



# Getting Started with EPA's Storm Water Management Model (SWMM)

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University of Cincinnati



# Speaker Introduction

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EPA Technical POC for SWMM  
(after the retirement of Lew Rossman  
April 2017)



Please see Feb 2018 SWMM presentation on  
<https://www.epa.gov/waterdata/surface-water-quality-modeling-training>



# Disclaimer

Any opinions expressed in this presentation are those of the author and do not necessarily reflect the views of the Agency, therefore, no official endorsement should be inferred. But it has been through USEPA's official clearance process. **Any mention of trade names or commercial products does not constitute USEPA or my personal endorsement or recommendation for use.**

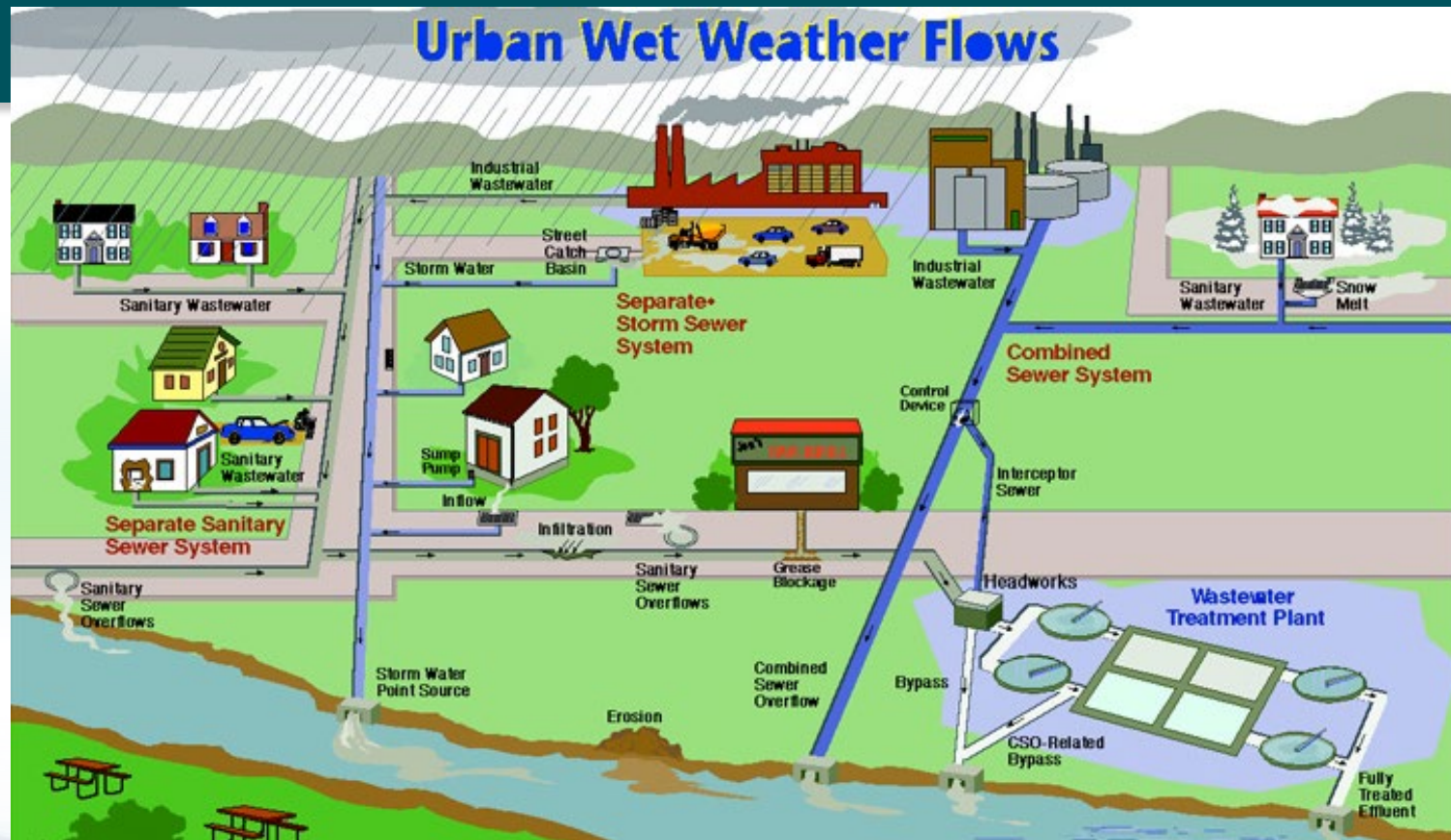
# Outline

## Storm Water Management Model

- Definition of SWMM
- Fundamentals of SWMM
  - Hydrology
  - Water Quality
  - Hydraulics
- National Stormwater Calculator
- Location of National Databases
- Technical Support
- Demonstration of some of the Features in SWMM
- Discussion & Questions

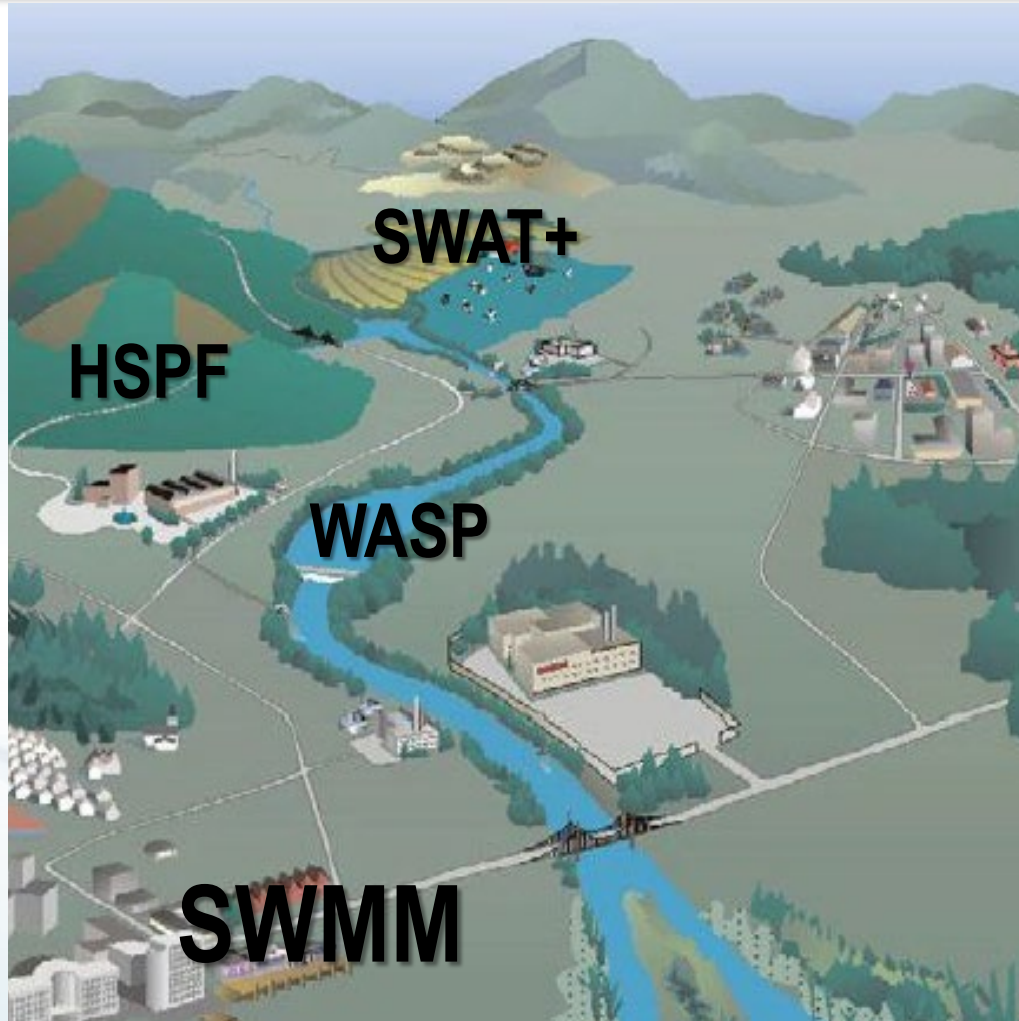


# What is SWMM?



SWMM is a public domain, distributed, dynamic hydrologic - hydraulic - water quality model used for continuous simulation of runoff quantity and quality from primarily urban areas.

# How SWMM, HSPF, SWAT, and WASP Relate



<https://cfpub.epa.gov/watertrain/pdf/modules/WshedModTools.pdf>

<https://www.aquaterra.com/resources/pubs/fiftyyearwatershedconferencePrograms.php>



# What is SWMM Used For?



Design and sizing of drainage system components.



Control of combined and sanitary sewer overflows.



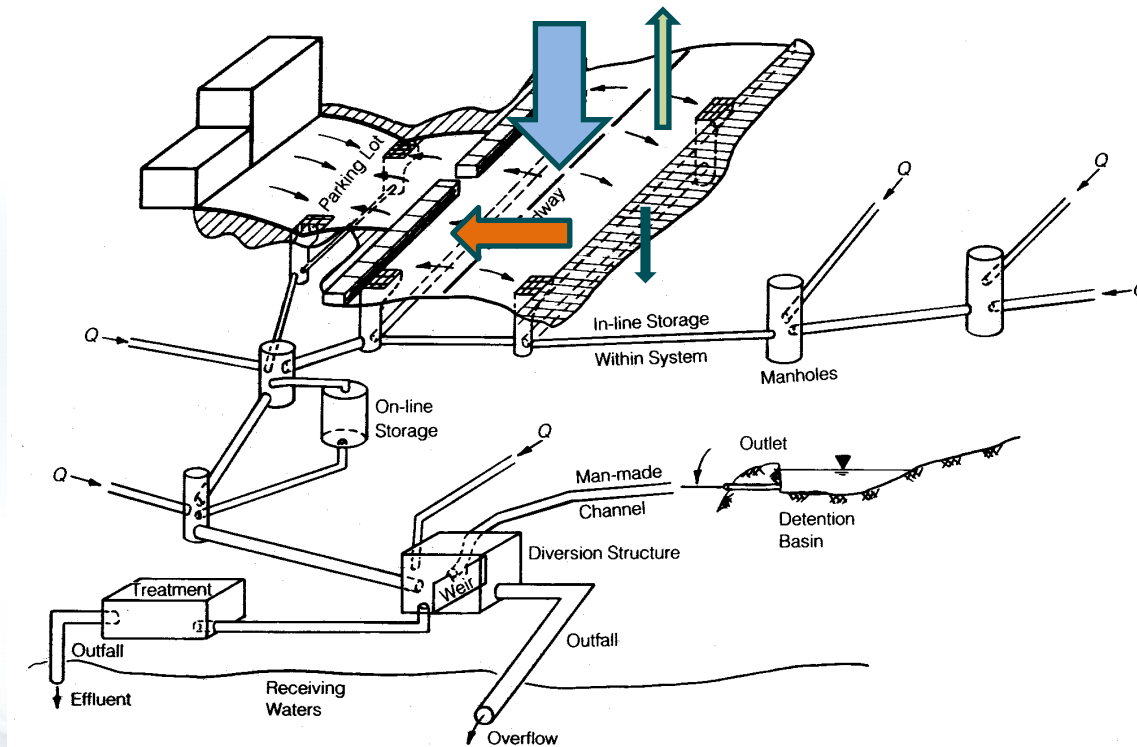
Modeling Inflow & Infiltration in sanitary sewer systems.



Generating non-point source pollutant loadings for load allocation studies.

Evaluating green infrastructure for sustainability goals.

# How does SWMM Model?

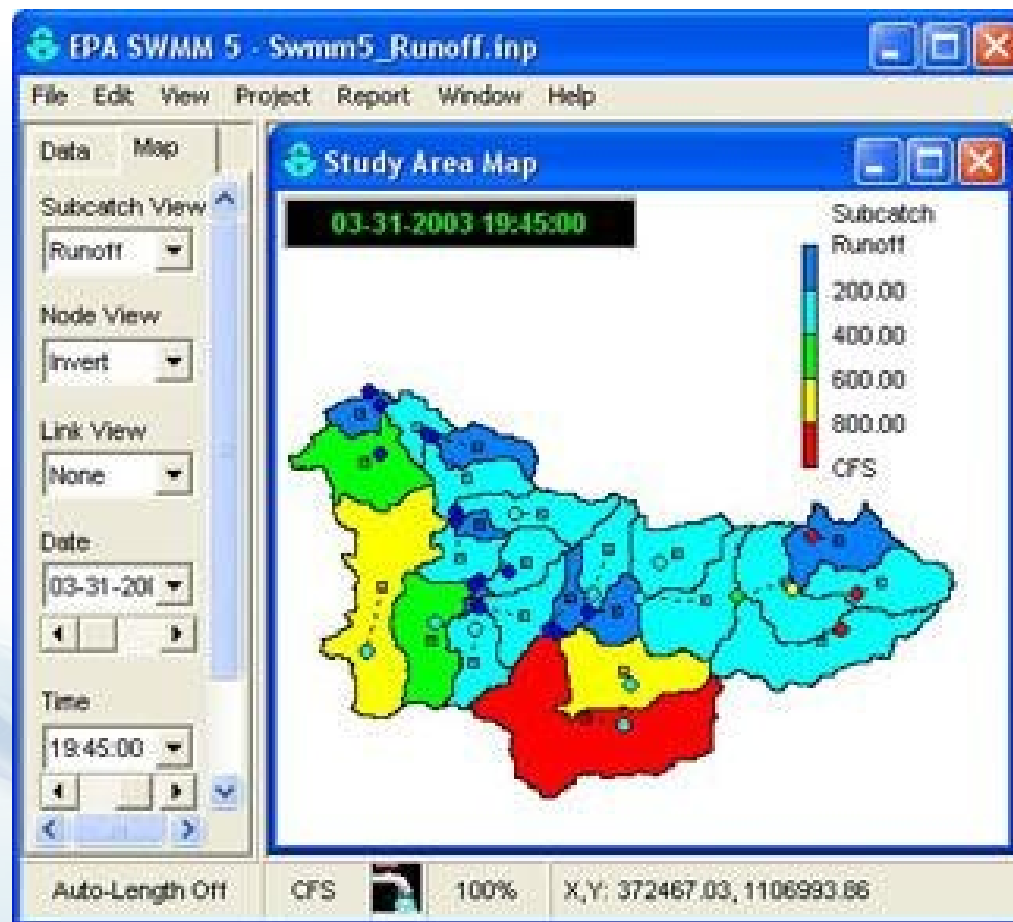


SWMM is a **distributed, dynamic rainfall-runoff** simulation model used for **single event** or long-term (**continuous**) simulation of runoff quantity and quality from **primarily urban areas**.



# Storm Water Management Model

<https://www.epa.gov/water-research/storm-water-management-model-swmm>



# SWMM Webpage, continued

<https://www.epa.gov/water-research/storm-water-management-model-swmm>

## Software

Date	Description
7/20/2020	<a href="#">Self-Extracting Installation Program for SWMM 5.1.015 (EXE)</a> (32 MB)
02/18/2020	<a href="#">Self-Extracting Installation Program for SWMM 5.1.014 (EXE)</a> (31 MB)
12/11/2014	<a href="#">SWMM-CAT Download Version 1</a> (4 MB)
05/25/2005	<a href="#">Utility for converting SWMM 4 data files to SWMM 5 files (EXE) Version 1.2</a> (2 MB)

# SWMM Webpage, continued

<https://www.epa.gov/water-research/storm-water-management-model-swmm>

## Documentation

Date	Title
09/30/2015	<a href="#">SWMM 5.1 User's Manual</a>
09/01/2014	<a href="#">SWMM-CAT User's Guide</a>
01/29/2016	<a href="#">SWMM Reference Manual Volume I—Hydrology</a>
08/07/2017	<a href="#">SWMM Reference Manual Volume II—Hydraulics</a>
09/08/2016	<a href="#">SWMM Reference Manual Volume III—Water Quality</a>
01/31/2017	<a href="#">SWMM Technical Fact Sheet</a>
07/06/2010	<a href="#">SWMM Applications Manual (ZIP)</a> (7 MB)
09/19/2006	<a href="#">Quality Assurance Report for Dynamic Wave Flow Routing (ZIP)</a> (3 MB)

# Storm Water Management Model Reference Manual

## Volume I – Hydrology (Revised)





# Storm Water Management Model Reference Manual

## Volume II –Hydraulics



## Plus LID Modules

# Storm Water Management Model Reference Manual Volume III – Water Quality



# SWMM Reference Manuals

## 4.4 Green-Ampt Method

The Green-Ampt equation (Green and Ampt, 1911) has received considerable attention in recent years. The original equation was for infiltration with excess water at the surface at all times. Mein and Larson (1973) showed how it could be adapted to a steady rainfall input and proposed a way in which the capillary suction parameter could be determined. Chu (1978) has shown the applicability of the equation to the unsteady rainfall situation, using data for a field catchment. The Green-Ampt method was added into SWMM III in 1981 by R.G. Mein and W. Huber (Huber et al., 1981).

### 4.4.1 Governing Equations

The Green-Ampt conceptualization of the infiltration process is one in which infiltrated water moves vertically downward in a saturated layer, beginning at the surface (Figure 4-5). In the wetted zone the moisture content  $\theta$  is at saturation  $\theta_s$  while the moisture content in the un-wetted zone is at some known initial level  $\theta_i$ .

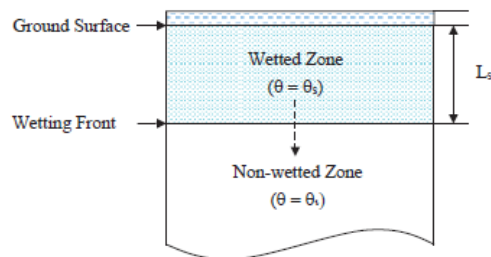


Figure 4-5 Two-zone representation of the Green-Ampt infiltration model (after Nicklow et al., 2006).

The water velocity within the wetted zone is given by Darcy's Law as a function of the saturated hydraulic conductivity  $K_s$ , the capillary suction head along the wetting front  $\psi_s$ , the depth of ponded water at the surface  $d$ , and the depth of the saturated layer below the surface  $L_s$ :

$$f_p = K_s \left[ \frac{d + L_s + \psi_s}{L_s} \right] \quad (4-26)$$

The depth of the saturated layer  $L_s$  can be expressed in terms of the cumulative infiltration,  $F$ , and the initial moisture deficit to be filled below the wetting front,  $\theta_d = \theta_s - \theta_i$  as  $L_s = F / \theta_d$ . Substituting this into Equation 4-26 and assuming that  $d$  is small compared to the other depths gives the Green-Ampt equation for saturated conditions:

$$f_p = K_s \left[ 1 + \frac{\psi_s \theta_d}{F} \right] \quad (4-27)$$

Equation 4-27 applies only after a saturated layer develops at the ground surface. Prior to this point in time the infiltration capacity will equal the rainfall intensity:

$$f_p = i \quad (4-28)$$

As time increases, one can test whether saturation has been reached by solving 4-27 for  $F$  (which will be denoted as  $F_s$ ) with  $f_p$  set equal to  $i$  and check if this value equals or exceeds the actual cumulative infiltration  $F$ :

$$F_s = \frac{K_s \psi_s \theta_d}{i - K_s} \quad (4-29)$$

Note that there is no calculation of  $F_s$  when  $i \leq K_s$ , although  $F$  still gets updated during such periods. Finally, in this scheme the actual infiltration  $f$  is the same as the potential value  $f_p$ :

$$f = f_p \quad (4-30)$$

The two equations are illustrated in Figure 4-6 for the situation  $K_s = 0.25$  in/hr,  $\psi_s = 6.5$  in, and  $\theta_d = 0.20$ . The initial, flat portion of the curve corresponds to  $f = i$ , up to the point where  $F = F_s$  (Equation 4-29). The remainder of the curve corresponds to the potential rate computed with Equation 4-27. Note that the infiltration rate approaches  $K_s$  (0.25 in/hr) asymptotically.

## Documentation

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01/29/2016	<a href="#">SWMM Reference Manual Volume I—Hydrology</a>
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# Use the SWMM Tutorial's

## CHAPTER 2 – QUICK START TUTORIAL

*This chapter provides a tutorial on how to use EPA SWMM. If you are not familiar with the elements that comprise a drainage system, and how these are represented in a SWMM model, you might want to review the material in Chapter 3 first.*

### 2.1 Example Study Area

In this tutorial we will model the drainage system serving a 12-acre residential area. The system layout is shown in Figure 2-1 and consists of subcatchment areas<sup>3</sup> S1 through S3, storm sewer conduits C1 through C4, and conduit junctions J1 through J4. The system discharges to a creek at the point labeled *Out1*. We will first go through the steps of creating the objects shown in this diagram on SWMM's study area map and setting the various properties of these objects. Then we will simulate the water quantity and quality response to a 3-inch, 6-hour rainfall event, as well as a continuous, multi-year rainfall record.

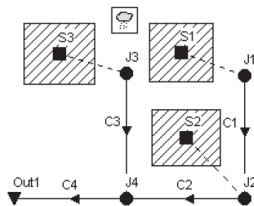


Figure 2-1 Example study area

### 2.2 Project Setup

Our first task is to create a new SWMM project and make sure that certain default options are selected. Using these defaults will simplify the data entry tasks later on.

1. Launch EPA SWMM if it is not already running and select **File >> New** from the Main Menu bar to create a new project.
2. Select **Project >> Defaults** to open the Project Defaults dialog.

<sup>3</sup> A subcatchment is an area of land containing a mix of pervious and impervious surfaces whose runoff drains to a common outlet point, which could be either a node of the drainage network or another subcatchment.

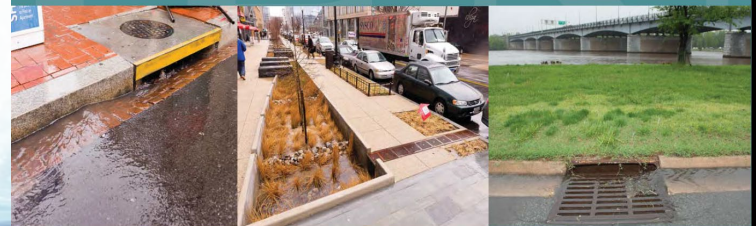
### Documentation

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09/30/2015	<a href="#">SWMM 5.1 User's Manual</a>
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<https://swmm5.org/2017/08/14/epa-swmm5-tutorial-with-images-for-swmm-5-1-012/>

**Storm Water Management Model  
User's Manual Version 5.1**

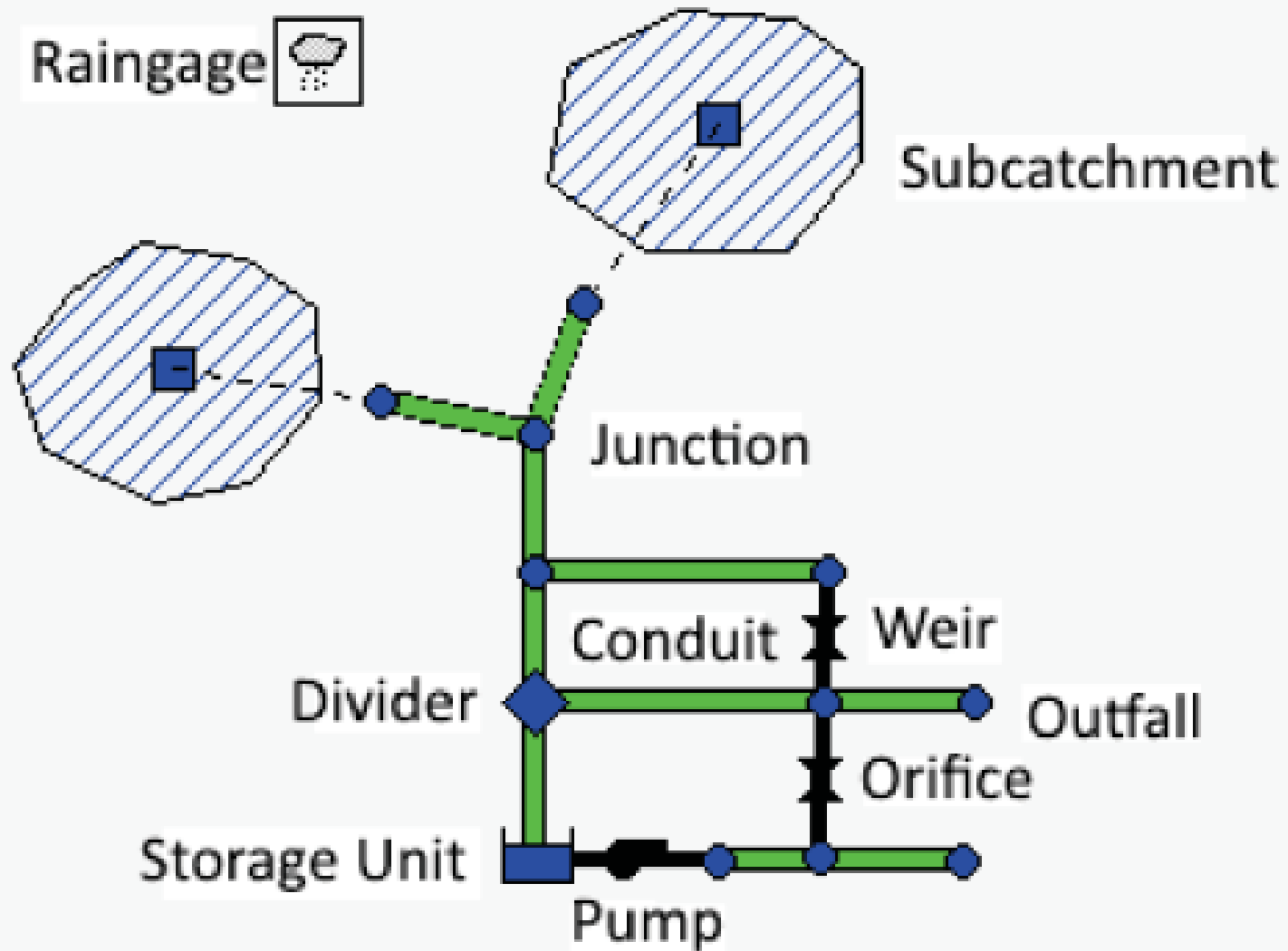




# Demonstration of SWMM

- Walk through governing equations
  - Hydrology
  - Low Impact Development
  - Water Quality
  - Hydraulics
- Then Stormwater Calculator
- Demonstrate SWMM

# SWMM's Conceptual Model



# Hydrology – Governing equations

## Reference Manual I Chapter 3

From conservation of mass, the net change in depth  $d$  per unit of time  $t$  is the difference between inflow and outflow rates over the subcatchment:

$$d/t = Q/A \text{ (cfs/ft}^2\text{)} = \text{ft/sec}$$

$$\frac{\partial d}{\partial t} = r + i - e - f - q \quad (3-1)$$

where:

- $r$  = rate of upstream runoff (ft/s)
- $i$  = rate of rainfall + snowmelt (ft/s)
- $e$  = surface evaporation rate (ft/s)
- $f$  = infiltration rate (ft/s)
- $q$  = runoff rate (ft/s).

Note that the fluxes  $r$ ,  $i$ ,  $e$ ,  $f$ , and  $q$  are expressed as flow rates per unit area.

Hydrology Reference Manual Equation 3-1 (modified)

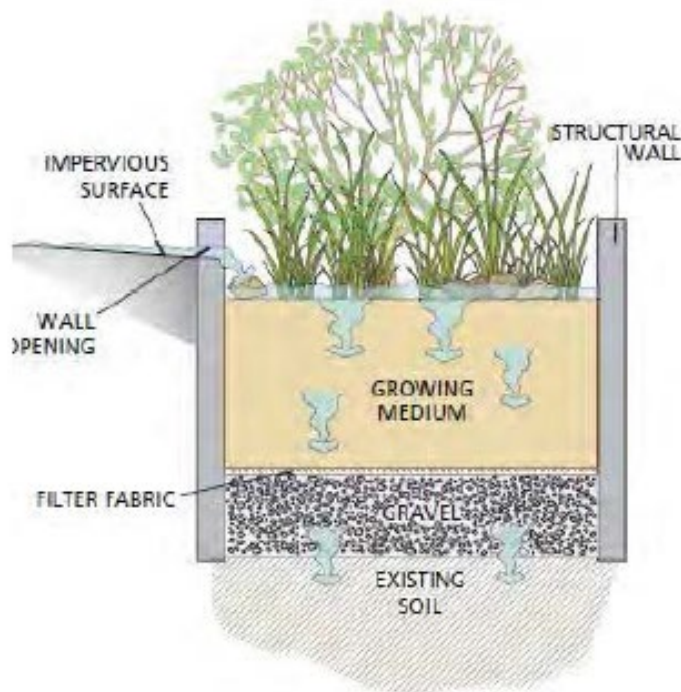
# LID Modeling in SWMM



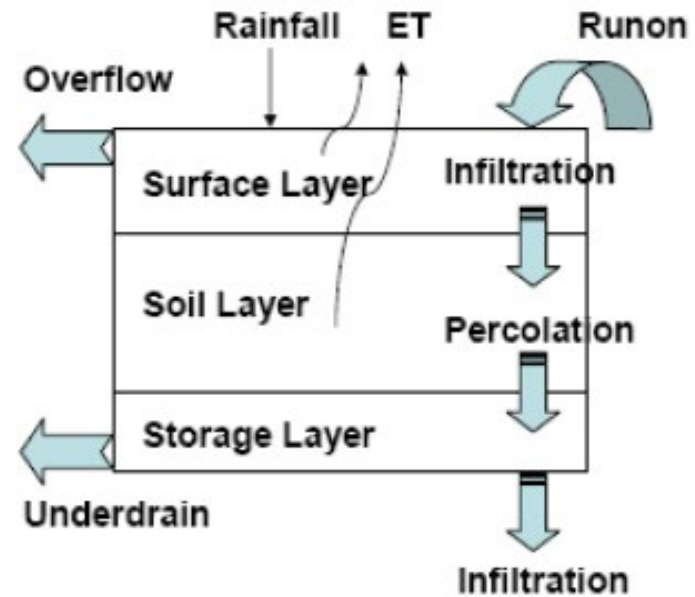


# Green Infrastructure Subcatchment

## Reference Manual III Chapter 6

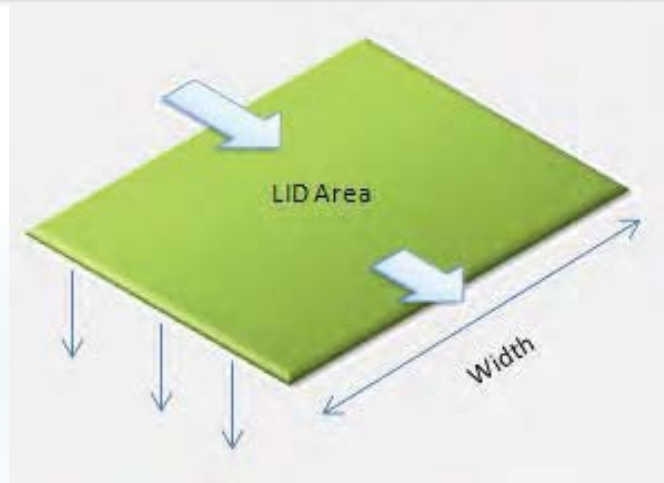


(A)

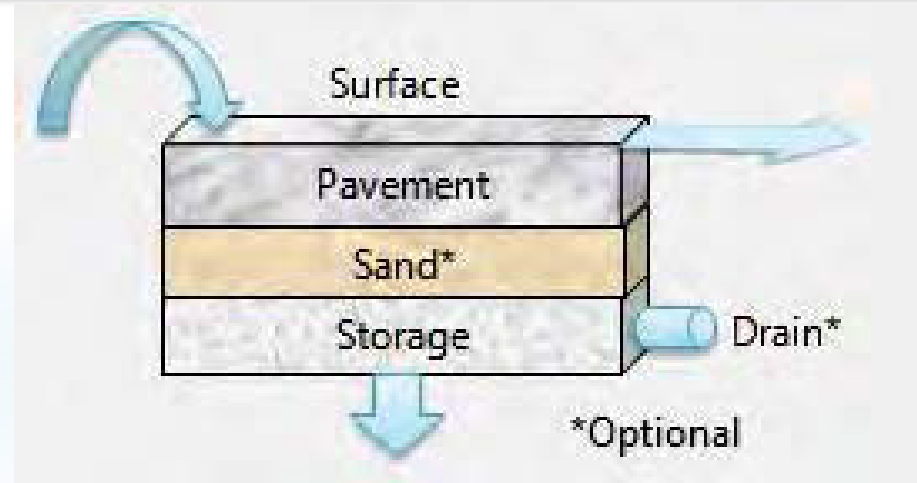


(B)

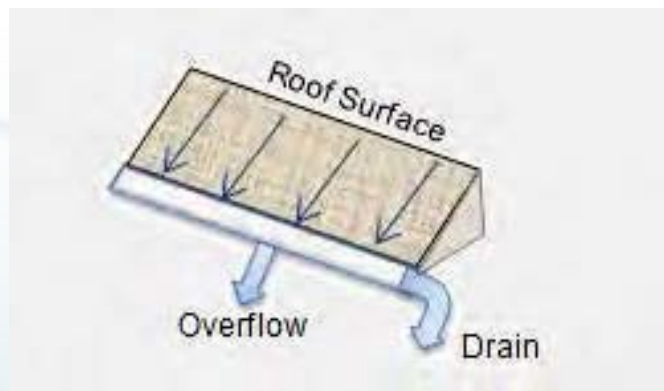
# More Green Infrastructure Subcatchments



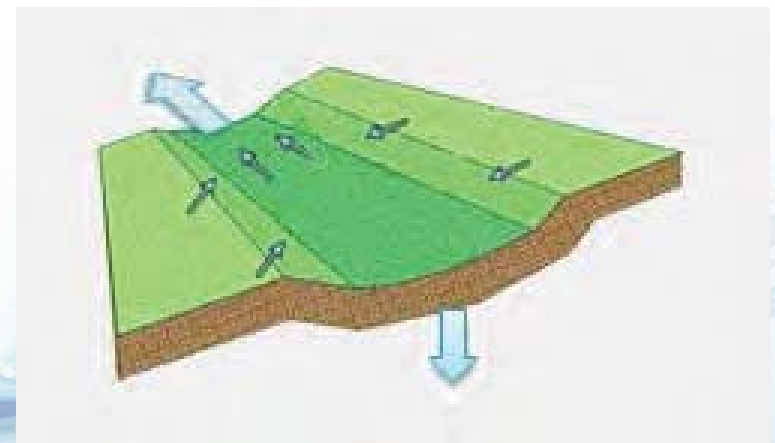
Green Roof



Permeable Pavement



Roof Disconnection



Vegetative Swale

# Types of LIDs Modeled



Disconnection



Infiltration Basin



Bioretention and Rain Garden



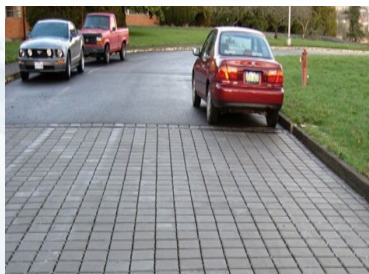
Cistern



Infiltration Trench



Green Roof



Porous Pavement



Vegetative Swale

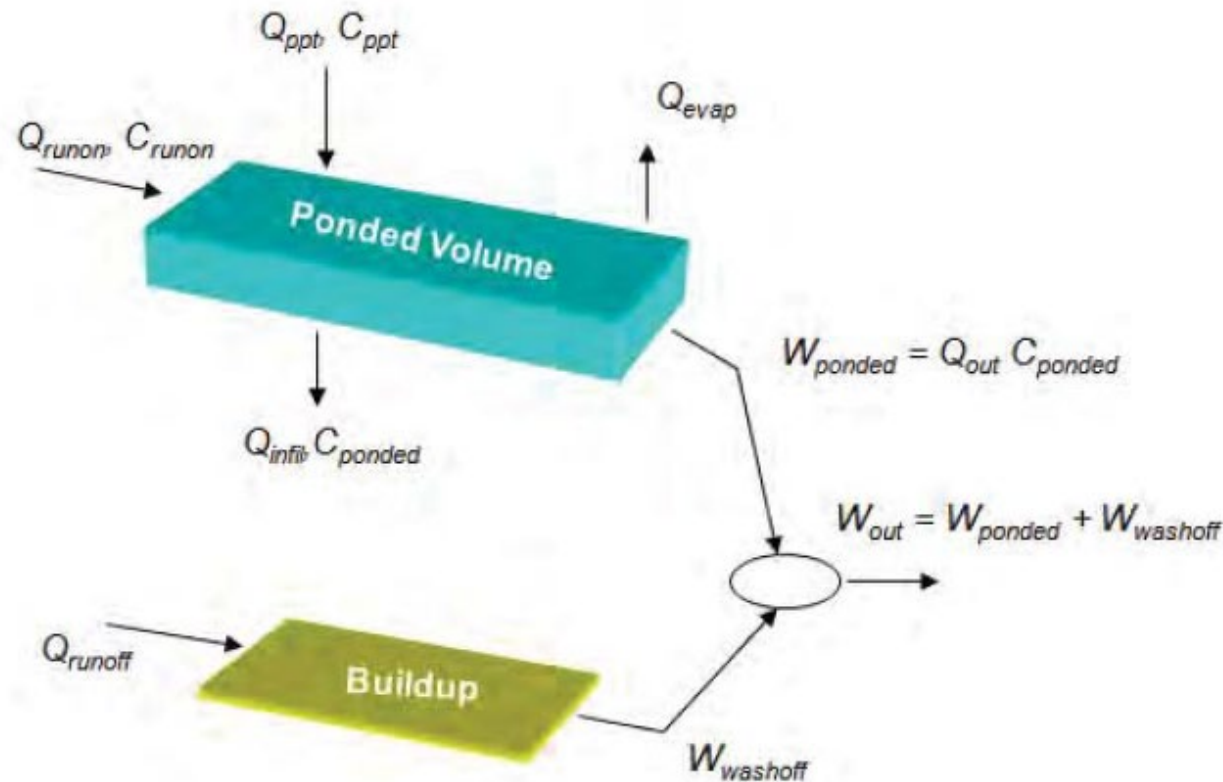


Street Planter



# Pollutant Buildup and Wash off

## Reference Manual III Chapters 3 and 4





# National Stormwater Calculator

<https://www.epa.gov/water-research/national-stormwater-calculator>


EPA National Stormwater Calculator

NEW SAVE OPEN RESOURCES CONTACT

Location

Directions

Bring your site into view on the map and then mark its exact location by clicking the mouse pointer over it or entering your address or zip code below.

Press the  icon to have the map locate.

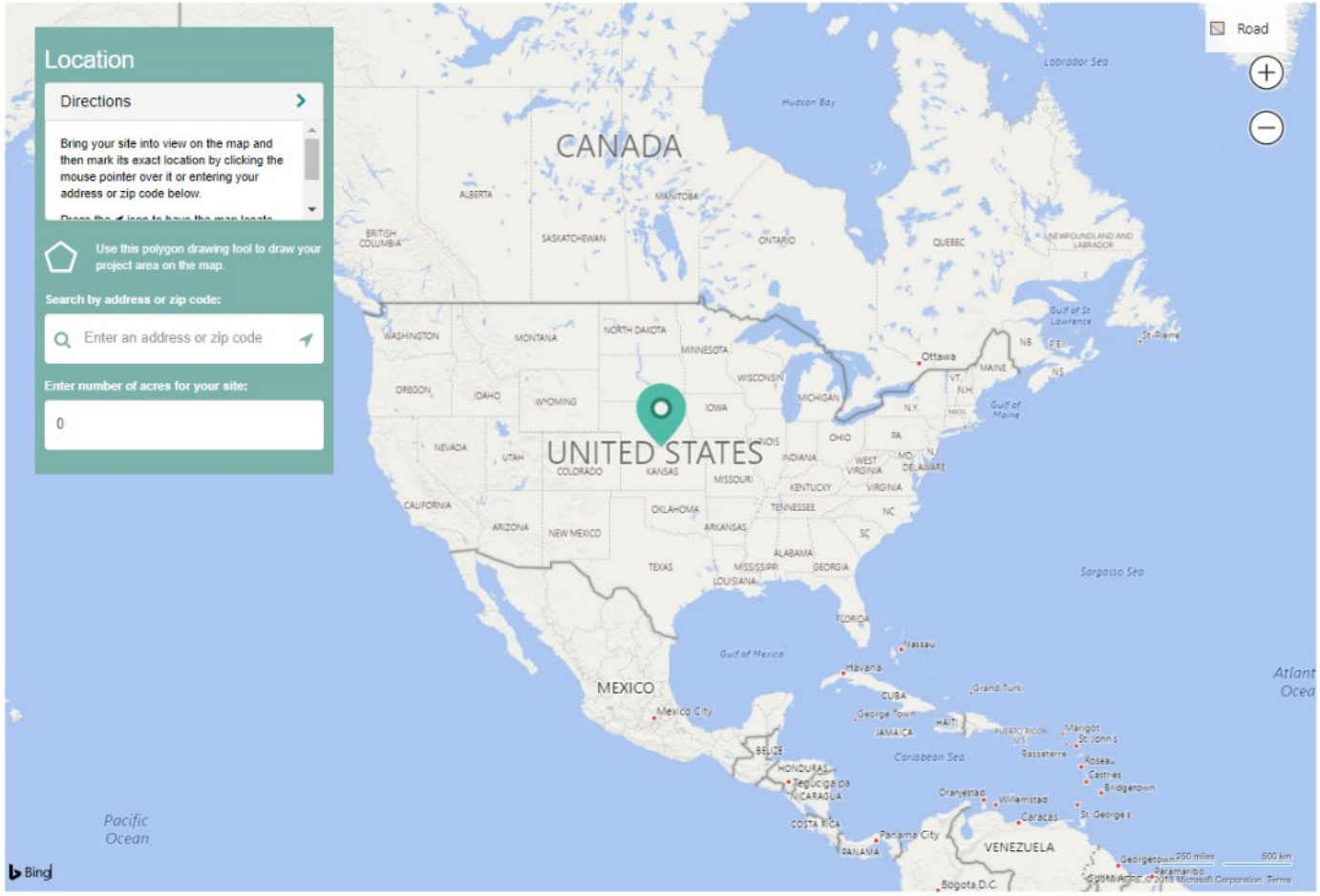
Use this polygon drawing tool to draw your project area on the map.

Search by address or zip code:

Enter an address or zip code

Enter number of acres for your site:

0



25

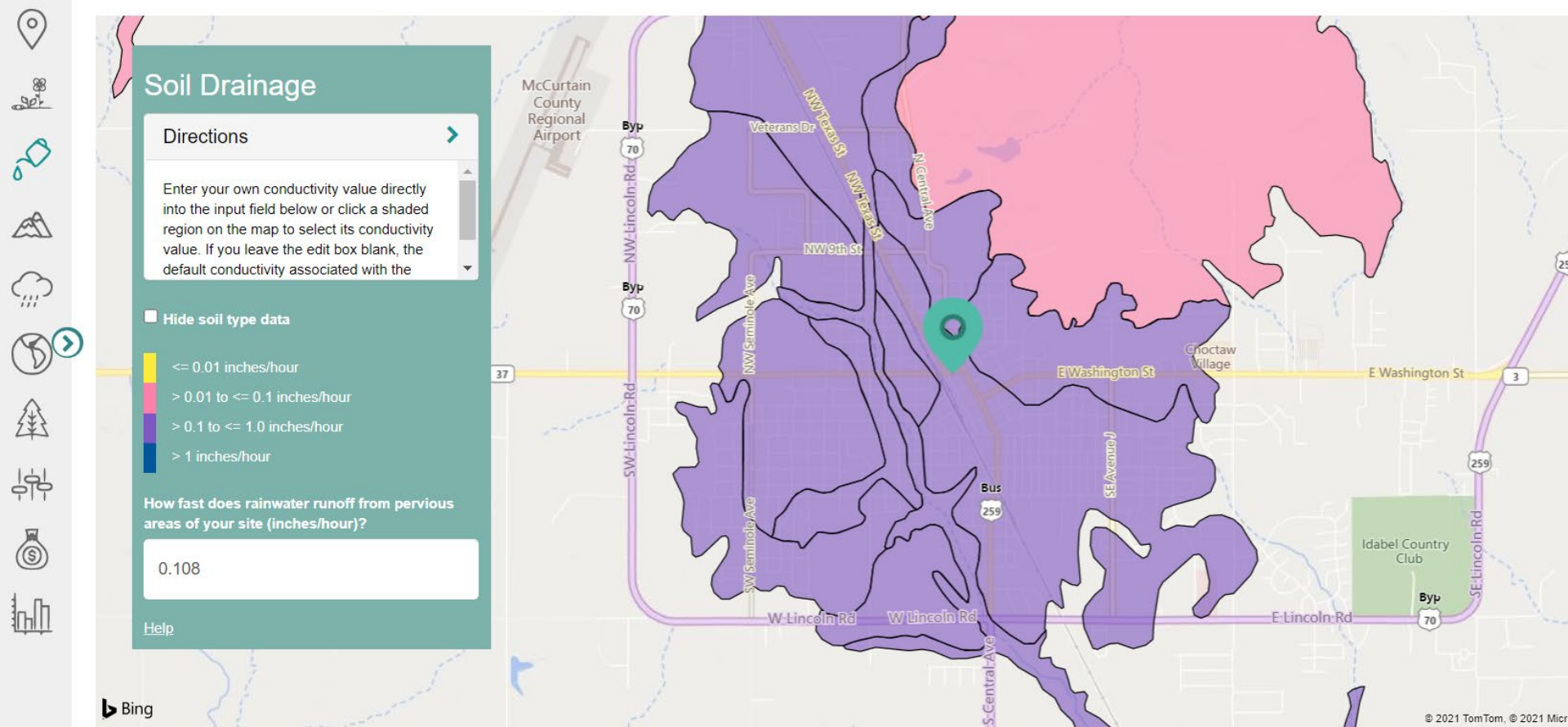
EPA United States Environmental Protection Agency

# National Stormwater Calculator

← → ↻ swcweb.epa.gov/stormwatercalculator/soildrainage

 National Stormwater Calculator

NEW SAVE OPEN



Displays soil properties obtained from querying the NRCS SSURGO database



# Land Use

swcweb.epa.gov/stormwatercalculator/landcover

**EPA** National Stormwater Calculator



## Land Cover

### Directions

Describe the site's land cover for the development scenario being analyzed.

Click on a category to see a more detailed description.

**Forest:**  14 %

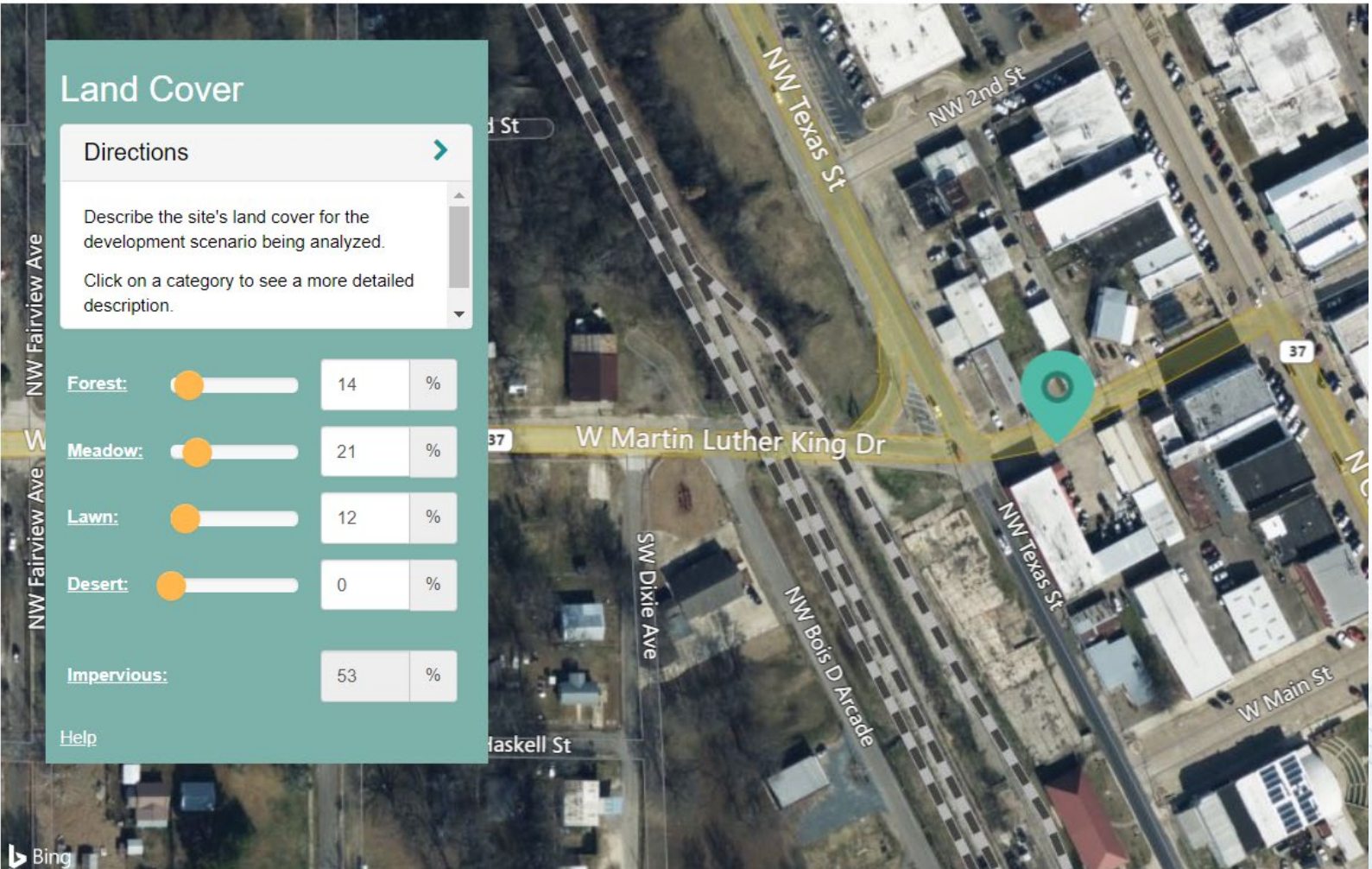
**Meadow:**  21 %

**Lawn:**  12 %

**Desert:**  0 %

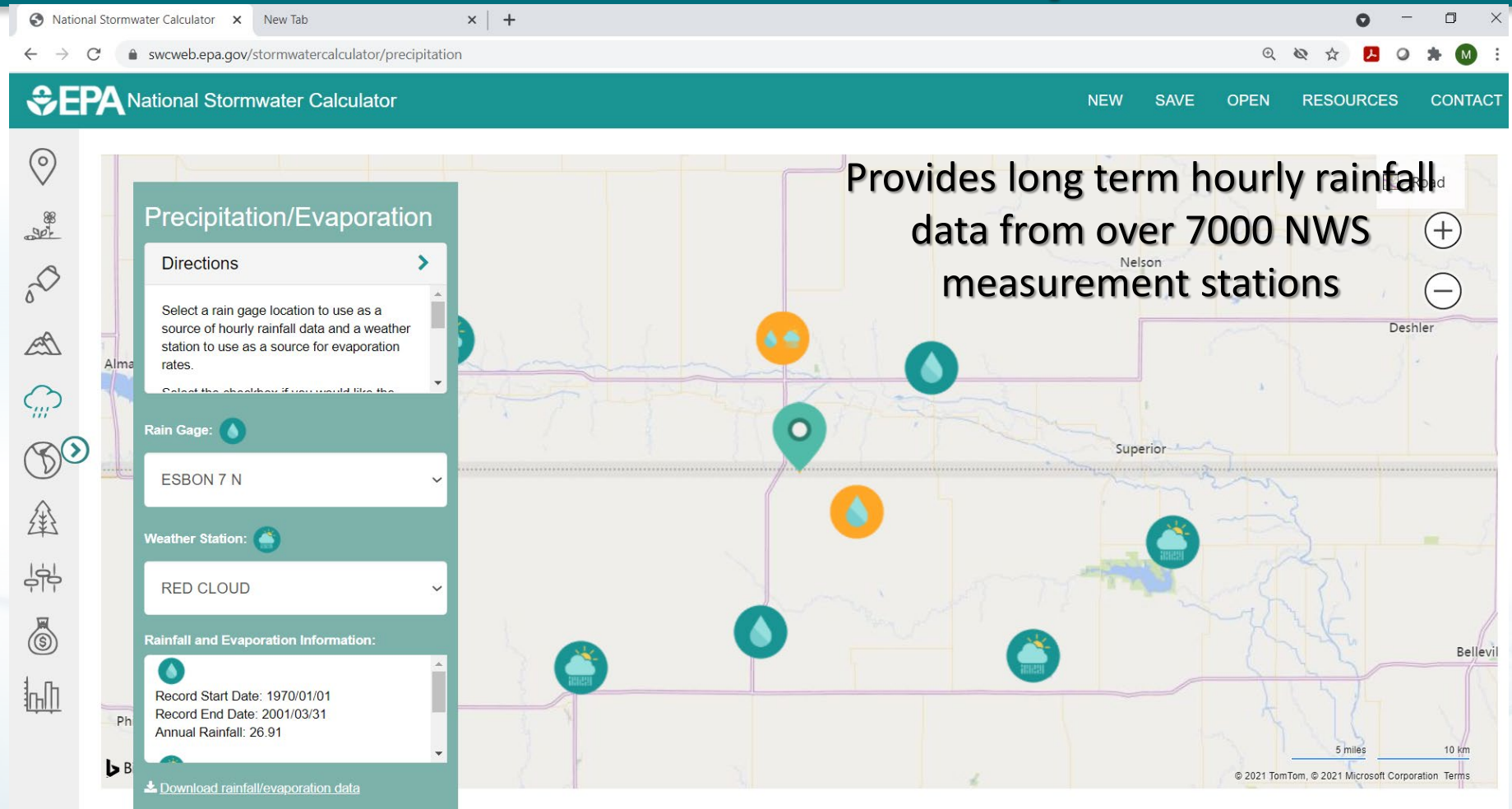
**Impervious:** 53 %

[Help](#)



# Climatology

## Reference Manual I Chapter 2





# National Stormwater Calculator

## LID Calculation

The user specifies the site's land cover and selects a set of LID controls.

### LID Controls

Directions >

Enter the percentage of your site's impervious area you would like to be treated by the listed LID Controls.



Click a practice to learn more about it or to change its design parameters.

Disconnection:	<input type="range"/>	0	%
Rain Harvesting:	<input type="range"/>	0	%
Rain Gardens:	<input type="range"/>	27	%
Green Roofs:	<input type="range"/>	0	%
Street Planters:	<input type="range"/>	0	%
Infiltration Basins:	<input type="range"/>	0	%
Permeable Pavement:	<input type="range"/>	0	%

Design Storm for Sizing: 2 in.

[Help](#)

### Rain Gardens



Rain Gardens are shallow depressions filled with an engineered soil mix that supports vegetative growth. They are usually used on individual home lots to capture roof runoff.

Typical soil depths range from 6 to 18 inches

The Capture Ratio is the ratio of the rain garden's area to the impervious area that drains onto it.

[Learn More](#)

Ponding Height:	<input type="range"/>	6	in.
Soil Media Thickness:	<input type="range"/>	12	in.
Soil Media Conductivity:	<input type="range"/>	10	in./hr
% Capture Ratio:	<input type="range"/>	5	%

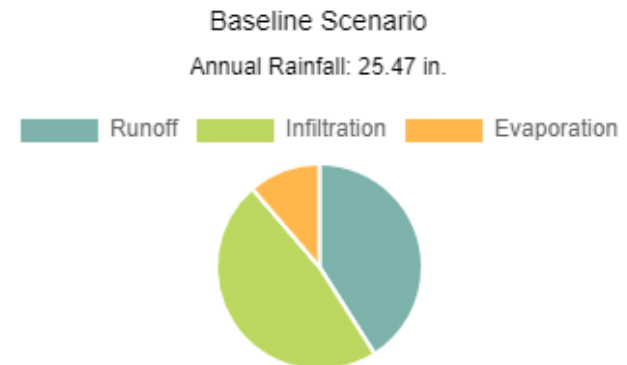
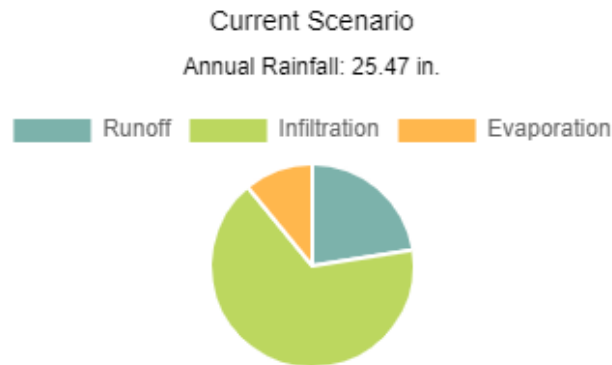
☐ Pre-Treatment

[Size for Design Storm](#) [Save and Return](#) [Restore Defaults](#)

# National Stormwater Calculator

The Calculator runs SWMM to generate daily rainfall/runoff statistics.

## Summary Results



Statistic	Current Scenario	Baseline Scenario
Average Annual Rainfall (inches)	25.47	25.47
Average Annual Runoff (inches)	5.74	10.49
Days per Year with Rainfall	48.72	48.72
Days per Year with Runoff	17.49	27.93
Percent of Wet Days Retained	64.10	42.67
Smallest Rainfall w/ Runoff (inches)	0.28	0.10
Largest Rainfall w/o Runoff (inches)	0.62	0.36
Max Rainfall Retained (inches)	2.54	1.57

# National Stormwater Calculator

The Calculator can provide ballpark costs.

## Cost Summary

Estimate of Probable Capital Costs (estimates in 2018 US.\$)

[Maintenance Costs](#) | [Graphical View](#)

Cost By LID Control Type	Drainage Area %	Has Pre-Treatment?	Current Scenario (C)		Baseline Scenario (B)		Difference (C - B)	
			Current / Baseline	Low High	Low High	Low High	Low High	Low High
Disconnection	0 / 0	No / No		\$0.00 \$0.00	\$0.00 \$0.00	\$0.00 \$0.00	\$0.00 \$0.00	\$0.00 \$0.00
Rainwater Harvesting	0 / 0	No / No		\$0.00 \$0.00	\$0.00 \$0.00	\$0.00 \$0.00	\$0.00 \$0.00	\$0.00 \$0.00
Rain Gardens	27 / 27	No / No		\$5,932.68 \$11,501.71	\$5,932.68 \$11,501.71	\$0.00 \$0.00	\$0.00 \$0.00	\$0.00 \$0.00
Green Roofs	27 / 0	No / No		\$66,500.50 \$139,338.81	\$0.00 \$0.00	\$0.00 \$0.00	\$66,500.50 \$139,338.81	\$0.00 \$0.00
Street Planters	0 / 0	No / No		\$0.00 \$0.00	\$0.00 \$0.00	\$0.00 \$0.00	\$0.00 \$0.00	\$0.00 \$0.00
Infiltration Basins	0 / 0	No / No		\$0.00 \$0.00	\$0.00 \$0.00	\$0.00 \$0.00	\$0.00 \$0.00	\$0.00 \$0.00
Permeable Pavement	40 / 0	No / No		\$178,055.69 \$237,830.20	\$0.00 \$0.00	\$0.00 \$0.00	\$178,055.69 \$237,830.20	\$0.00 \$0.00
<b>Total</b>	<b>94 / 27</b>	<b>Varies</b>		<b>\$250,488.86 \$388,670.72</b>	<b>\$5,932.68 \$11,501.71</b>	<b>\$244,556.19 \$377,169.01</b>		

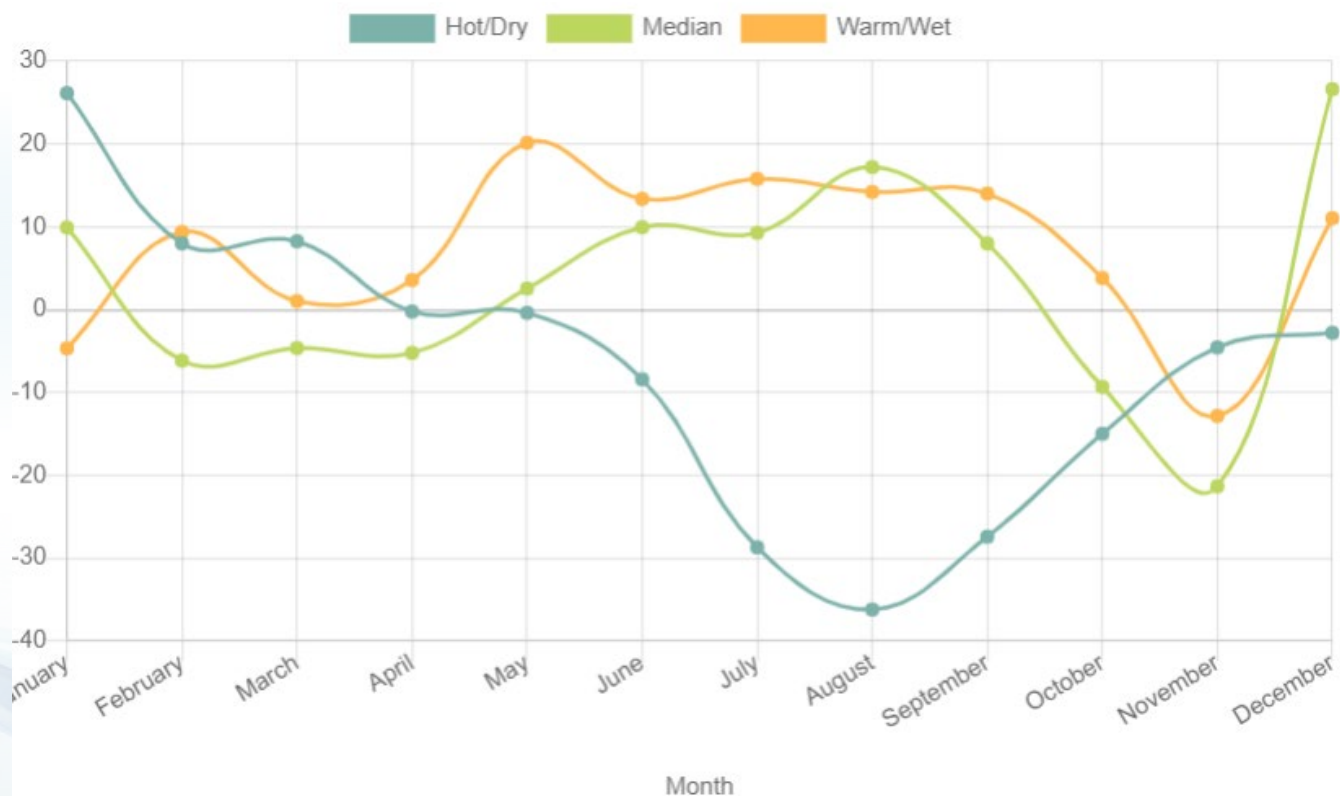
**Note:** site complexity variables that affect cost shown below:

	Current Scenario	Baseline Scenario	Chart Key	
Dev. Type	Re-Development	Re-Development	D - Disconnection	IB - Infiltration Basins
Site Suitability	Poor	Poor	RH - Rain Harvesting	PP - Permeable Pavement
Topography	Mod. Flat (5% Slope)	Mod. Flat (5% Slope)	RG - Rain Gardens	
Soil Type	B	B	GR - Green Roofs	
Cost Region	Denver(345 miles) 1.01	Denver(345 miles) 1.01	SP - Street Planters	

# National Stormwater Calculator

## Climate Change

Percentage Change in Monthly Rainfall for Far Term Projections





# SWMM-CAT

SWMM-Climate Adjustment Tool

Enter your location's latitude, longitude  
or its 5-digit zip code:

32.240625,-110.94791



Select a future projection period:

☒ Near Term (2020 - 2049)

☐ Far Term (2045 - 2074)

Select a climate change outcome:

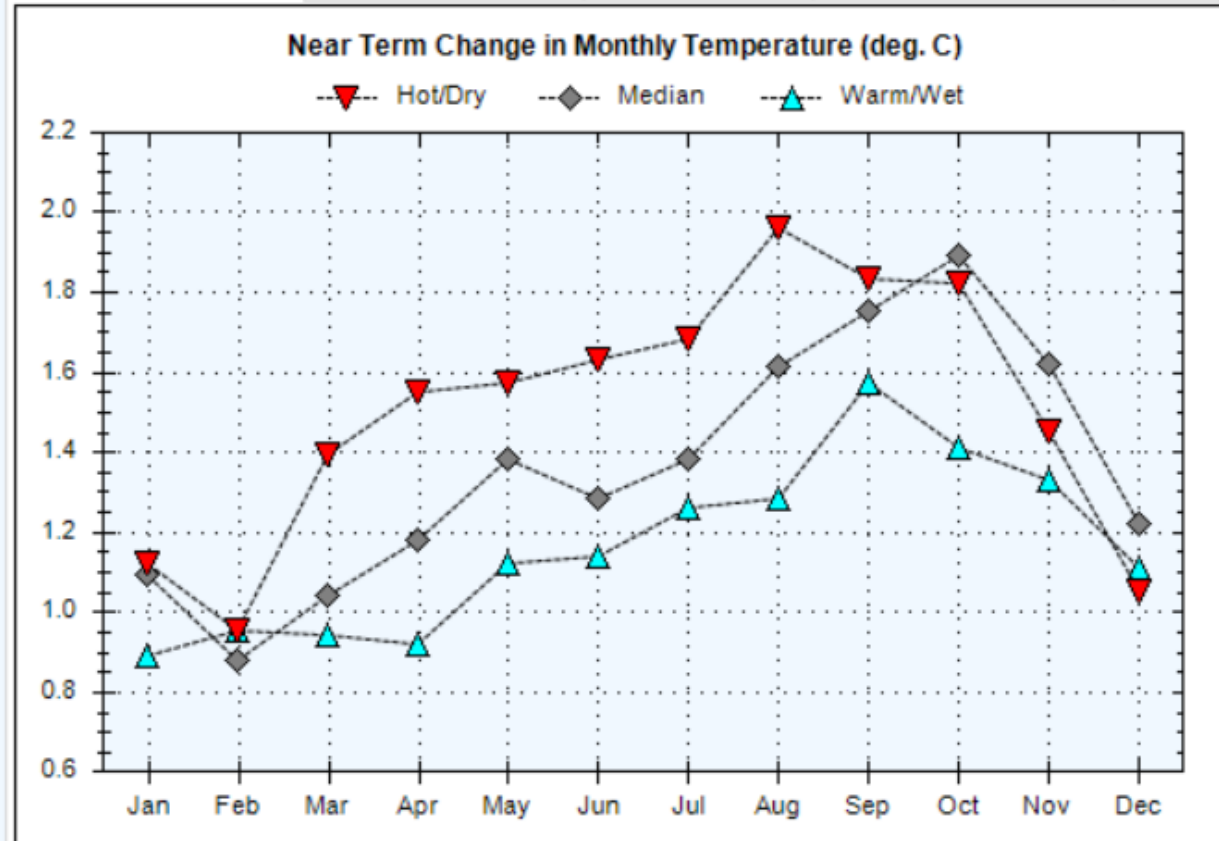
☐ Hot/Dry

☒ Median change

☐ Warm/Wet

[Save Adjustments to SWMM and Exit](#)

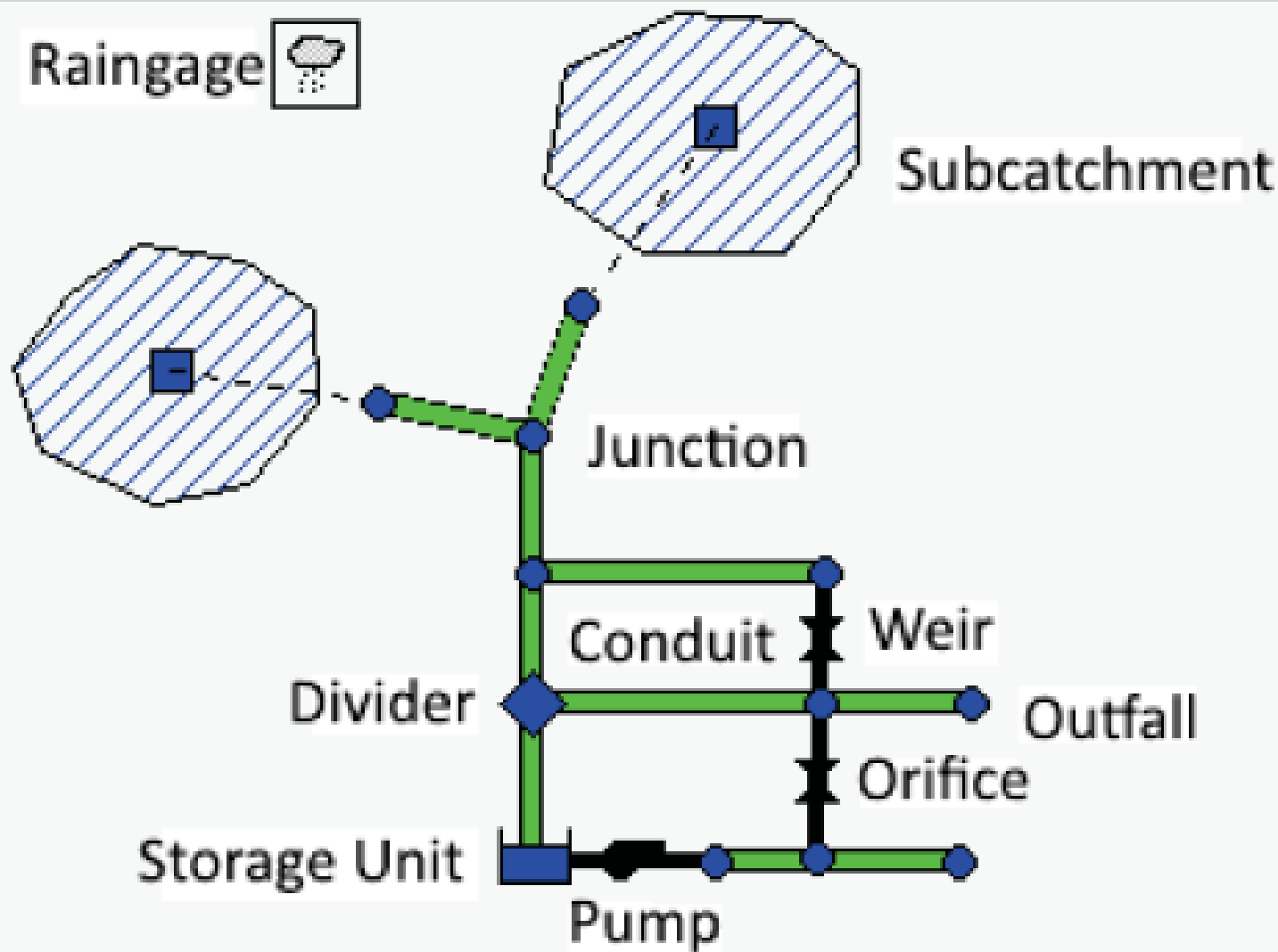
Monthly Temperature Monthly Evaporation Monthly Rainfall 24-Hour Design Storm Help



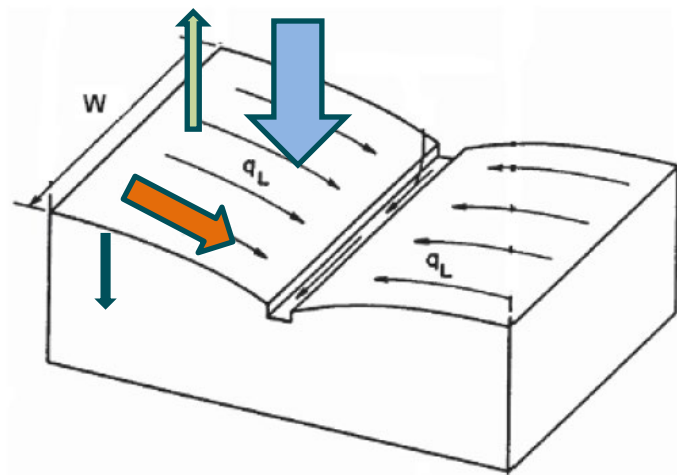
Version 1.0.0.0

[Exit](#)

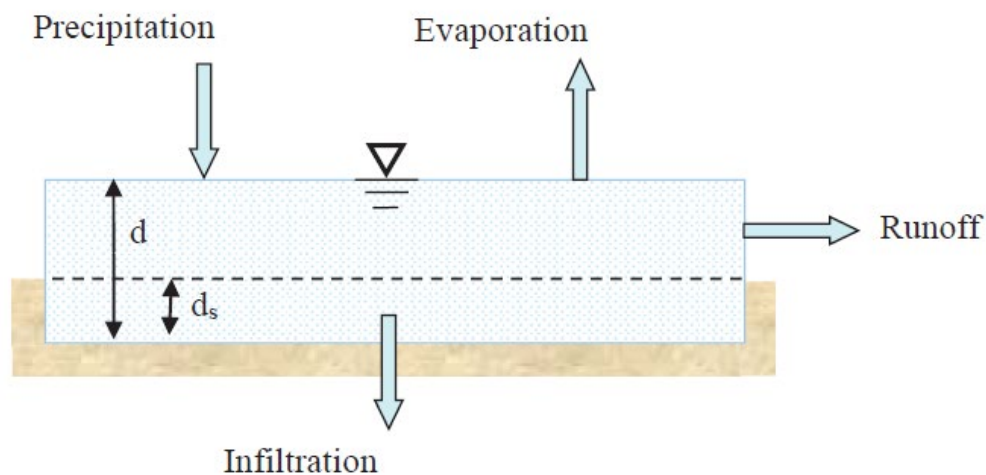
# Pulling the Hydrology of SWMM together



# Idealized Subcatchment – Reference Manual I Sections 3



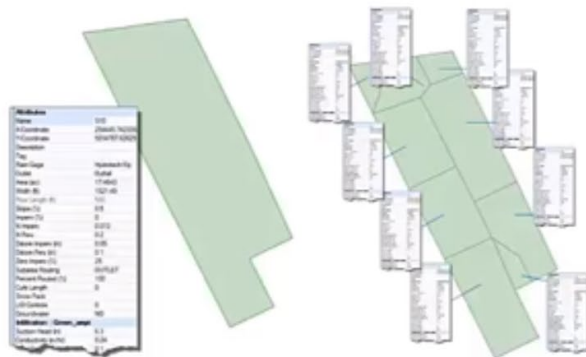
- Pervious
- Impervious
- Impervious w/o Depression Storage



# Idealized Subcatchment

(Courtesy of Rob James, CHI Water)

## Subcatchment parameters



- Parameters may be averaged (lumped) over a coarse number of subcatchments
- Or further sub-divided (distributed) into a finer number of subcatchments

[https://www.youtube.com/watch?v=HZnX\\_GsABUA](https://www.youtube.com/watch?v=HZnX_GsABUA)



# Subcatchments – Reference Manual I Section 3

SWMM 5.1

File Edit View Project Report Tools Window Help

Project Map

- Title/Notes
- Options
- Climatology
- Hydrology
  - Rain Gages
  - Subcatchments
  - Aquifers
  - Snow Packs
  - Unit Hydrographs
  - LID Controls
- Hydraulics
- Quality
- Curves
- Time Series
- Time Patterns
- Map Labels

Study Area Map

Subcatchment Sub1

Property	Value
Name	Sub1
X-Coordinate	1298.905
Y-Coordinate	6255.869
Description	
Tag	
Rain Gage	*
Outlet	*
Area	5
Width	500
% Slope	0.5
% Imperv	25
N-Imperv	0.01
N-Perv	0.1
Dstore-Imperv	0.05
Dstore-Perv	0.05
%Zero-Imperv	25
Subarea Routing	OUTLET
Percent Routed	100
Infiltration Data	GREEN_AMPT
Groundwater	NO
Snow Pack	
LID Controls	0
Land Uses	0
Initial Buildup	NONE
Curb Length	0
N-Perv Pattern	
Dstore Pattern	
Infil. Pattern	
Width of overland flow path (m)	

Auto-Length: Off   Offsets: Elevation   Flow Units: LPS   Zoom Level: 100%   X,Y: 13251.174, 5868.545

# Mix of Infiltration Methods

SWMM 5.1 - pipe2020408.inp

File Edit View Project Report Tools Window Help

Project Map

Study Subcatchment 1

Property	Value
Name	1
X-Coordinate	527851.684
Y-Coordinate	3902393.730
Description	
Tag	
Rain Gage	Weir-Fourplex
Outlet	196
Area	0.71
Width	82.79
% Slope	5.300
% Imperv	15.1
N-Imperv	0.011
N-Perv	0.24
Dstore-Imperv	0.05
Dstore-Perv	0.05
%Zero-Imperv	25.0
Subarea Routing	OUTLET
Percent Routed	100
Infiltration Data	GREEN_AMPT ...
Groundwater	NO

Infiltration parameters (click to edit)

Infiltration Editor

Infiltration Method: GREEN\_AMPT

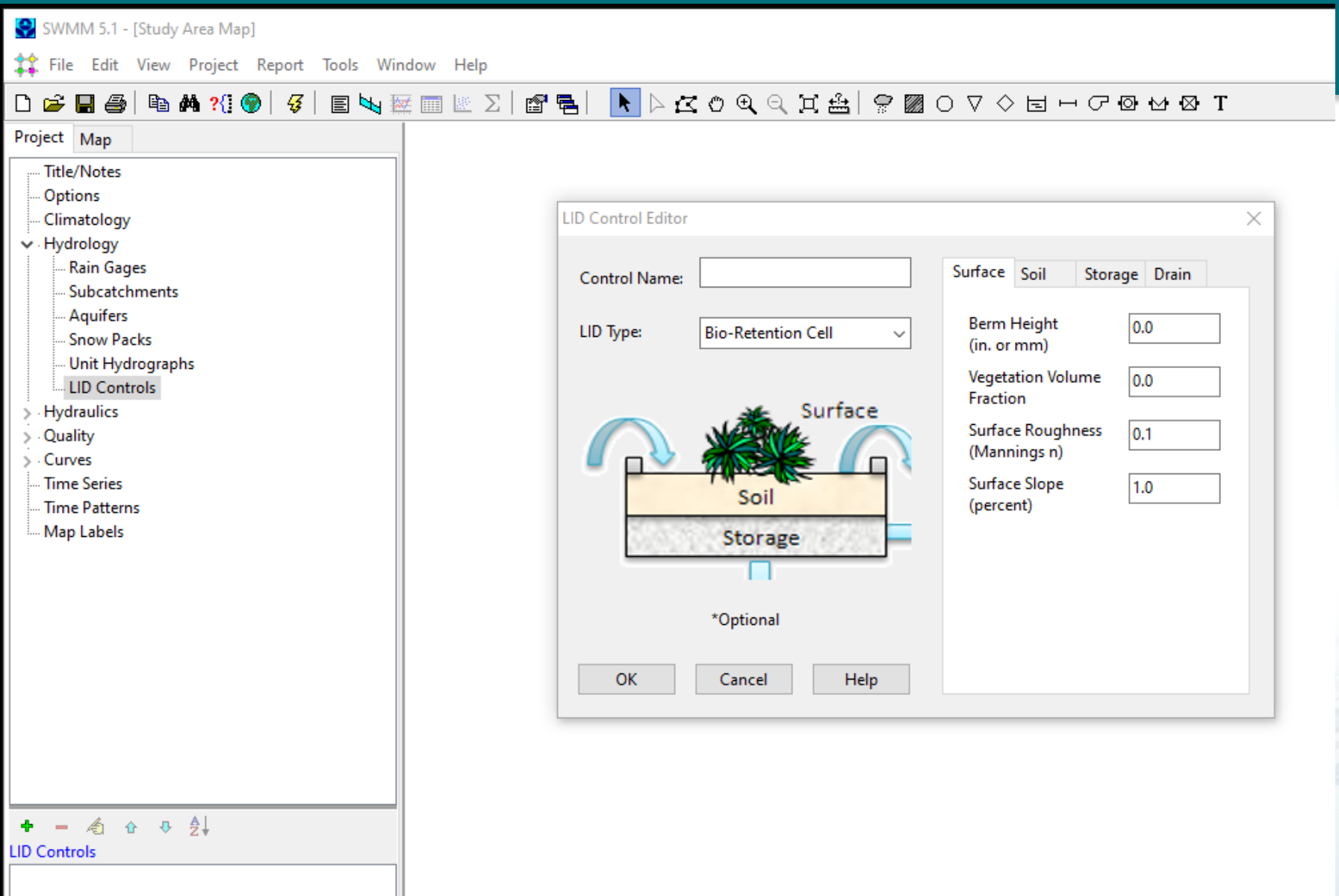
Property	Value
Suction Head	110
Conductivity	6.200
Initial Deficit	0.412

Soil capillary suction head (inches or mm)

OK Cancel Help

Auto-Lenth: Off Offsets: Elevation Flow Units: CMS Zoom Level: 100% X.Y: 527745.837, 3902678.466

# LID Controls



# Water Quality – see Reference Manual III and User's Manual

SWMM 5.1

File Edit View Project Report Tools Window Help

Project Map

- Title/Notes
- Options
- Climatology
- > Hydrology
- > Hydraulics
- > Quality
  - Pollutants
  - Land Uses
- > Curves
- Time Series
- Time Patterns
- Map Labels

Pollutant Editor

Property	Value
Name	TSS
Units	MG/L
Rain Concen.	0.1
GW Concen.	0.05
I&I Concen.	0.2
DWF Concen.	0.0
Init. Concen.	0.0
Decay Coeff.	0.0
Snow Only	NO
Co-Pollutant	
Co-Fraction	

Concentration of the pollutant in dry weather sanitary flow.

Land Use Editor

General Buildup Washoff

Property	Value
Land Use Name	Residential
Description	
STREET SWEEPING	
Interval	0
Availability	0
Last Swept	0

Days between street sweeping within the land use (0 for no sweeping).

OK Cancel Help

OK Cancel Help



# SWMM Demonstration

## Getting started with SWMM following the User's Manual Chapter 2 Tutorial

### CHAPTER 2 – QUICK START TUTORIAL

*This chapter provides a tutorial on how to use EPA SWMM. If you are not familiar with the elements that comprise a drainage system, and how these are represented in a SWMM model, you might want to review the material in Chapter 3 first.*

#### 2.1 Example Study Area

In this tutorial we will model the drainage system serving a 12-acre residential area. The system layout is shown in Figure 2-1 and consists of subcatchment areas<sup>3</sup> S1 through S3, storm sewer conduits C1 through C4, and conduit junctions J1 through J4. The system discharges to a creek at the point labeled Out1. We will first go through the steps of creating the objects shown in this diagram on SWMM's study area map and setting the various properties of these objects. Then we will simulate the water quantity and quality response to a 3-inch, 6-hour rainfall event, as well as a continuous, multi-year rainfall record.

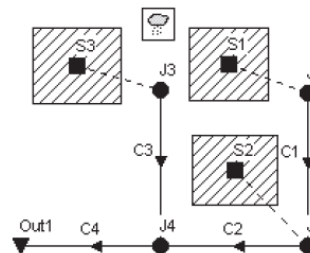
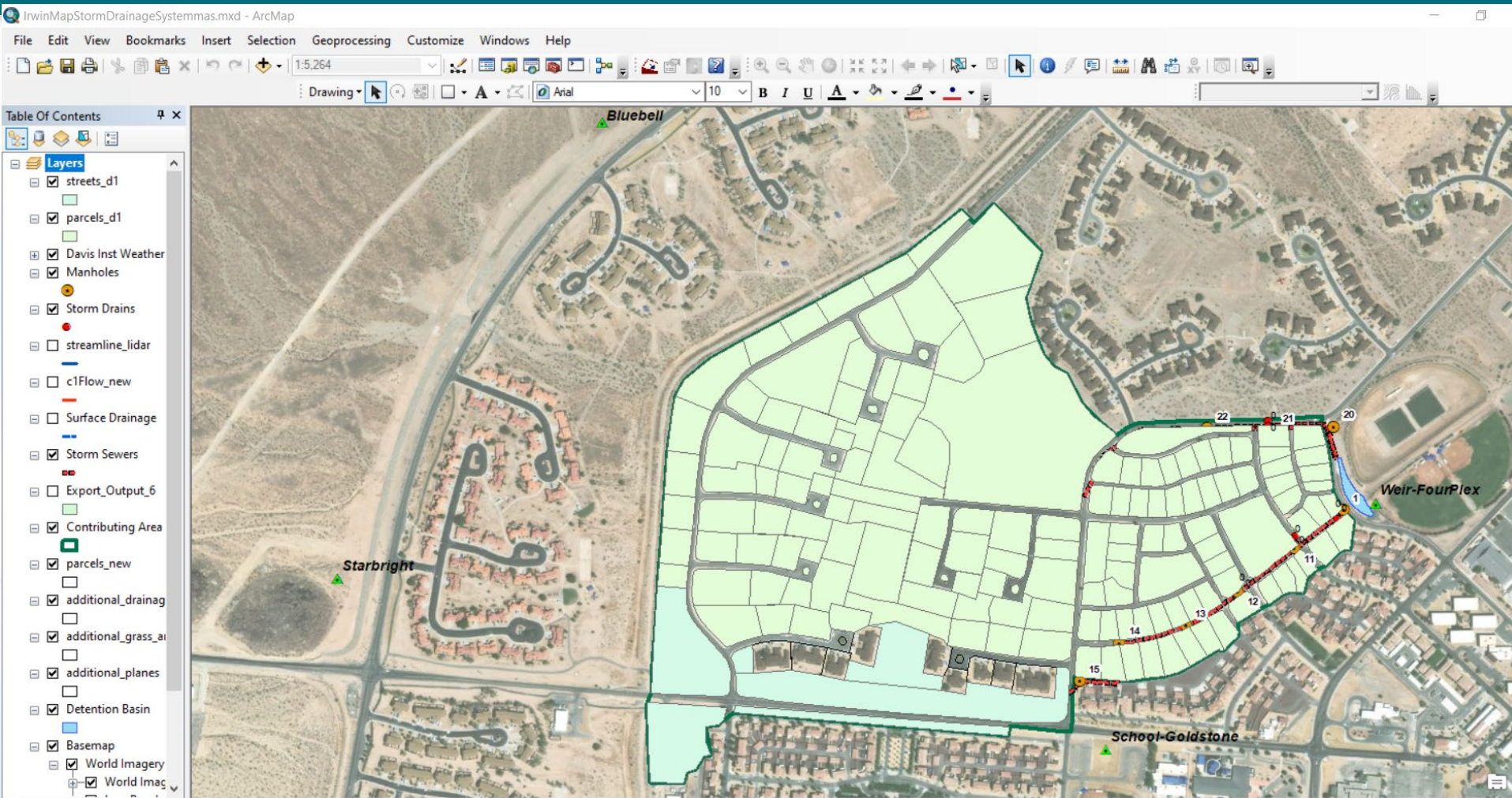


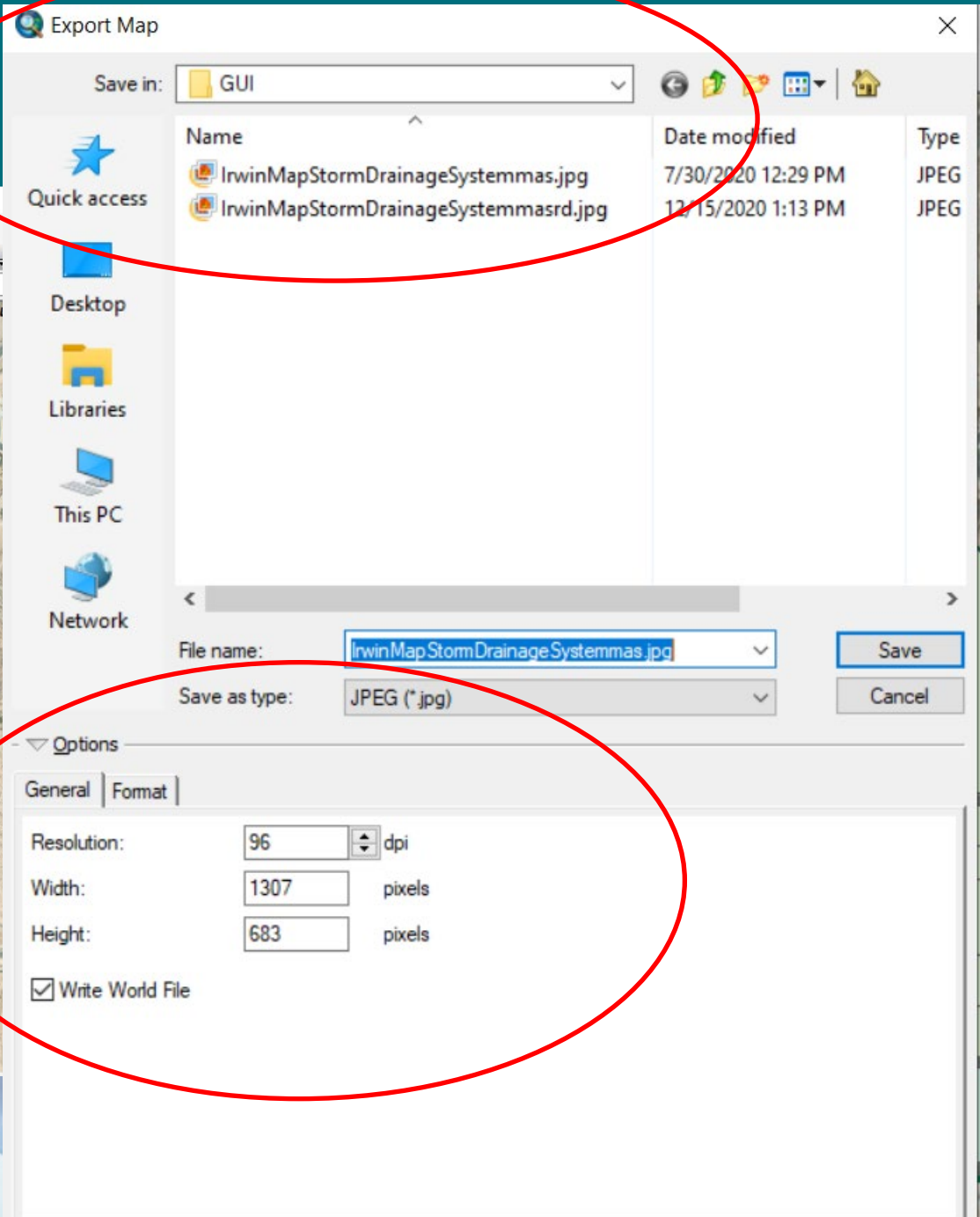
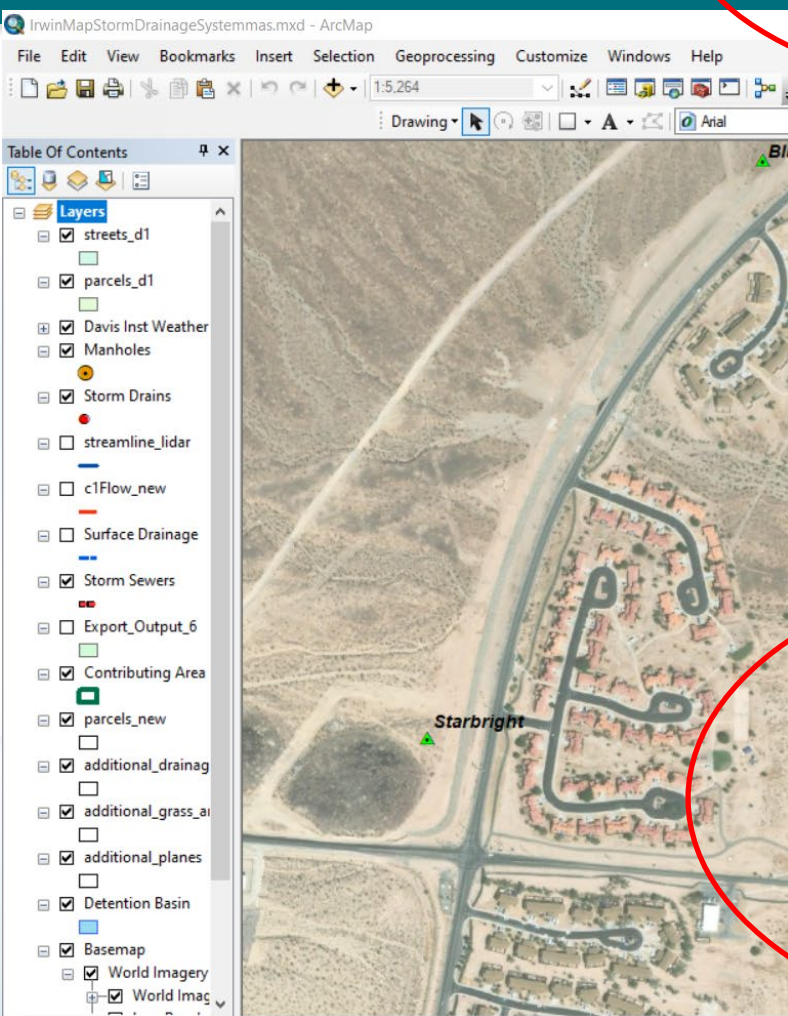
Figure 2-1 Example study area

# Export Map from ArcGIS





# Export Map from ArcGIS





Project Map

- Title/Notes
- Options
- Climatology
- Hydrology
  - Rain Gages
  - Subcatchments
  - Aquifers
  - Snow Packs
  - Unit Hydrographs
  - LID Controls
- Hydraulics
- Quality
- Curves
- Time Series
- Time Patterns
- Map Labels

Unit Hydrographs

Study Area Map

## Backdrop Image Selector

Backdrop Image File



World Coordinates File (optional)

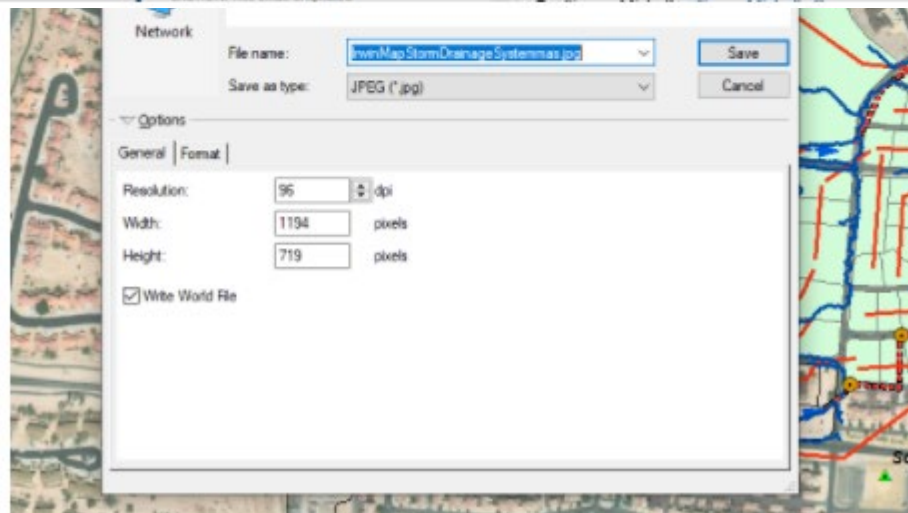
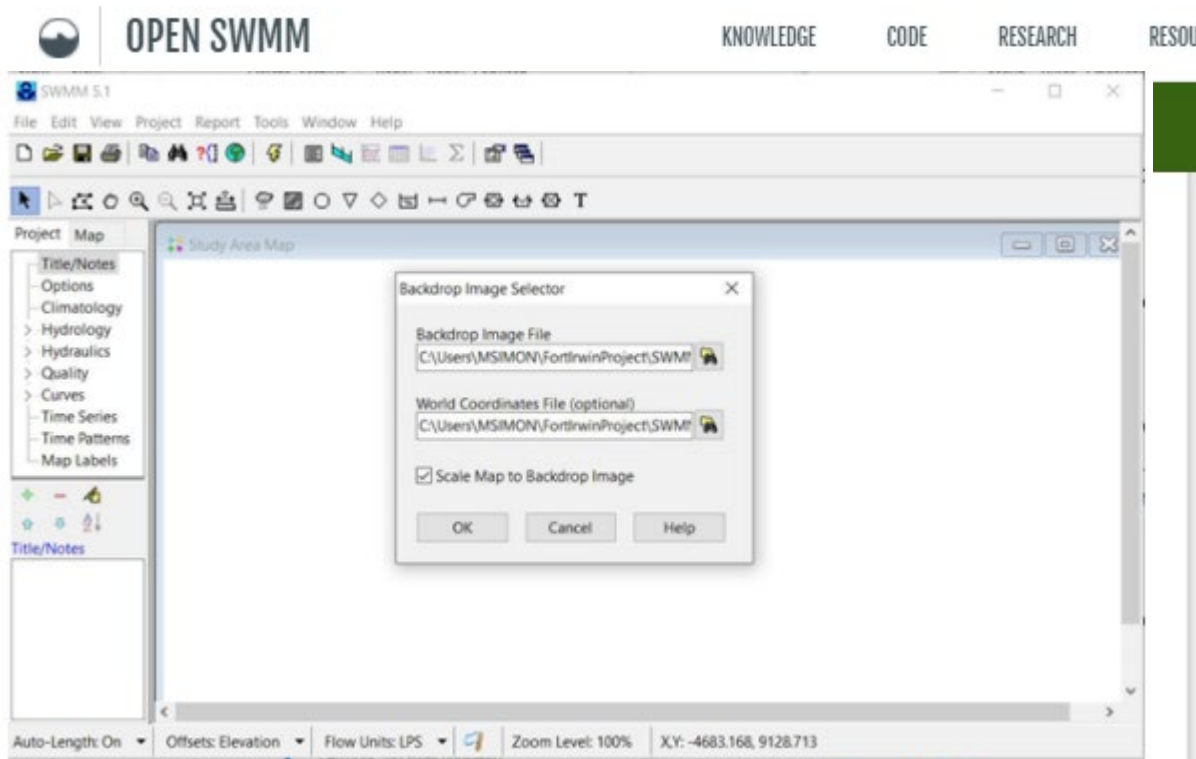
☐ Scale Map to Backdrop Image

OK

Cancel

Help





# Map

<https://www.openswmm.org/Topic/27275/how-to-import-a-georeferenced-swmm-backdrop-with-world-coordinates-from-an-arcgis-map-into-swmm>

# Project Defaults – see User's Manual Chapter 2

The screenshot displays the SWMM 5.1 software interface. The 'Project' menu is highlighted in the top menu bar. The 'Project Defaults' dialog box is open, showing the 'Subcatchments' tab. The 'Infiltration Editor' sub-dialog is also open, showing the 'Infiltration Method' set to 'GREEN\_AMPT' and a table of properties and values.

**Project Defaults Dialog - Subcatchments Tab**

Property	Default Value
Area	5
Width	500
% Slope	0.5
% Imperv	25
N-Imperv	0.01
N-Perv	0.1
Dstore-Imperv	0.05
Dstore-Perv	0.05
%Zero-Imperv	25
Infiltration Model	GREEN_AMPT

☐ Save as defaults for all new projects

**Infiltration Editor Dialog**

Infiltration Method: **GREEN\_AMPT**

Property	Value
Suction Head	3.0
Conductivity	0.5
Initial Deficit	4

Soil capillary suction head (inches or mm)

Buttons: OK, Cancel, Help

SWMM 5.1 status bar: Auto-Length: Off | Offsets: Elevation | Flow Units: LPS | Zoom Level: 100% | X,Y: -1031.977, 10000.000

# Project Defaults – see User's Manual Chapter 2

SWMM 5.1

File Edit View **Project** Report Tools Window Help

Project Map

- Title/Notes
- Options
- Climatology
- > Hydrology
- > Hydraulics
- > Quality
- > Curves
- Time Series
- Time Patterns
- Map Labels

Study Area Map

Auto-Length: Off Offsets: Elevation Flow Units: LP

### Project Defaults

ID Labels Subcatchments **Nodes/Links**

Option	Default Value
Node Invert	0
Node Max. Depth	0
Node Ponded Area	0
Conduit Length	400
Conduit Geometry	RECT_OPEN
Conduit Roughness	0.01
Flow Units	LPS
Link Offsets	ELEVATION
Routing Method	Kinematic Wave
Force Main Equation	Hazen-Williams

☐ Save as defaults for all new projects

OK Cancel Help

# Options

The screenshot shows the SWMM 5.1 software interface with the 'Options' dialog box open. The 'Time Steps' tab is selected, showing various simulation parameters. The background shows the 'Project' and 'Map' panes, with 'Options' selected in the Project pane. The status bar at the bottom displays 'Auto-Length: Off', 'Offsets: Elevation', 'Flow Units: LPS', 'Zoom Level: 100%', and 'X,Y: -1904.070, 9360.465'.

**SWMM 5.1**

File Edit View Project Report Tools Window Help

Project Map

- Title/Notes
- Options
- Climatology
- Hydrology
- Hydraulics
- Quality
- Curves
- Time Series
- Time Patterns
- Map Labels

Study Area Map

**Simulation Options**

General Dates **Time Steps** Dynamic Wave Files

Reporting Step: Days: 0 Hr:Min:Sec: 00:15:00

Runoff Step: Dry Weather: 0 01:00:00

Runoff Step: Wet Weather: 0 00:05:00

Control Rule Step: 00:00:00

Routing Step (seconds): 30

Steady Flow Periods

☐ Skip Steady Flow Periods

System Flow Tolerance (%): 5

Lateral Flow Tolerance (%): 5

OK Cancel Help

Auto-Length: Off Offsets: Elevation Flow Units: LPS Zoom Level: 100% X,Y: -1904.070, 9360.465



# Climatology – See Manual I Section 2.2

The screenshot displays the SWMM 5.1 software interface. The main window shows a 'Study Area Map' with a toolbar at the top and a project tree on the left. The project tree includes 'Title/Notes', 'Options', 'Climatology' (selected), 'Hydrology', 'Hydraulics', 'Quality', 'Curves', 'Time Series', 'Time Patterns', and 'Map Labels'. The 'Climatology' sub-tree is expanded, showing 'Temperature', 'Evaporation', 'Wind Speed', 'Snow Melt', 'Areal Depletion', and 'Adjustments'. The 'Temperature' option is selected. A 'Climatology Editor' dialog box is open, showing the 'Temperature' tab. The 'Source of Temperature Data' section has three radio buttons: 'No Data' (selected), 'Time Series', and 'External Climate File'. The 'Time Series' option has a dropdown menu and a file selection icon. The 'External Climate File' option has a text input field and a file selection icon. There is also a checkbox for 'Start Reading File at' with a date input field. The dialog box has 'OK', 'Cancel', and 'Help' buttons at the bottom. The status bar at the bottom shows 'Auto-Length: Off', 'Offsets: Elevation', 'Flow Units: LPS', 'Zoom Level: 100%', and 'X,Y: -1918.605, 8909.884'.

SWMM 5.1

File Edit View Project Report Tools Window Help

Project Map

Title/Notes  
Options  
Climatology  
Hydrology  
Hydraulics  
Quality  
Curves  
Time Series  
Time Patterns  
Map Labels

Climatology  
Temperature  
Evaporation  
Wind Speed  
Snow Melt  
Areal Depletion  
Adjustments

Study Area Map

Climatology Editor

Snow Melt Areal Depletion Adjustments  
Temperature Evaporation Wind Speed

Source of Temperature Data:

☒ No Data

☐ Time Series

☐ External Climate File

☐ Start Reading File at

OK Cancel Help

Auto-Length: Off Offsets: Elevation Flow Units: LPS Zoom Level: 100% X,Y: -1918.605, 8909.884

# Rain Gage

## Precipitation

Measure  
Download from NOAA  
SWC  
BASINS Weather Processor

## Evaporation

Hargreaves  
PET  
SWC

## Climate Change

SWMM-CAT  
SWC-CAT

SWMM 5.1

File Edit View Project Report Tools Window Help

Project Map

Study Area Map

Rain Gage RG1

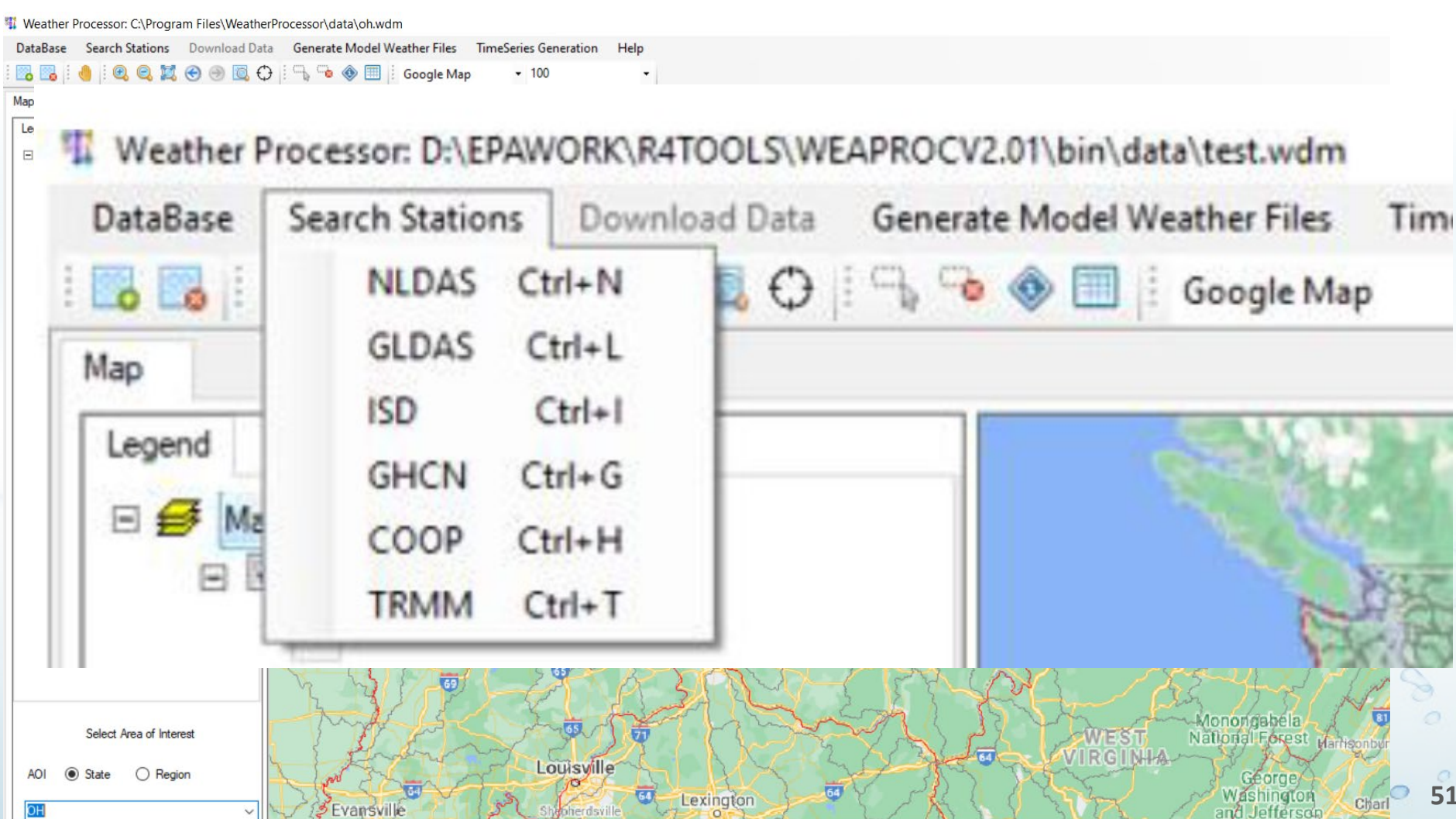
Property	Value
Name	RG1
X-Coordinate	-857.558
Y-Coordinate	9418.605
Description	
Tag	
Rain Format	INTENSITY
Time Interval	1:00
Snow Catch Factor	1.0
Data Source	TIMESERIES
TIME SERIES:	
- Series Name	*
DATA FILE:	
- File Name	*
- Station ID	*
- Rain Units	IN

User-assigned name of rain gage

Auto-Length: Off Offsets: Elevation Flow Units: LPS Zoom Level: 100%

# EPA BASINs Weather Processor Tool

<https://www.epa.gov/ceam/basins-download-and-installation>



# Most Common Format of Precipitation file

## See Reference Manual I Chapter 2

change.log x DryWell.inp x weir20200408.dat x pipe2020408a.inp x							
1	Weir	2020	4	6	14	15	0.25
2	Weir	2020	4	6	14	34	0.26
3	Weir	2020	4	6	18	23	0.25
4	Weir	2020	4	6	18	34	0.26
5	Weir	2020	4	6	18	45	0.28
6	Weir	2020	4	6	19	6	0.25
7	Weir	2020	4	6	22	41	0.27
8	Weir	2020	4	6	22	58	0.26
9	Weir	2020	4	6	23	9	0.27
10	Weir	2020	4	7	0	5	0.26
11	Weir	2020	4	7	0	13	0.28
12	Weir	2020	4	7	0	24	0.26
13	Weir	2020	4	7	1	18	0.26
14	Weir	2020	4	7	1	49	0.27
15	Weir	2020	4	7	2	5	0.30
16	Weir	2020	4	7	2	13	0.28
17	Weir	2020	4	7	2	23	0.29
18	Weir	2020	4	7	2	33	0.27



# Unit Hydrograph

SWMM 5.1

File Edit View Project Report Tools Window Help

Project Map

- Title/Notes
- Options
- Climatology
- Hydrology
  - Rain Gages
  - Subcatchments
  - Aquifers
  - Snow Packs
  - Unit Hydrographs
  - LID Controls
- Hydraulics
- Quality
- Curves
- Time Series
- Time Patterns
- Map Labels

Study Area Map

Unit Hydrograph Editor

Name of UH Group: SSOAP

Rain Gage Used: RG1

Hydrographs For: All Months

Response	R	T	K
Short-Term	0.2	0.4	0.5
Medium-Term	0.6	0.5	0.4
Long-Term	0.2	0.1	0.1

R = fraction of rainfall that becomes I&I  
T = time to hydrograph peak (hours)  
K = falling limb duration / rising limb duration

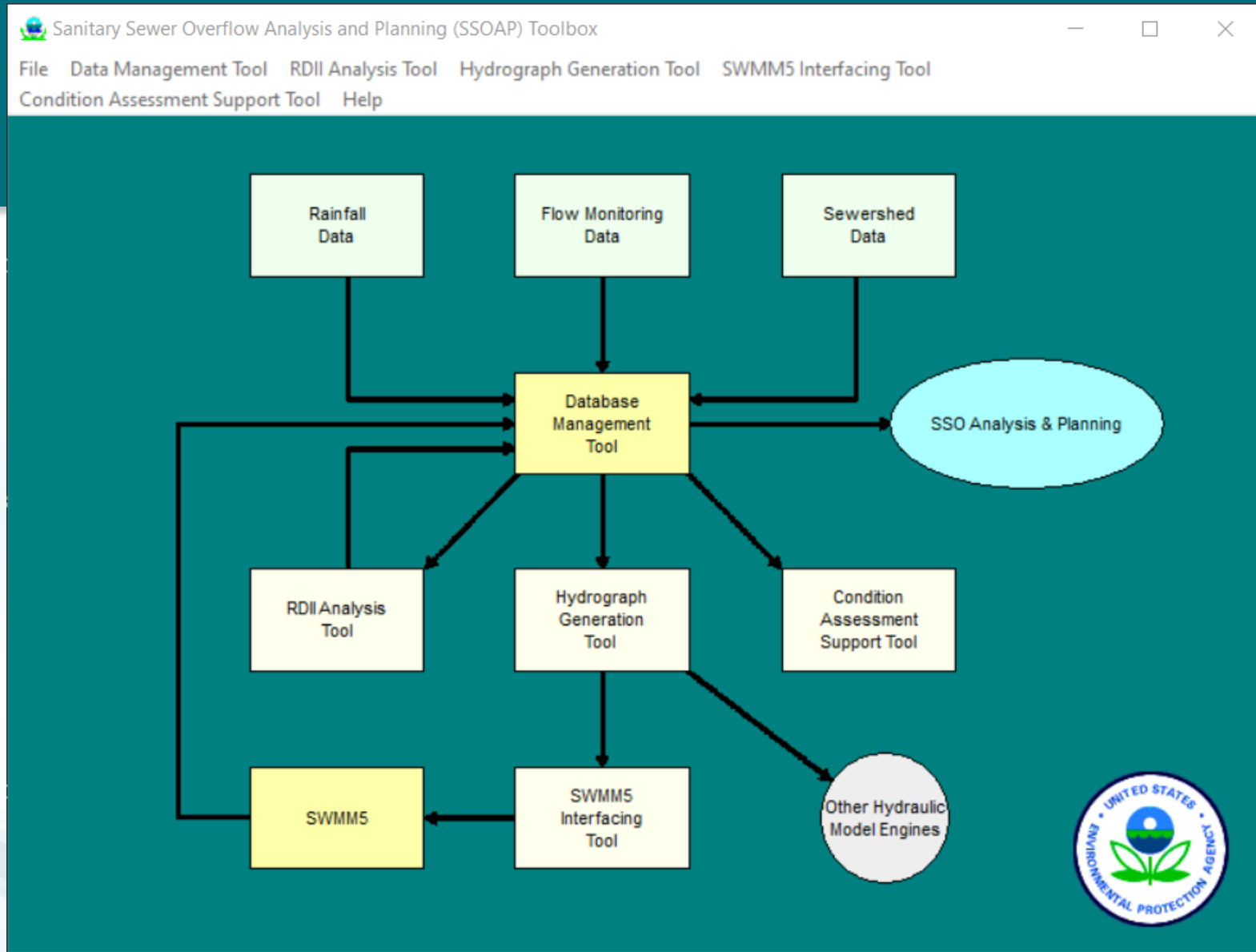
Months with UH data have a (\*) next to them.

OK Cancel Help

Unit Hydrographs

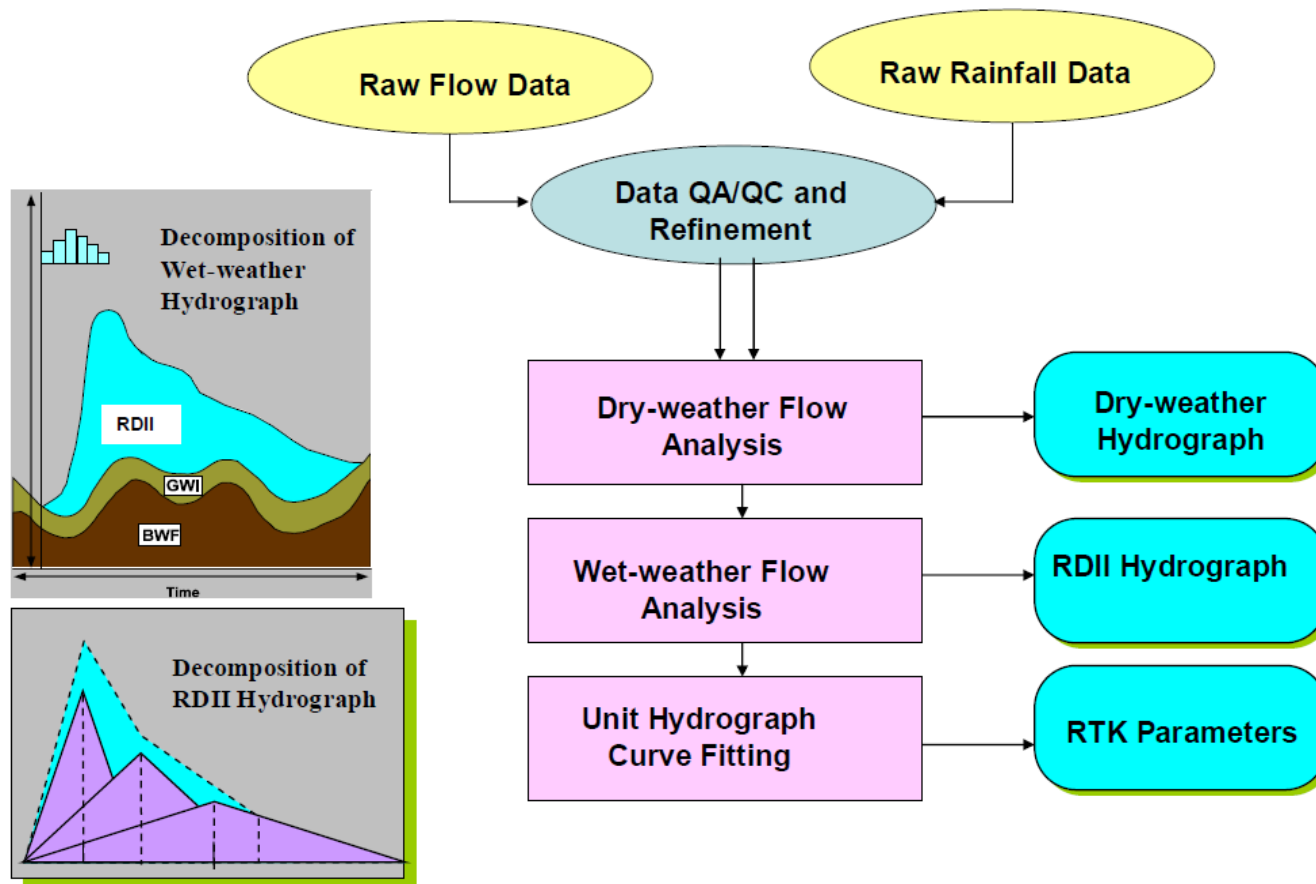
Agency

# SSOAP



<https://www.epa.gov/water-research/sanitary-sewer-overflow-analysis-and-planning-ssop-toolbox>

# How SSOAP works

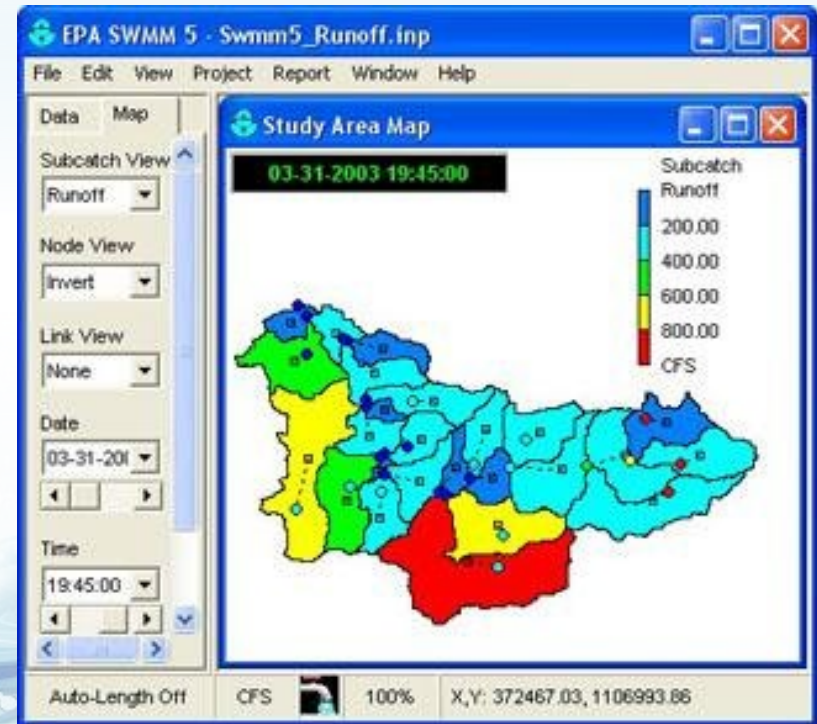


**Figure 4. Flow Chart of the Analyses Performed by the RDII Analysis Tool**

# Data that you need for SWMM

Either you measure it or

- Soil Infiltration from a Soil database (SSURGO or STATSGO)
- Land Use – Land Cover (National Land Cover Dataset – NLCD)
- Climatic Data – find closest NOAA station
  - use Stormwater Calculator
  - BASINS Weather Processor Tool
- Site Configuration
  - Subcatchment area
  - Drainage flow
- Hydraulic Configuration
  - Conduit geometry, length, material
  - Network schematic







United States Department of Agriculture

## Geospatial Data Gateway



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You are here: [Home](#) / GDGHome.aspx

### Welcome to GDG

System Status:  
Welcome to GDG 6.0.4.7481. All products and services are running normally.

PLEASE NOTE: As of April 21, 2017 the NAIP datasets are only available through the "NAIP Download" option on the home page and are no longer be available through the Gateway ordering process. Also note, NAIP images are titled by county FIPS codes. FIPS codes may be referenced by clicking on the "county FIPS" link on the Direct Download page.



The Geospatial Data Gateway (GDG) provides access to a map library of over 100 high resolution vector and raster layers in the Geospatial Data Warehouse. It is the One Stop Source for environmental and natural resources data, at any time, from anywhere, to anyone. It allows you to choose your area of interest, browse and select data, customize the format, then review and download.

This service is made available through a close partnership between the three Service Center Agencies ([SCA](#)); Natural Resources Conservation Service ([NRCs](#)), Farm Service Agency ([FSA](#)) and Rural Development ([RD](#)).

GET DATA



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- [Order by entering Latitude/Longitude Bounding Rectangle](#)
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# Technical Support - Open SWMM



OPEN SWMM

KNOWLEDGE

CODE

RESEARCH

RESOURCES



Expand your knowledge of SWMM  
with the people who know it best: its  
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## Find and share solutions.

[SWMM KNOWLEDGE BASE](#) >

An easy-to-search knowledge center for EPA SWMM users that has 25 years of shared knowledge, more than 1,500 contributors and over 13,000 posts.

## Understand your engine.

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Browse the SWMM source code in an engineer-friendly way. View and share comments, solutions, modifications and suggestions for improvement.

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# Technical Support - Open SWMM



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18162

POSTS

5851

THREADS

2064

CONTRIBUTORS

27

YEARS

## About OPEN SWMM

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### — Mission and Intent

The SWMM Knowledge Base is intended to function as an online learning resource for users of the public domain EPA SWMM program. It consists of digitally curated content from the SWMM-USERS list server, organized in an easily readable format. Fully searchable, the SWMM Knowledge Base provides a high signal-to-noise ratio, and promotes content discoverability through related topic suggestions.

Together with the open access [Journal of Water Management Modeling](#), the annual [International Conference on Water Management Modeling](#), and the SWMM-USERS list server, the SWMM Knowledge Base rounds out a group of high quality resources that supports, promotes and encourages development of SWMM by the EPA and the user community.

The SWMM Knowledge Base continuously solicits feedback from the community in making the presentation and content as accessible and useful as possible. Please send any comments and questions to staff at [info@openswmm.org](mailto:info@openswmm.org). The SWMM Knowledge Base is hosted and moderated by the staff of [CHI](#).



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# SWMM Applications Manual

<https://www.epa.gov/water-research/storm-water-management-model-swmm>



<https://www.epa.gov/water-research/storm-water-management-model-swmm>

Figure 9-1. Drainage system and detention pond (SU1) designed in Example 3





## **EPA Water Modeling Workgroup Webpage:**

<https://www.epa.gov/waterdata/surface-water-quality-modeling-training>

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# Thank You!



**Michelle Simon**

U.S. EPA Office of Research and Development (ORD)

513-720-2970 [Simon.michelle@epa.gov](mailto:Simon.michelle@epa.gov)

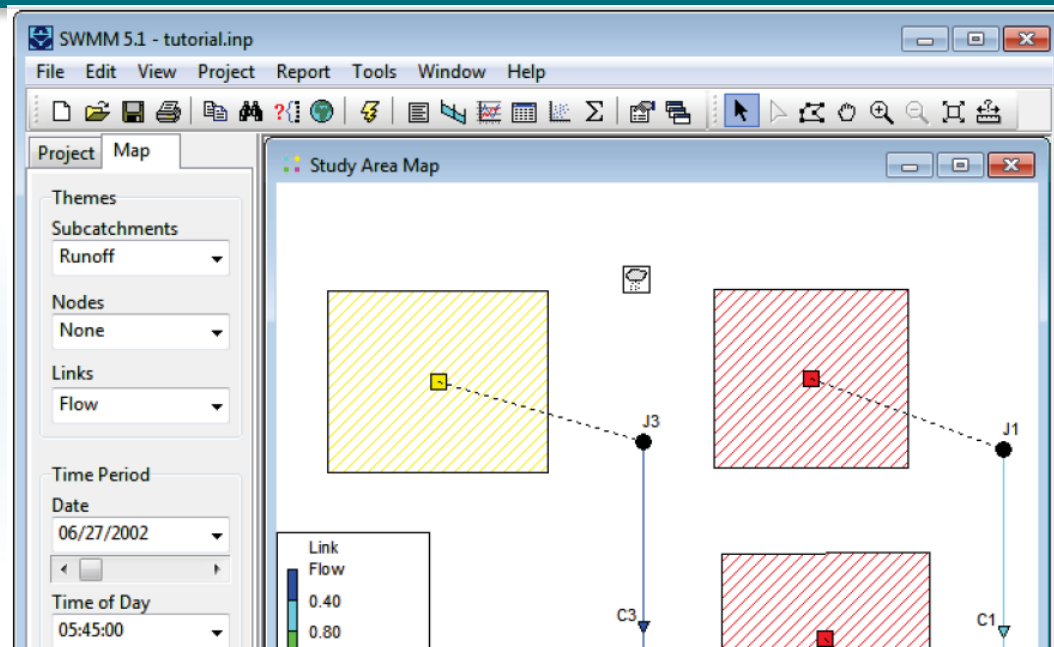


# Getting Started with EPA's Storm Water Management Model (SWMM)

Michelle Simon  
October 6, 2021  
University of Cincinnati



# SWMM Hydrology Results – from SWMM User's Manual Tutorial



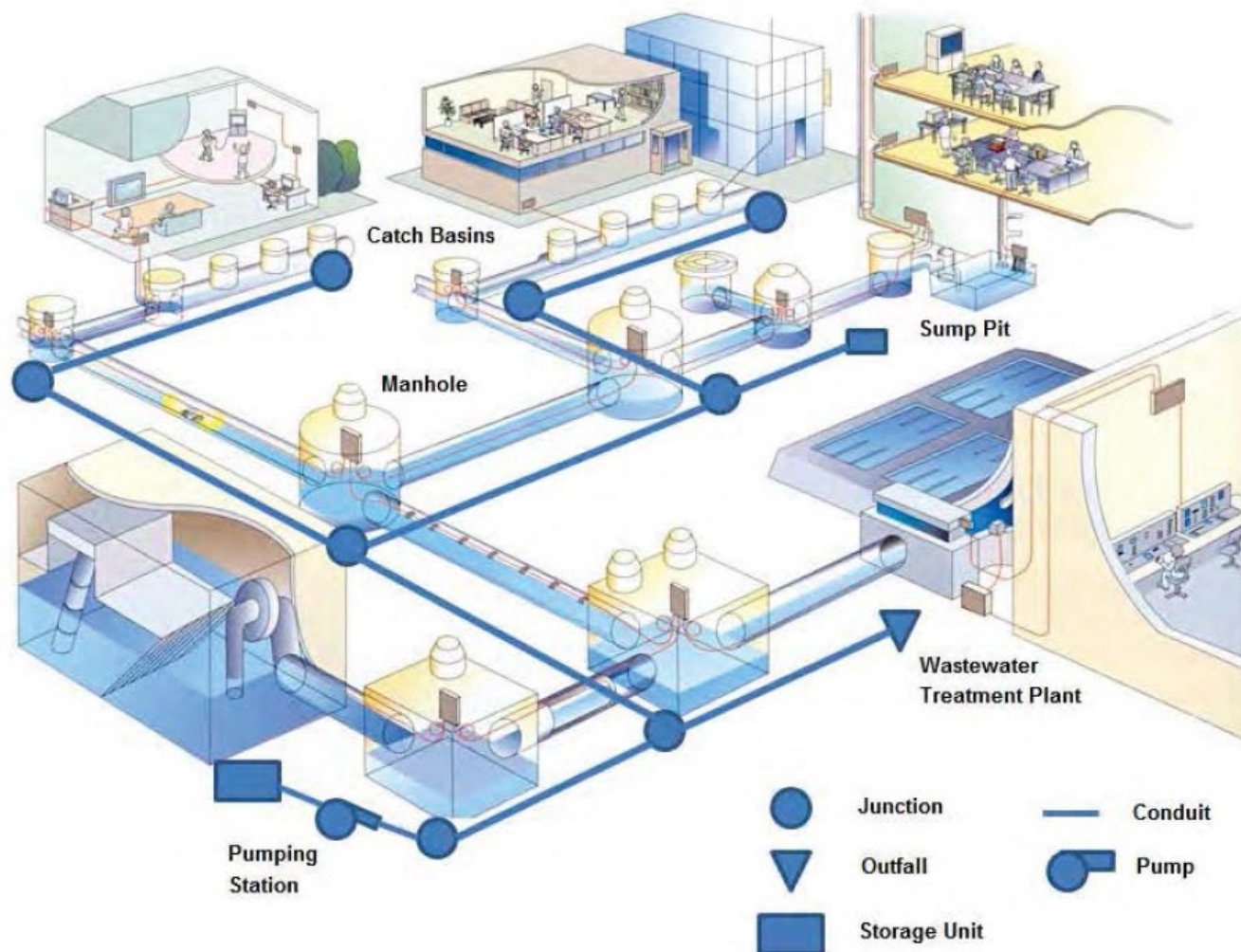
Summary Results

Topic: Subcatchment Runoff Click a column header to sort the column.

Subcatchment	Total Precip in	Total Runon in	Total Evap in	Total Infil in	Imperv Runoff in	Perv Runoff in	Total Runoff in	Total Runoff 10 <sup>6</sup> gal	Peak Runoff CFS
Sub3	3.00	0.00	0.00	1.50	1.48	0.00	1.48	0.16	2.02
Sub1	3.00	0.00	0.00	1.50	1.48	0.00	1.48	0.16	2.02
Sub2	3.00	0.00	0.00	1.50	1.48	0.00	1.48	0.16	2.02



# Hydraulic Model Reference Manual II



# Continuity equation at node

$$H_{t+\Delta t} = H_t + \Sigma Q_t \Delta t / A_{st}$$

where

$H_{t+\Delta t}$  = hydraulic head at next time step (ft)

$H_t$  = hydraulic head at beginning of simulation (ft)

$Q_t$  = flow rate (ft<sup>3</sup>/sec)

$\Delta t$  = time (sec)

$A_{st}$  = surface area of node (ft<sup>2</sup>)

# Governing Equations

## Conservation of Momentum in a conduit

$$\frac{\partial Q}{\partial t} + gA \frac{\partial H}{\partial x} + gAS_f + \frac{\partial (Q^2 / A)}{\partial x} = 0$$

where

$Q_t$  = flow rate (ft<sup>3</sup>/sec)

$t$  = time (sec)

$g$  = gravitational constant (32.2 ft/sec<sup>2</sup>)

$H$  = hydraulic head (ft)

$x$  = length (ft)

$A$  = surface area of conduit (ft<sup>2</sup>)

$S_f$  = slope (ft/ft)

# Level of Sophistication

## Level of Sophistication

- Steady Flow Routing
- Kinematics Wave Routing
- Dynamic Wave Routing



# Kinematic Wave

## Reference Manual II Chapter 4

Cannot have

- Looped networks
- Backwater effects
- Pressure-flow conditions

$$\frac{\partial Q}{\partial t} = gA \frac{\partial H}{\partial x} + gAS_f$$

# SWMM - Manning Equation

## Open Channel Flow

$$Q = \frac{1.49}{n} A R^{2/3} S^{1/2}$$

Q = flow rate (ft<sup>3</sup>/sec)

A = cross sectional area (ft<sup>2</sup>)

R = hydraulic radius (ft)

S = slope (ft/ft)

n = Manning roughness coefficient (-)

# Dynamic Wave Routing

## Reference Manual II Chapter 3

Used for

- Branched or looped networks
- Backwater due to tidal or other conditions
- Free-surface flow
- Pressure flow or surcharge
- Flow reversals

$$\frac{\partial Q}{\partial t} = \frac{\partial (Q^2 / A)}{\partial x} + gA \frac{\partial H}{\partial x} + gAS_f$$

# Pipes with Circular Force

## Main Cross sections

### Hazen-Williams

$$Q = 1.318 C A R^{0.63} S^{0.54}$$

Q = flow rate

C = Hazen Williams C-factor

A = cross sectional area

R = hydraulic radius

S = slope

### Darcy-Weisbach

$$Q = \sqrt{\frac{8g}{f}} A R^{1/2} S^{1/2}$$

Q = flow rate

g = gravity acceleration

f = Darcy-Weisbach friction factor

A = cross sectional area

R = hydraulic radius

S = slope



# Hydraulics Nodes

**SWMM 5.1 - [Study Area Map]**

File Edit View Project Report Tools Window Help

Project Map

- Title/Notes
- Options
- Climatology
- > Hydrology
- Hydraulics
  - Nodes
    - Junctions
    - Outfalls
    - Dividers
    - Storage Units
  - Links
  - Transects
  - Controls
- Quality
- Curves
- Time Series
- Time Patterns
- Map Labels

+ - ↺ ↻ ↕ ⌂

### Junction J1

Property	Value
Name	J1
X-Coordinate	3089.005
Y-Coordinate	5523.560
Description	
Tag	
Inflows	NO
Treatment	NO
Invert El.	0
Max. Depth	0
Initial Depth	0
Surcharge Depth	0
Ponded Area	0

### Outfall Out1

Property	Value
Name	Out1
X-Coordinate	4502.618
Y-Coordinate	5261.780
Description	
Tag	
Inflows	NO
Treatment	NO
Invert El.	0
Tide Gate	NO
Route To	
Type	FREE
Fixed Outfall	
Fixed Stage	0
Tidal Outfall	
Curve Name	*
Time Series Out	
Series Name	*

Auto-Length: Off    Offsets: Elevation    Flow Units: LPS    Zoom Level: 100%    X,Y: 3891.243, 70.621

Divider 1	
Property	Value
Name	1
X-Coordinate	4816.754
Y-Coordinate	7329.843
Description	
Tag	

Inflows	NO
Treatment	NO
Invert El.	0
Max. Depth	0
Initial Depth	0
Surcharge Depth	0
Ponded Area	0
Diverted Link	*
Type	CUTOFF
Cutoff Divider	
Cutoff Flow	0
Tabular Divider	
Curve Name	*
Weir Divider	
Min. Flow	0
Max. Depth	0
Coefficient	0

Property	Value
Name	Stor1
X-Coordinate	1649.215
Y-Coordinate	3298.429
Description	
Tag	
Inflows	NO
Treatment	NO
Invert El.	0
Max. Depth	0
Initial Depth	0
Surcharge Dept	0
Evap. Factor	0
Seepage Loss	NO
Storage Curve	FUNCTIONAL
Functional Curve	
Coefficient	1000
Exponent	0
Constant	0
Tabular Curve	
Curve Name	*

# Hydraulics - Links

SWMM 5.1

File Edit View Project Report Tools Window Help

Conduit C1

Property	Value
Name	C1
Inlet Node	J1

Project Map

- Title/Notes
- Options
- Climatology
- Hydrology
- Hydraulics
  - Nodes
  - Links
    - Conduits
    - Pumps
    - Orifices
    - Weirs
    - Outlet
  - Transects
  - Controls
- Quality
- Curves
- Time Series
- Time Patterns
- Map Labels

Cross-Section Editor

Number of Barrels: 1

Maximum Height: 0.032

Dimensions are meters unless otherwise stated.

Standard circular pipe.

OK Cancel Help

Conduits

C1

Parabolic

Power

Irregular

Circular

Force Main

Filled Circular

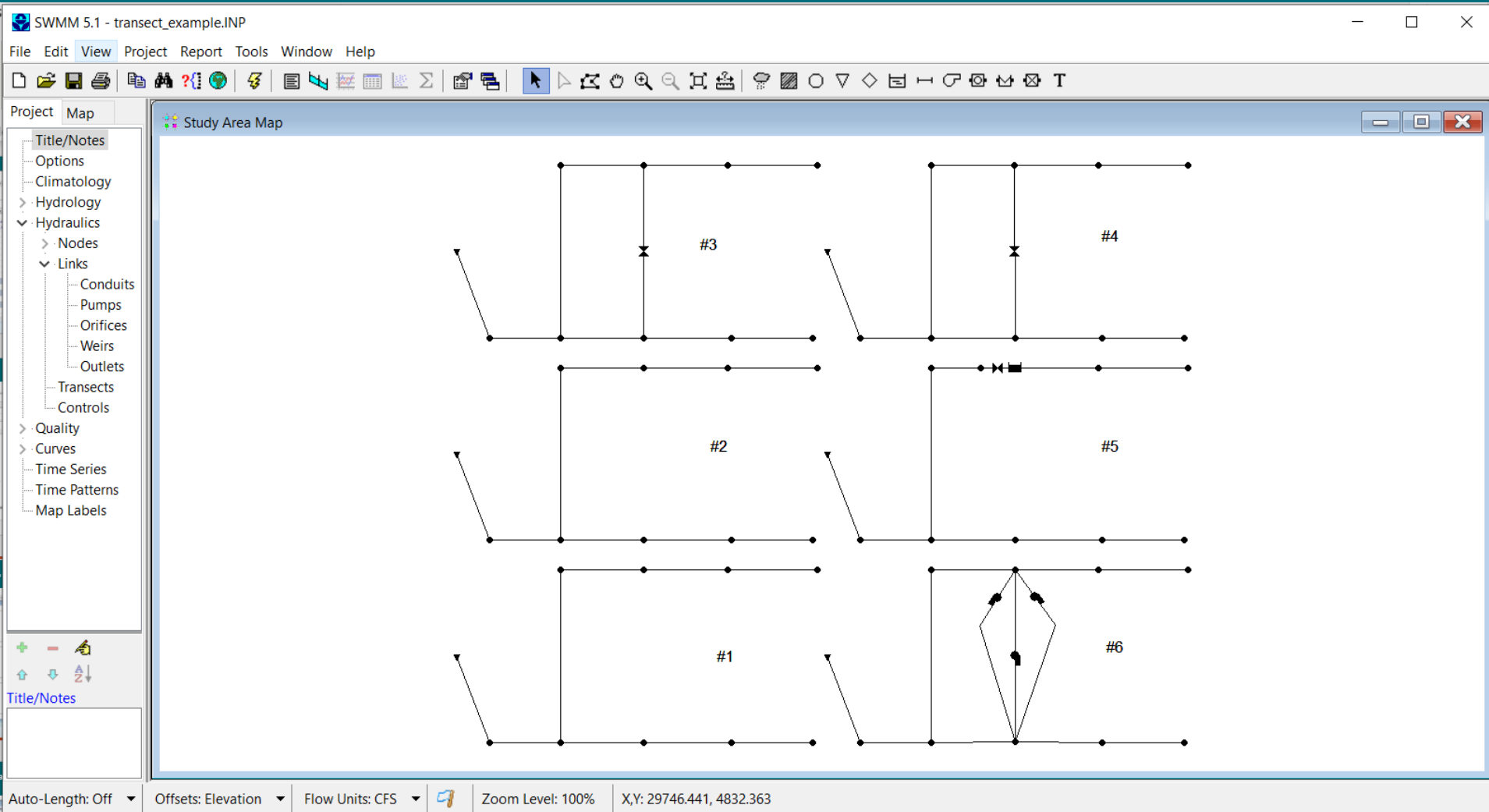
Closed Rectangular

Horizontal Elliptical

Vertical Elliptical

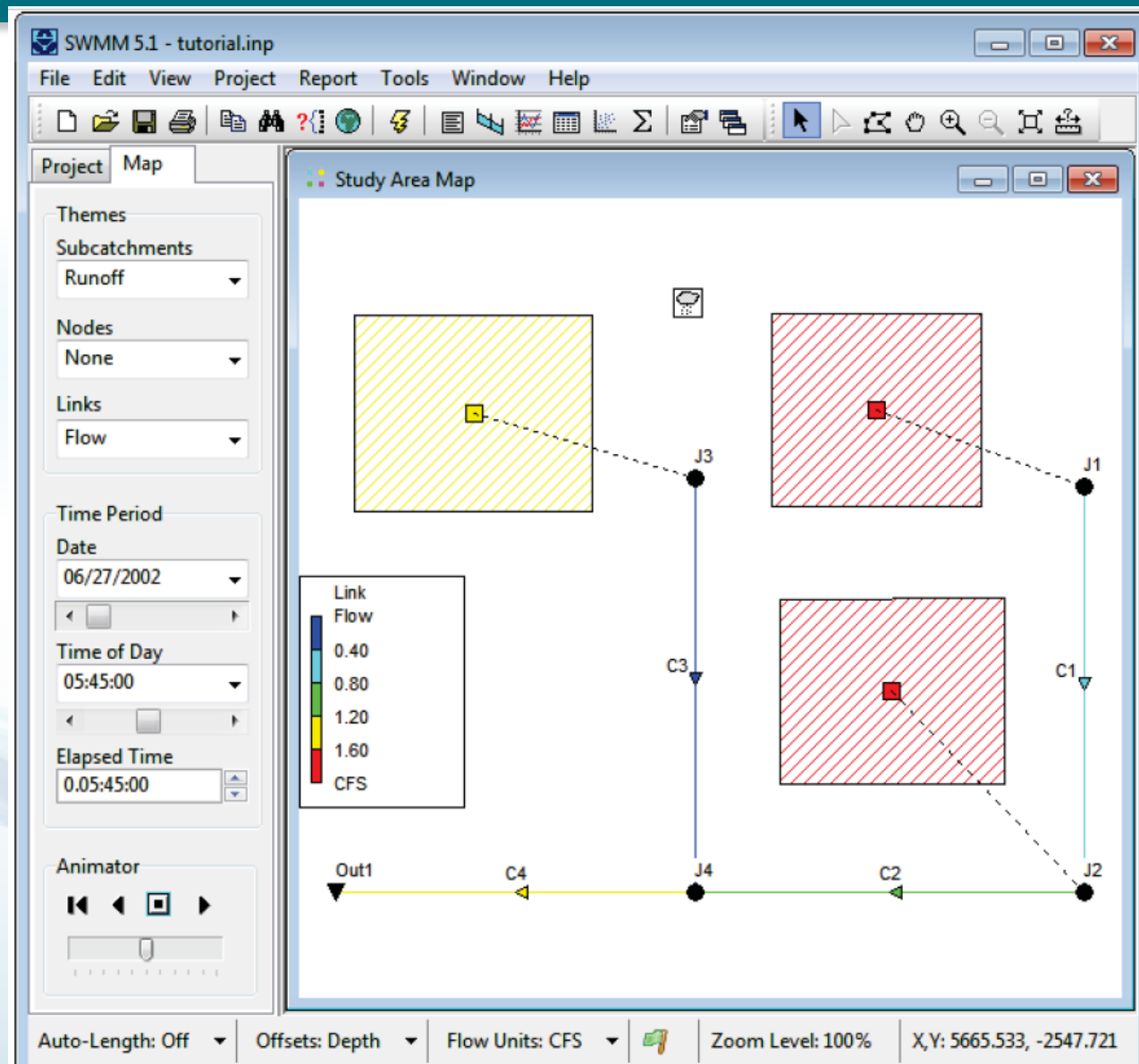
# Hydraulic Link – Reference Manual II

## Pumps, Orifices, Weirs, Outlets



# SWMM User's Manual

## Tutorial Example





# Results – from SWMM User's Manual Tutorial Example

## Summary Results

Topic: **Conduit Surcharge**

Click a column header to sort the column.

Conduit	Hours Both Ends Full	Hours Upstream Full	Hours Dnstream Full	Hours Above Normal Flow	Hours Capacity Limited
C2	1.03	1.03	1.03	1.03	1.03

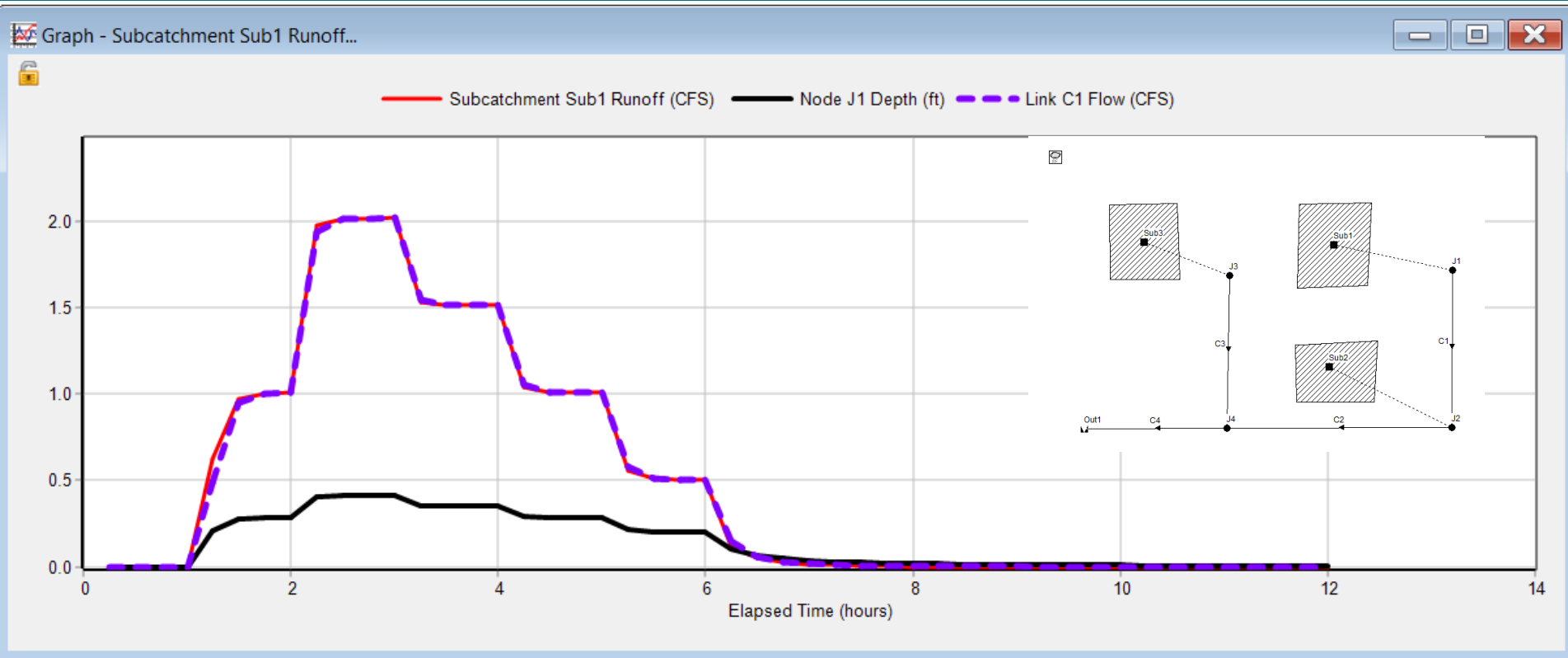
## Summary Results

Topic: **Outfall Loading**

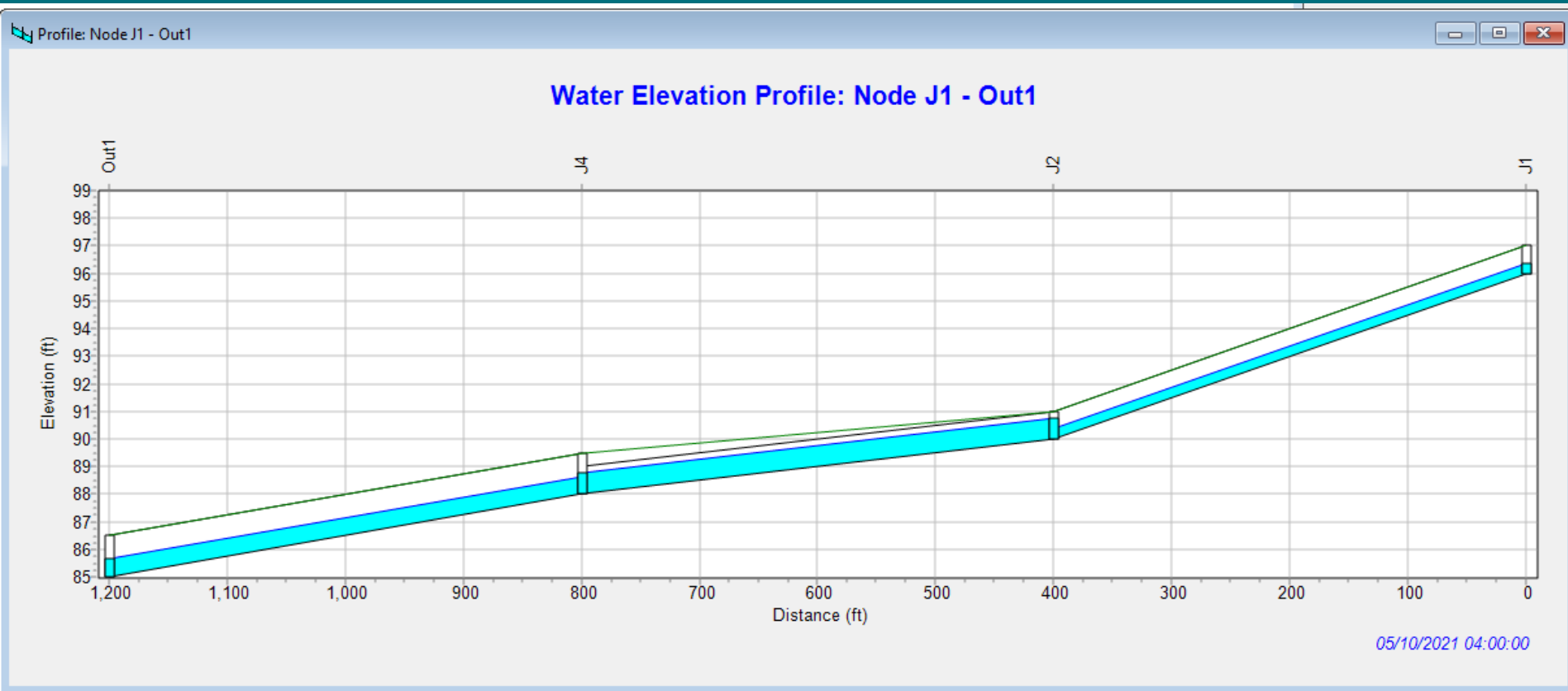
Click a column header to sort the column.

Outfall Node	Flow Freq. Pcnt.	Avg. Flow CFS	Max. Flow CFS	Total Volume 10 <sup>6</sup> gal
Out1	90.97	1.58	5.34	0.465

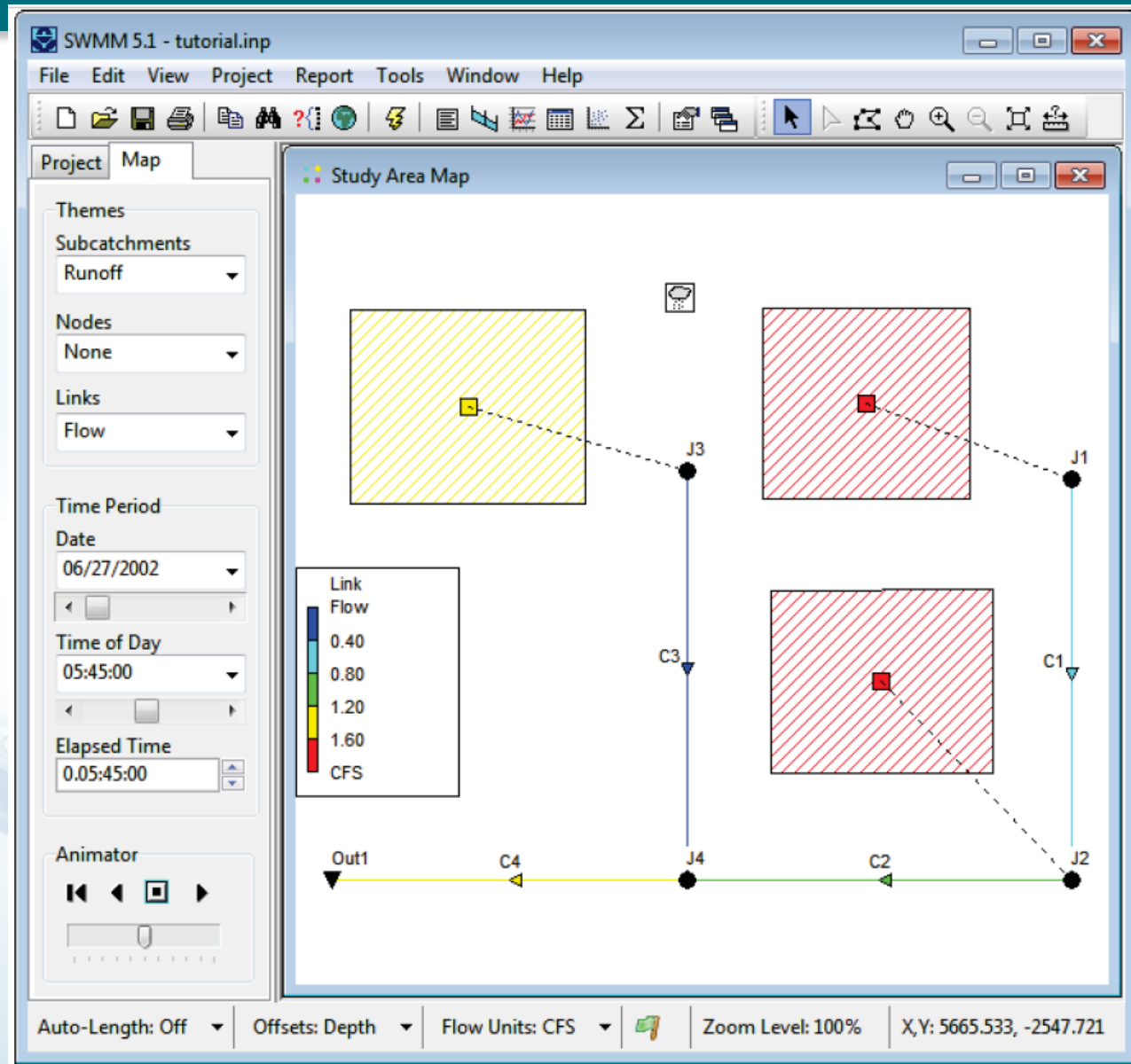
# Graph – from SWMM User's Manual Tutorial Example



# Profile – from SWMM User's Manual Tutorial Example



# Viewing Results on a Map – SWMM Tutorial Example







The diagram illustrates a submerged weir setup. On the left, a reservoir with water level  $E$  and surface area  $S_m$  is shown. Water flows over a weir of length  $L_s$ , with discharge  $Q_s$ . The water level in the reservoir is  $E$  above the weir crest. The flow velocity is  $Q_m$ . The weir is shown in cross-section with a blue water area and a black weir structure.

The diagram illustrates a three-chambered system (2, 1, 3) with a central dashed circle labeled 'Main'. The diagram shows energy levels  $E_1$ ,  $E_2$ ,  $E_3$  and vertical distances  $y_1$ ,  $y_2$  relative to 'Main Invert' levels.

# Questions?



# Summary

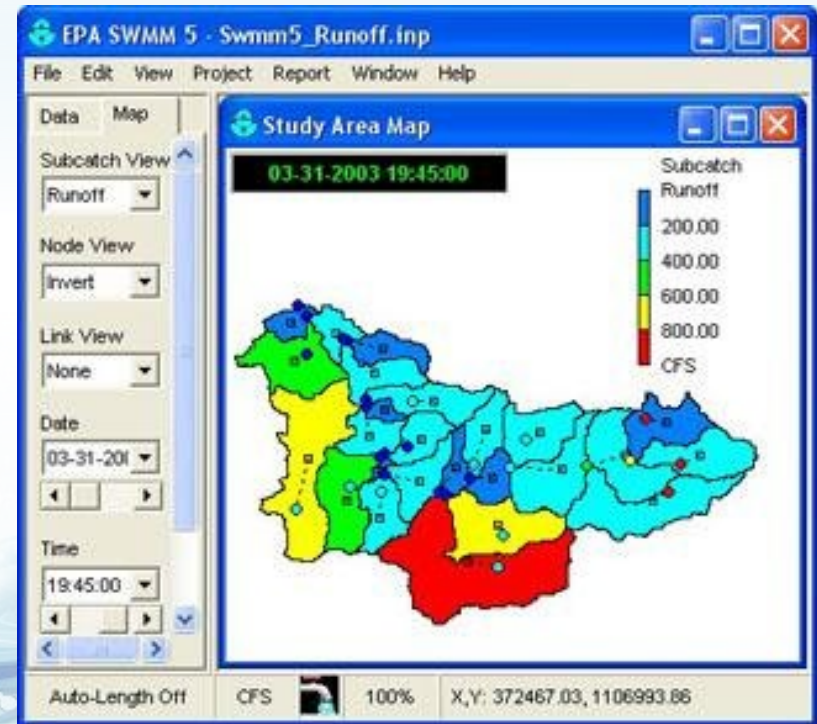
## Storm Water Management Model

- Basics of SWMM
- Processes Modeled by SWMM
- Demonstration of SWMM
- National Stormwater Calculator
- Location of Data
- Technical Support
- Discussion & Questions

# Data you need for SWMM

Either you measure it or

- Soil Infiltration from a Soil database (SSURGO or STATSGO)
- Land Use – Land Cover (National Land Cover Dataset – NLCD)
- Climatic Data – find closest NOAA station
  - use Stormwater Calculator
  - BASINS Weather Processor Tool
- Site Configuration
  - Subcatchment area
  - Drainage flow
- Hydraulic Configuration
  - Conduit geometry, length, material
  - Network schematic







United States Department of Agriculture

## Geospatial Data Gateway



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You are here: [Home](#) / GDGHome.aspx

### Welcome to GDG

System Status:  
Welcome to GDG 6.0.4.7481. All products and services are running normally.

PLEASE NOTE: As of April 21, 2017 the NAIP datasets are only available through the "NAIP Download" option on the home page and are no longer be available through the Gateway ordering process. Also note, NAIP images are titled by county FIPS codes. FIPS codes may be referenced by clicking on the "county FIPS" link on the Direct Download page.



The Geospatial Data Gateway (GDG) provides access to a map library of over 100 high resolution vector and raster layers in the Geospatial Data Warehouse. It is the One Stop Source for environmental and natural resources data, at any time, from anywhere, to anyone. It allows you to choose your area of interest, browse and select data, customize the format, then review and download.

This service is made available through a close partnership between the three Service Center Agencies ([SCA](#)); Natural Resources Conservation Service ([NRCs](#)), Farm Service Agency ([FSA](#)) and Rural Development ([RD](#)).

GET DATA



### I Want To...

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# Technical Support - Open SWMM



OPEN SWMM

KNOWLEDGE

CODE

RESEARCH

RESOURCES



Expand your knowledge of SWMM  
with the people who know it best: its  
users, developers and innovators.

## Find and share solutions.

[SWMM KNOWLEDGE BASE](#) >

An easy-to-search knowledge center for EPA SWMM users that has 25 years of shared knowledge, more than 1,500 contributors and over 13,000 posts.

## Understand your engine.

[SWMM CODE VIEWER](#) >

Browse the SWMM source code in an engineer-friendly way. View and share comments, solutions, modifications and suggestions for improvement.

## View and share research.

[RESEARCH PROJECTS](#) >

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# Technical Support - Open SWMM



OPEN SWMM

KNOWLEDGE

CODE

RESEARCH

RESOURCES



18162

POSTS

5851

THREADS

2064

CONTRIBUTORS

27

YEARS

## About OPEN SWMM

[Collapse all](#)

### — Mission and Intent

The SWMM Knowledge Base is intended to function as an online learning resource for users of the public domain EPA SWMM program. It consists of digitally curated content from the SWMM-USERS list server, organized in an easily readable format. Fully searchable, the SWMM Knowledge Base provides a high signal-to-noise ratio, and promotes content discoverability through related topic suggestions.

Together with the open access [Journal of Water Management Modeling](#), the annual [International Conference on Water Management Modeling](#), and the SWMM-USERS list server, the SWMM Knowledge Base rounds out a group of high quality resources that supports, promotes and encourages development of SWMM by the EPA and the user community.

The SWMM Knowledge Base continuously solicits feedback from the community in making the presentation and content as accessible and useful as possible. Please send any comments and questions to staff at [info@openswmm.org](mailto:info@openswmm.org). The SWMM Knowledge Base is hosted and moderated by the staff of [CHI](#).



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# Key Websites discussed

## **Storm Water Management Model:**

<https://www.epa.gov/water-research/storm-water-management-model-swmm>

## **National Stormwater Calculator Website:**

<https://www.epa.gov/water-research/national-stormwater-calculator>

## **Water Research Program Webinar Series Website:**

<https://www.epa.gov/water-research/water-research-program-webinar-series>

## **USGS's online Seamless Data Warehouse:**

<https://datagateway.nrcs.usda.gov>

## **YouTube Tutorials:**

<https://www.youtube.com>

## **Openswmm:**

<https://www.openswmm.org/>



# Thank You!



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# **EPA Water Modeling Workgroup Webpage:**

**[https://www.epa.gov/waterdata/surface-  
water-quality-modeling-training](https://www.epa.gov/waterdata/surface-water-quality-modeling-training)**



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