                    |              |           |           |           |               |                |                    |                    |                          |
| 9  |   | Subwatershed Name                                  | Area (acres)                       | BMP          | BMP Area  |           |           |               |                |                    |                    |                          |
| 10 |   | Subcatchment a                                     | 100                                | Permeable    | 25        |           |           |               |                |                    |                    |                          |
| 11 |   | Subcatchment 2                                     | 32                                 | Extended D   | 32        |           |           |               |                |                    |                    |                          |
| 12 |   | Subcatchment 3                                     | 13                                 | Wetland Ba   | 13        |           |           |               |                |                    |                    |                          |
| 13 |   | <b>Total Area</b>                                  | 145                                |              | 70        |           |           |               |                |                    |                    |                          |
| 14 |   |                                                    |                                    |              |           |           |           |               |                |                    |                    |                          |
| 15 |   | <b>Capital Cost Data</b>                           |                                    |              |           |           |           |               |                |                    |                    |                          |
| 16 |   | Subwatershed Name                                  | BMP Area                           | Base \$/acre | Adjustmen | Cap Cost  | E&P       | Land          | Other          | Total              |                    |                          |
| 17 |   | Subcatchment a                                     | 25                                 | \$1,000      | 1.42      | \$35,500  | \$50,000  | \$250,000     | \$0            | \$335,500          |                    |                          |
| 18 |   | Subcatchment 2                                     | 32                                 | \$3,750      | 2         | \$240,000 | \$0       | \$0           | \$0            | \$240,000          |                    |                          |
| 19 |   | Subcatchment 3                                     | 13                                 | \$3,750      | 1.42      | \$69,225  | \$0       | \$0           | \$0            | \$69,225           |                    |                          |
| 20 |   | <b>Total Capital Costs</b>                         |                                    |              |           | \$344,725 | \$50,000  | \$250,000     | \$0            | \$644,725          |                    |                          |
| 21 |   |                                                    |                                    |              |           |           |           |               |                |                    |                    |                          |
| 22 |   | <b>O&amp;M and Replacement Cost Data</b>           |                                    |              |           |           |           |               |                |                    |                    |                          |
| 23 |   | Subwatershed Name                                  | Discount Rate                      | Life Span    | O&M %     | O&M \$    | O&M PV    | Replacement % | Replacement \$ | NPV Replacement \$ |                    |                          |
| 24 |   | Subcatchment a                                     | 5.5                                | 20           | 1         | \$3,355   | \$40,094  | 80            | \$268,400      | \$91,988           |                    |                          |
| 25 |   | Subcatchment 2                                     | 5.5                                | 20           | 2.7       | \$6,480   | \$77,438  | 80            | \$192,000      | \$65,804           |                    |                          |
| 26 |   | Subcatchment 3                                     | 5.5                                | 25           | 1.4       | \$969     | \$13,000  | 80            | \$55,380       | \$14,523           |                    |                          |
| 27 |   | <b>Total Capital O&amp;M and Replacement Costs</b> |                                    |              |           |           | \$130,532 |               |                | \$172,315          |                    |                          |
| 28 |   |                                                    |                                    |              |           |           |           |               |                |                    |                    |                          |
| 29 |   | <b>Grand Totals</b>                                |                                    |              |           |           |           |               |                |                    |                    |                          |
| 30 |   | Subwatershed Name                                  | Total NPV                          |              |           |           |           |               |                |                    |                    |                          |
| 31 |   | Subcatchment a                                     | \$467,582                          |              |           |           |           |               |                |                    |                    |                          |
| 32 |   | Subcatchment 2                                     | \$383,242                          |              |           |           |           |               |                |                    |                    |                          |
| 33 |   | Subcatchment 3                                     | \$96,748                           |              |           |           |           |               |                |                    |                    |                          |
| 34 |   | <b>Grand Total of All Costs</b>                    | \$947,572                          |              |           |           |           |               |                |                    |                    |                          |
| 35 |   |                                                    |                                    |              |           |           |           |               |                |                    |                    |                          |
| 36 |   |                                                    |                                    |              |           |           |           |               |                |                    |                    |                          |
| 37 |   |                                                    |                                    |              |           |           |           |               |                |                    |                    |                          |
| 38 |   |                                                    |                                    |              |           |           |           |               |                |                    |                    |                          |

## References

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Pomeroy, C.A. and Houdeshel, C.D. 2009. User's Guide to the BMP and LID Whole Life Cost Models. Version 2.0. Report # SW2R08. Water Environment Research Foundation, Alexandria, VA.

U.S. EPA. 1983. *Results of the Nationwide Urban Runoff Program*, Volume 1 – Final Report, Water Plann. Division, Washington, D.C.

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## WASTEWATER UTILITY

### Alabama

Montgomery Water Works & Sanitary Sewer Board

### Alaska

Anchorage Water & Wastewater Utility

### Arizona

Avondale, City of  
Glendale, City of, Utilities Department  
Mesa, City of  
Peoria, City of  
Phoenix Water Services Dept.  
Pima County Wastewater Management  
Safford, City of  
Tempe, City of

### Arkansas

Little Rock Wastewater Utility

### California

Central Contra Costa Sanitary District  
Corona, City of  
Crestline Sanitation District  
Delta Diablo Sanitation District  
Dublin San Ramon Services District  
East Bay Dischargers Authority  
East Bay Municipal Utility District  
El Dorado Irrigation District  
Fairfield-Suisun Sewer District  
Fresno Department of Public Utilities  
Inland Empire Utilities Agency  
Irvine Ranch Water District  
Las Gallinas Valley Sanitary District  
Las Virgenes Municipal Water District  
Livermore, City of  
Los Angeles, City of  
Los Angeles County, Sanitation Districts of  
Napa Sanitation District  
Novato Sanitary District  
Orange County Sanitation District  
Palo Alto, City of  
Riverside, City of  
Sacramento Regional County Sanitation District  
San Diego Metropolitan Wastewater Department, City of  
San Francisco, City & County of  
San Jose, City of  
Santa Barbara, City of  
Santa Cruz, City of  
Santa Rosa, City of  
South Bayside System Authority  
South Coast Water District

South Orange County Wastewater Authority  
South Tahoe Public Utility District

Stege Sanitary District  
Sunnyvale, City of  
Union Sanitary District  
West Valley Sanitation District

### Colorado

Aurora, City of  
Boulder, City of  
Greeley, City of  
Littleton/Englewood Water Pollution Control Plant  
Metro Wastewater Reclamation District, Denver

### Connecticut

Greater New Haven WPCA  
Stamford, City of

### District of Columbia

District of Columbia Water & Sewer Authority

### Florida

Broward, County of  
Fort Lauderdale, City of  
Jacksonville Electric Authority (JEA)  
Miami-Dade Water & Sewer Authority  
Orange County Utilities Department  
Pinellas, County of  
Reedy Creek Improvement District  
Seminole County Environmental Services  
St. Petersburg, City of  
Tallahassee, City of  
Toho Water Authority  
West Palm Beach, City of

### Georgia

Atlanta Department of Watershed Management  
Augusta, City of  
Clayton County Water Authority  
Cobb County Water System  
Columbus Water Works  
Fulton County  
Gwinnett County Department of Public Utilities  
Savannah, City of

### Hawaii

Honolulu, City & County of

### Idaho

Boise, City of

### Illinois

Decatur, Sanitary District of  
Greater Peoria Sanitary District  
Kankakee River Metropolitan Agency  
Metropolitan Water Reclamation District of Greater Chicago  
Wheaton Sanitary District

### Indiana

Jeffersonville, City of

### Iowa

Ames, City of  
Cedar Rapids Wastewater Facility  
Des Moines, City of  
Iowa City

### Kansas

Johnson County Wastewater Unified Government of Wyandotte County/  
Kansas City, City of

### Kentucky

Louisville & Jefferson County Metropolitan Sewer District  
Sanitation District No. 1

### Louisiana

Sewerage & Water Board of New Orleans

### Maine

Bangor, City of  
Portland Water District

### Maryland

Anne Arundel County Bureau of Utility Operations  
Howard County Bureau of Utilities  
Washington Suburban Sanitary Commission

### Massachusetts

Boston Water & Sewer Commission  
Massachusetts Water Resources Authority (MWRA)  
Upper Blackstone Water Pollution Abatement District

### Michigan

Ann Arbor, City of  
Detroit, City of  
Holland Board of Public Works  
Saginaw, City of  
Wayne County Department of Environment  
Wyoming, City of

### Minnesota

Rochester, City of  
Western Lake Superior Sanitary District

### Missouri

Independence, City of  
Kansas City Missouri Water Services Department  
Little Blue Valley Sewer District  
Metropolitan St. Louis Sewer District

### Nebraska

Lincoln Wastewater & Solid Waste System

### Nevada

Henderson, City of  
Las Vegas, City of  
Reno, City of

### New Jersey

Bergen County Utilities Authority  
Ocean County Utilities Authority

### New York

New York City Department of Environmental Protection

### North Carolina

Charlotte/Mecklenburg Utilities  
Durham, City of  
Metropolitan Sewerage District of Buncombe County  
Orange Water & Sewer Authority  
University of North Carolina, Chapel Hill

### Ohio

Akron, City of  
Butler County Department of Environmental Services  
Columbus, City of  
Metropolitan Sewer District of Greater Cincinnati  
Montgomery, County of  
Northeast Ohio Regional Sewer District  
Summit, County of

### Oklahoma

Oklahoma City Water & Wastewater Utility Department  
Tulsa, City of

### Oregon

Albany, City of  
Clean Water Services  
Eugene, City of  
Gresham, City of  
Portland, City of Bureau of Environmental Services  
Lake Oswego, City of  
Oak Lodge Sanitary District  
Water Environment Services

### Pennsylvania

Hemlock Municipal Sewer Cooperative (HMSC)  
Philadelphia, City of  
University Area Joint Authority

### South Carolina

Charleston Water System  
Mount Pleasant Waterworks & Sewer Commission  
Spartanburg Water

### Tennessee

Cleveland Utilities  
Murfreesboro Water & Sewer Department  
Nashville Metro Water Services

### Texas

Austin, City of  
Dallas Water Utilities  
Denton, City of  
El Paso Water Utilities



Fort Worth, City of  
Houston, City of  
San Antonio Water System  
Trinity River Authority

## Utah

Salt Lake City Corporation

## Virginia

Alexandria Sanitation Authority  
Arlington, County of  
Fairfax County  
Hampton Roads Sanitation District  
Hanover, County of  
Henrico, County of  
Hopewell Regional Wastewater Treatment Facility  
Loudoun Water  
Lynchburg Regional Wastewater Treatment Plant  
Prince William County Service Authority  
Richmond, City of  
Rivanna Water & Sewer Authority

## Washington

Everett, City of  
King County Department of Natural Resources  
Seattle Public Utilities  
Sunnyside, Port of  
Yakima, City of

## Wisconsin

Green Bay Metro Sewerage District  
Kenosha Water Utility  
Madison Metropolitan Sewerage District  
Milwaukee Metropolitan Sewerage District  
Racine, City of  
Sheboygan Regional Wastewater Treatment  
Wausau Water Works

## Water Services Association of Australia

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Barwon Water  
Central Highlands Water  
City West Water  
Coliban Water Corporation  
Cradle Mountain Water  
Gippsland Water  
Gladstone Area Water Board  
Gold Coast Water  
Gosford City Council  
Hunter Water Corporation  
Logan Water  
Melbourne Water  
Onstream  
Power & Water Corporation  
SEQ Water  
South Australia Water Corporation  
South East Water Limited  
Sunshine Coast Water  
Sydney Catchment Authority

Sydney Water  
Wannon Regional Water Corporation  
Watercare Services Limited (NZ)  
Water Corporation  
Water Distribution Brisbane City Council  
Western Water  
Yarra Valley Water

## Canada

Edmonton, City of/Edmonton Waste Management Centre of Excellence  
Lethbridge, City of  
Regina, City of, Saskatchewan  
Toronto, City of, Ontario  
Winnipeg, City of, Manitoba

## STORMWATER UTILITY

## California

Fresno Metropolitan Flood Control District  
Los Angeles, City of, Department of Public Works  
Monterey, City of  
San Francisco, City & County of  
Santa Rosa, City of  
Sunnyvale, City of

## Colorado

Aurora, City of  
Boulder, City of

## Florida

Orlando, City of

## Iowa

Cedar Rapids Wastewater Facility  
Des Moines, City of

## Kansas

Lenexa, City of  
Overland Park, City of

## Kentucky

Louisville & Jefferson County Metropolitan Sewer District

## Maine

Portland Water District

## North Carolina

Charlotte, City of, Stormwater Services

## Pennsylvania

Philadelphia, City of

## Tennessee

Chattanooga Stormwater Management

## Texas

Harris County Flood Control District, Texas

## Washington

Bellevue Utilities Department  
Seattle Public Utilities

## STATE

Connecticut Department of Environmental Protection  
Kansas Department of Health

& Environment  
New England Interstate Water Pollution Control Commission (NEIWPCC)  
Ohio Environmental Protection Agency  
Ohio River Valley Sanitation Commission  
Urban Drainage & Flood Control District, CO

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Siemens Water Technologies  
The Soap & Detergent Association  
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Stratus Consulting Inc.  
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Tetra Tech Inc.  
Trojan Technologies Inc.  
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URS Corporation  
Wallingford Software  
Westfin Engineering Inc.  
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American Water  
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United Utilities North West (UUNW)  
United Water Services LLC  
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