

LECTURE 8-B

INTRODUCTION TO SWMM



*CEEN 4800/6965 - Special Topics
Geographic Information Systems and Hydrologic & Hydraulic Modeling
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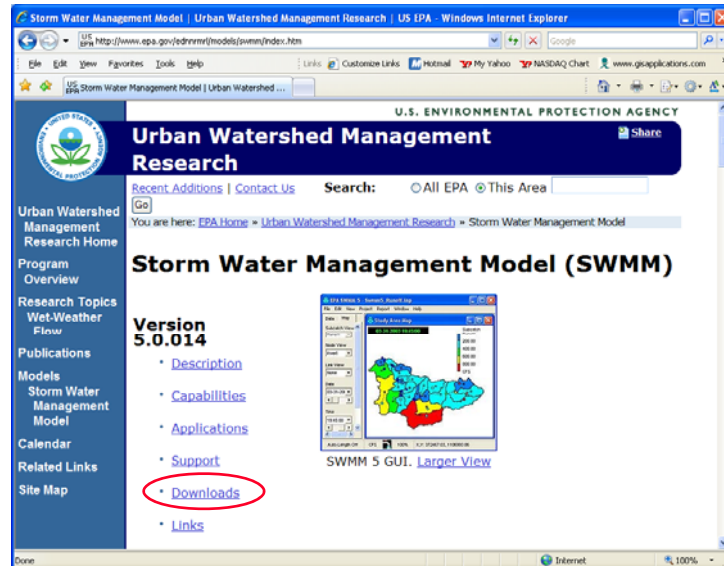
OUTLINE

- ◆ Download instructions
- ◆ Description
- ◆ Capabilities
- ◆ Applications
- ◆ User interface
- ◆ Input data
- ◆ Output results
- ◆ Tutorial
- ◆ Exercise

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EPA SWMM WEB SITE

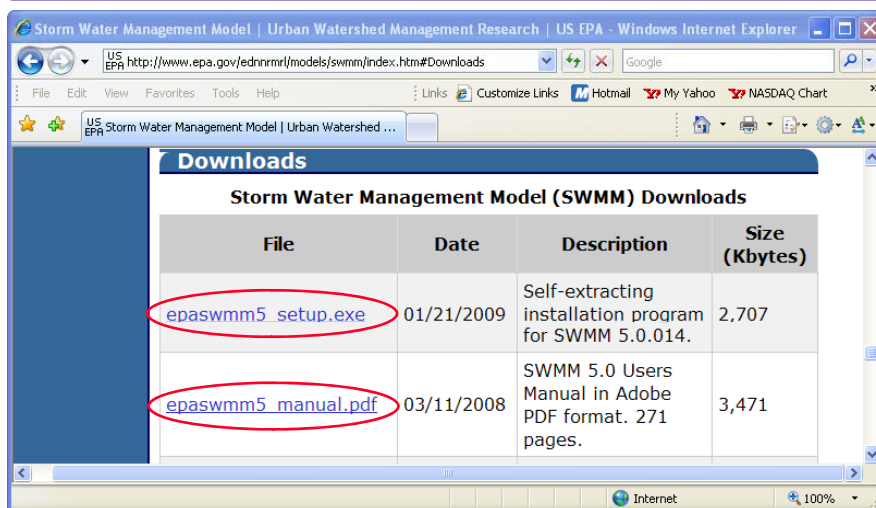
<http://www.epa.gov/ednnrmrl/models/swmm/index.htm>



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SWMM DOWNLOAD

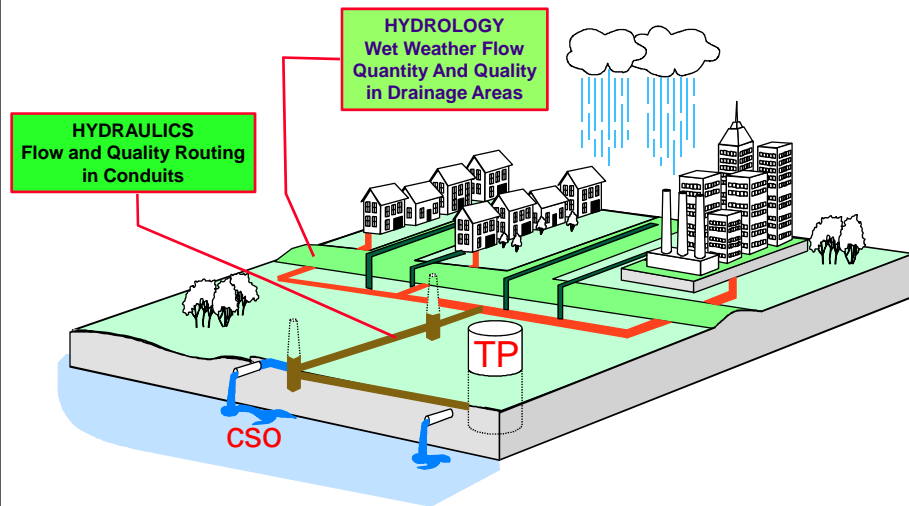
<http://www.epa.gov/ednnrmrl/models/swmm/index.htm#Downloads>



4

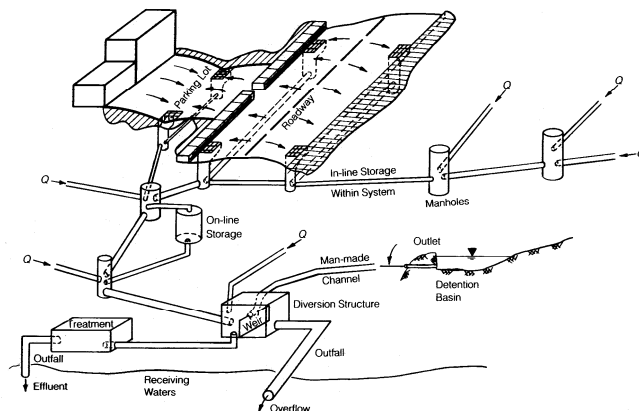
WHAT IS SWMM?

- A hydrologic and hydraulic (H&H) and water quality model
- Models sanitary, combined, and storm sewers and their drainage areas



WHAT IS SWMM?

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



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HYDROLOGIC MODELING FEATURES

- ◆ Spatially and time varying rainfall
- ◆ Evaporation of standing surface water
- ◆ Snow accumulation and melting
- ◆ Interception from depression storage
- ◆ Infiltration into soil layers
- ◆ Nonlinear routing of overland flow

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HYDRAULIC MODELING FEATURES

- ◆ Models drainage networks of any size
- ◆ Accommodates various conduit shapes as well as irregular natural channels
- ◆ Models pumps, regulators, storage basins
- ◆ Allows external inflows, For example:
 - ◆ Rainfall Dependent Inflow and Infiltration (RDII)
 - ◆ Dry Weather Flow (DWF) or sanitary flow
- ◆ Models various flow regimes, such as backwater, surcharging, reverse flow, and surface ponding

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WATER QUALITY MODELING FEATURES

- ◆ Pollutant buildup over different land uses
- ◆ Pollutant washoff during runoff events
- ◆ Reduction in buildup from street cleaning
- ◆ Reduction in washoff from Best Management Practices (BMPs)
- ◆ Water quality routing through the drainage network
- ◆ User-defined treatment functions

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TYPICAL APPLICATIONS OF SWMM

- ◆ Design and sizing of drainage system components including detention facilities
- ◆ Control of combined and sanitary sewer overflows
- ◆ Generating non-point source (NPS) pollutant loadings for wasteload allocation studies
- ◆ Evaluating BMPs for sustainability goals
- ◆ Flood plain mapping of natural channel systems

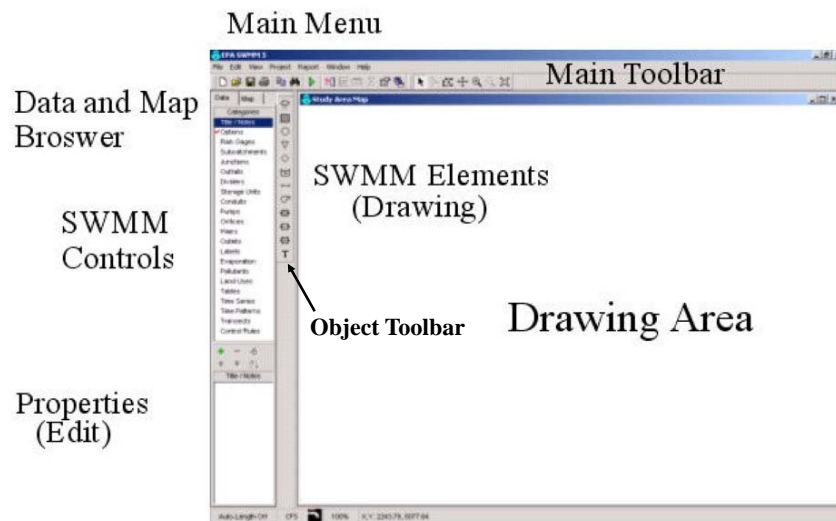
10

LIMITATIONS OF SWMM

- ◆ Not applicable to large-scale, non-urban watersheds
- ◆ Not applicable to forested areas or irrigated cropland
- ◆ Not suitable with highly aggregated (e.g., daily) rainfall data
- ◆ It's an analysis tool, not an *automated* design tool

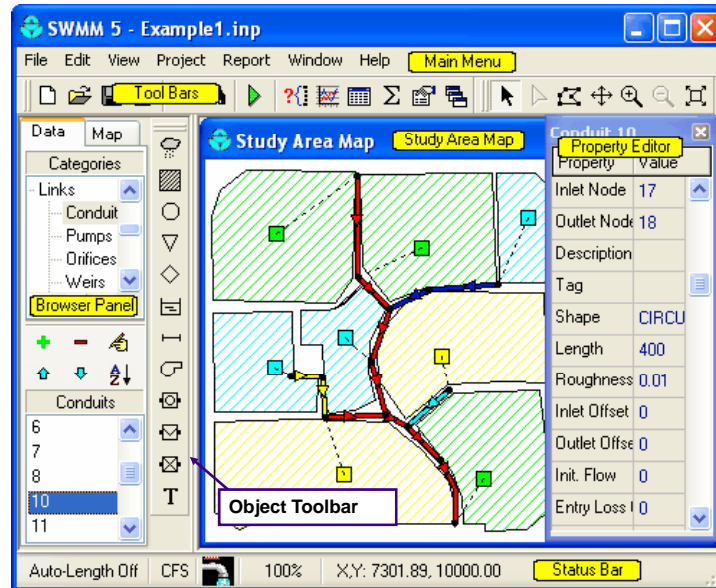
11

USER INTERFACE



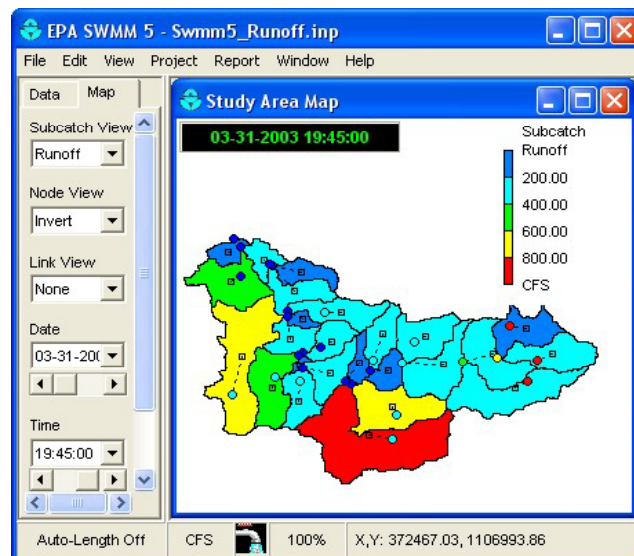
12

USER INTERFACE (DATA BROWSER)



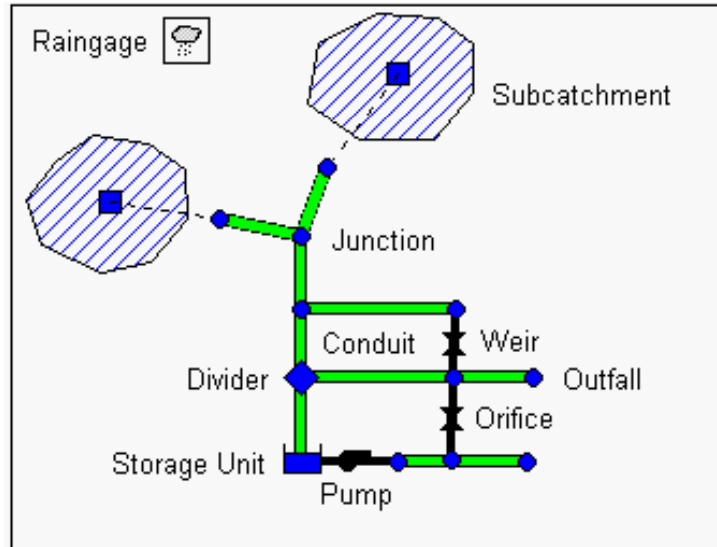
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USER INTERFACE (MAP BROWSER)



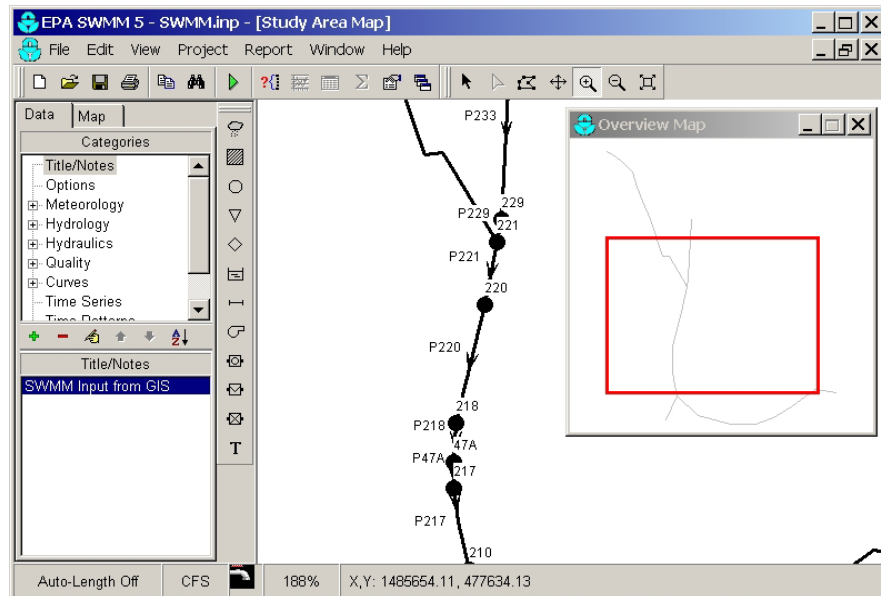
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SWMM'S VISUAL OBJECTS



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SWMM NETWORK (JUNCTIONS AND CONDUITS)



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INPUT DATA - HYDROLOGIC

- Precipitation
- Channel Characteristics
- Watershed characteristics
 - Imperviousness
 - Slope
 - Roughness
 - Width (a shape factor)
 - Depression Storage
 - Infiltration Parameters
 - Infiltration parameters for either the Horton or Green-Ampt equations for up to 100 subcatchments.

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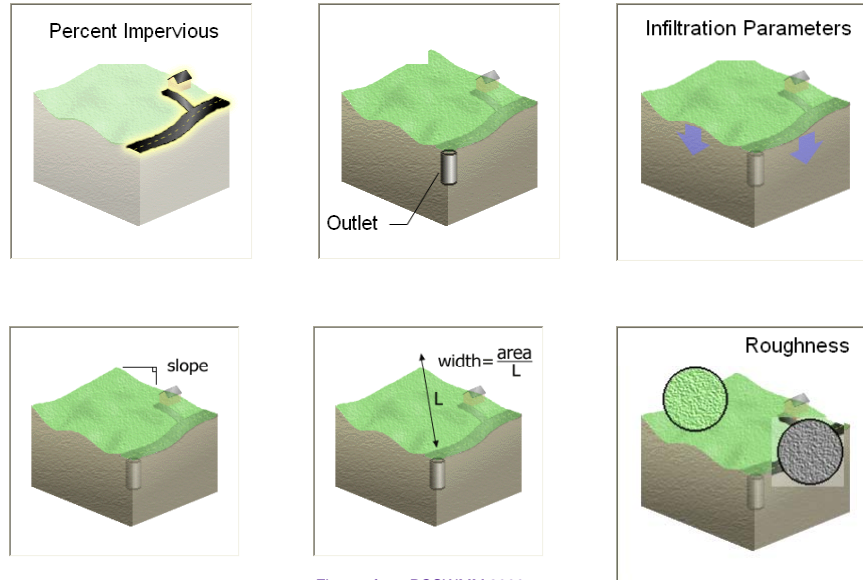
SWMM INPUT: SUBCATCHMENTS

- ◆ Coordinates (can import from GIS)
- ◆ Rain gauge (rainfall hyetograph)
- ◆ Outlet
- ◆ Area
- ◆ Width
- ◆ Slope (%)
- ◆ Percent imperviousness
- ◆ Roughness
- ◆ Infiltration parameters

Subcatchment 1	
Property	Value
Name	1
X-Coordinate	1939.849
Y-Coordinate	8093.233
Description	
Tag	
Rain Gage	RG1
Outlet	9
Area	10
Width	500
% Slope	0.01
% Imperv	50
N-Imperv	0.001
N-Perv	0.10
Dstore-Imperv	0.05
Dstore-Perv	0.05
%Zero-Imperv	25
Subarea Routing	OUTLET
Percent Routed	100
Infiltration	HORTON
Groundwater	NO
Snow Pack	
Land Uses	1
Initial Buildup	NONE
Curb Length	0
User-assigned name of subcatchment	

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KEY SUBCATCHMENT PROPERTIES



Figures from PCSWMM 2000

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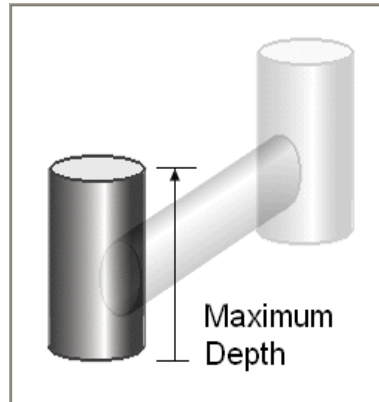
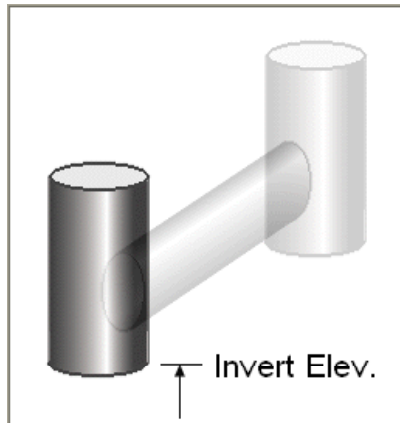
SWMM INPUT: NODES

- ◆ Nodes (manholes)
 - ◆ Coordinates (can import from GIS)
 - ◆ Inflow (cfs)
 - ◆ Invert (bottom) elevation
 - ◆ Maximum depth

Junction 9	
Property	Value
Name	9
X-Coordinate	4042.110
Y-Coordinate	9600.000
Description	
Tag	
Inflows	NO
Treatment	NO
Invert El.	1000
Max. Depth	3
Initial Depth	0
Surcharge Depth	0
Ponded Area	0
User-assigned name of junction	

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KEY NODE PROPERTIES



Figures from PCSWMM 2000

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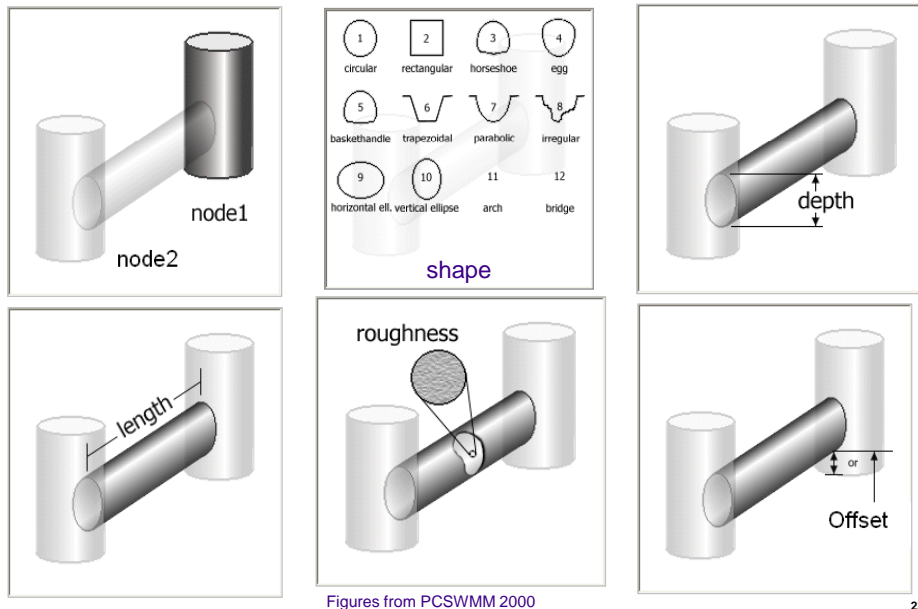
SWMM INPUT: CONDUITS

- ◆ Inlet node
- ◆ Outlet node
- ◆ Shape (e.g., circular)
- ◆ Maximum depth
 - ◆ Diameter for circular pipes
- ◆ Length
- ◆ Roughness (Manning's coefficient)
- ◆ Offset

Conduit 1	
Property	Value
Name	1
Inlet Node	9
Outlet Node	10
Description	
Tag	
Shape	CIRCULAR
Max. Depth	1.5
Length	400
Roughness	0.01
Inlet Offset	0
Outlet Offset	0
Initial Flow	0
Maximum Flow	0
Entry Loss Coeff.	0
Exit Loss Coeff.	0
Avg. Loss Coeff.	0
Flap Gate	NO
Manning's roughness coefficient	

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KEY CONDUIT PROPERTIES



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ROUGHNESS TABLES

EPA SWMM Help

Manning's Roughness n for Closed Conduits

Conduit Material	Manning n
Asbestos-cement pipe	0.011 - 0.015
Brick	0.013 - 0.017
Cast iron pipe	
- Cement-lined & seal coated	0.011 - 0.015
Concrete (monolithic)	
- Smooth forms	0.012 - 0.014
- Rough forms	0.015 - 0.017
Concrete pipe	0.011 - 0.015
Corrugated-metal pipe (1/2-in. x 2-2/3-in. corrugations)	
- Plain	0.022 - 0.026
- Paved invert	0.018 - 0.022
- Spun asphalt lined	0.011 - 0.015
Plastic pipe (smooth)	0.011 - 0.015
Vitrified clay	
- Pipes	0.011 - 0.015
- Liner plates	0.013 - 0.017

Source: ASCE (1982). *Gravity Sanitary Sewer Design and Construction*, ASCE Manual of Practice No. 60, New York, NY.

EPA SWMM Help

Manning's Roughness n for Open Channels

Channel Type	Manning n
Lined Channels	
- Asphalt	0.013 - 0.017
- Brick	0.012 - 0.018
- Concrete	0.011 - 0.020
- Rubble or riprap	0.020 - 0.035
- Vegetal	0.030 - 0.40
Excavated or dredged	
- Earth, straight and uniform	0.020 - 0.030
- Earth, winding, fairly uniform	0.025 - 0.040
- Rock	0.030 - 0.045
- Unmaintained	0.050 - 0.140
Natural channels (minor streams, top width at flood stage < 100 ft)	
- Fairly regular section	0.030 - 0.070
- Irregular section with pools	0.040 - 0.100

Source: ASCE (1982). *Gravity Sanitary Sewer Design and Construction*, ASCE Manual of Practice No. 60, New York, NY.

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SWMM INPUT FILE (*.INP)

Like EPANET input file

[JUNCTIONS]

Name	Invert Elev.	Max. Depth	Init. Depth	Surcharge Depth	Ponded Area
9	1000	3	0	0	0
10	995	0	0	0	0
13	995	0	0	0	0
14	990	0	0	0	0
15	987	0	0	0	0
16	985	0	0	0	0
17	980	0	0	0	0
18	975	0	0	0	0
19	1010	0	0	0	0
20	1005	0	0	0	0
21	990	0	0	0	0
22	987	0	0	0	0
23	980	0	0	0	0
24	984	0	0	0	0

[CONDUITS]

Name	Inlet Node	Outlet Node	Length	Manning N	Inlet Height	Outlet Height	Init Flow
1	9	10	400	0.01	0	0	0
2	19	20	200	0.01	0	0	0
3	20	21	200	0.01	0	0	0
4	10	21	400	0.01	0	0	0
5	21	22	300	0.01	0	0	0
6	22	16	300	0.01	0	0	0
7	18	14	400	0.01	0	0	0
8	13	14	400	0.01	0	0	0
9	14	15	400	0.01	0	0	0
10	15	16	400	0.01	0	0	0
11	23	24	400	0.01	0	0	0
12	16	24	100	0.01	0	0	0
13	24	17	400	0.01	0	0	0

[SECTIONS]

Link	Type	Geom1	Geom2	Geom3	Geom4
1	CIRCULAR	1.5	0	0	0
2	CIRCULAR	1.5	0	0	0
3	CIRCULAR	1.5	0	0	0
4	CIRCULAR	1.5	0	0	0
5	CIRCULAR	1.5	0	0	0
6	CIRCULAR	1.5	0	0	0
7	CIRCULAR	1.5	0	0	0
8	CIRCULAR	1.5	0	0	0
9	CIRCULAR	1.5	0	0	0
10	CIRCULAR	1.5	0	0	0

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SWMM OUTPUT

◆ Subcatchments

- ◆ rainfall rate (in/hr or mm/hr)
- ◆ snow depth (inches or millimeters)
- ◆ losses (infiltration + evaporation in in/hr or mm/hr)
- ◆ runoff flow (flow units)
- ◆ groundwater flow into the drainage network (flow units)
- ◆ groundwater elevation (ft or m)
- ◆ washoff concentration of each pollutant (mass/liter)

Table by Variable

Start Date: 01/01/1998 End Date: 01/02/1998

Time Format: Elapsed Time Object Category: Subcatchments

Variables:

- ☒ Rainfall
- ☐ Snow Depth
- ☐ Losses
- ☐ Runoff
- ☐ GW Flow
- ☐ GW Elev.
- ☐ TSS

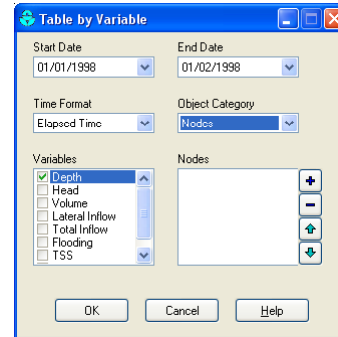
Subcatchments:

OK Cancel Help

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SWMM OUTPUT

- ◆ Nodes (manholes)
 - ◆ water depth (ft or m above the node invert elevation)
 - ◆ hydraulic head (ft or m, absolute elevation per vertical datum)
 - ◆ stored water volume (including ponded water, ft³ or m³)
 - ◆ lateral inflow (runoff + all other external inflows, in flow units)
 - ◆ total inflow (lateral inflow + upstream inflows, in flow units)
 - ◆ surface flooding (flow lost from the system when the water depth exceeds the defined maximum node depth, flow units)
 - ◆ concentration of each pollutant after any treatment (mass/liter)

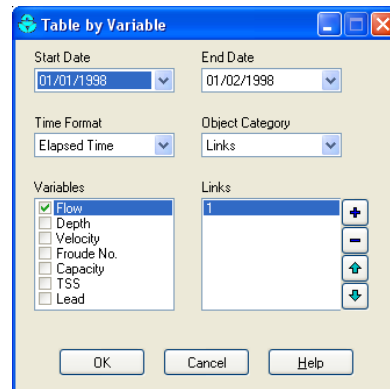


[Support\Manhole overflow Youtube.avi](#)

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SWMM OUTPUT

- ◆ Links (pipes)
 - ◆ Flow rate (flow units)
 - ◆ Average water depth (ft or m)
 - ◆ Flow velocity (ft/sec or m/sec)
 - ◆ Froude number (dimensionless)
 - ◆ Capacity (ratio of depth to full depth)
 - ◆ Concentration of each pollutant (mass/liter)
 - ◆ Total suspended solids (TSS)
 - ◆ Lead
 - ◆ etc.



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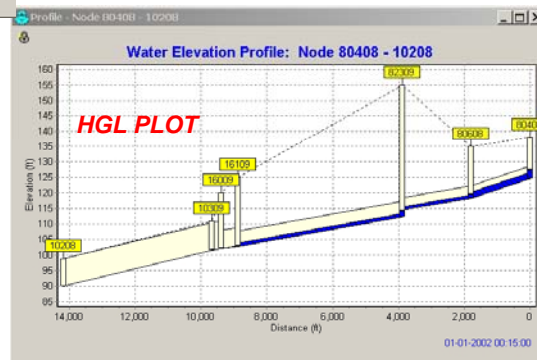
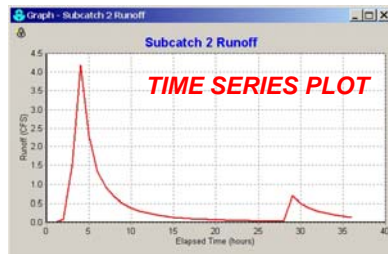
SWMM OUTPUT

Tabular output

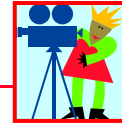
Days	Hours	Flow (CFS)
0	00:15:00	5.59
0	00:30:00	42.45
0	00:45:00	70.17
0	01:00:00	70.27
0	01:15:00	70.31
0	01:30:00	70.35
0	01:45:00	70.36
0	02:00:00	70.36
0	02:15:00	70.36
0	02:30:00	70.35
0	02:45:00	70.35
0	03:00:00	70.33
0	03:15:00	50.30
0	03:30:00	36.09
0	03:45:00	21.16
0	04:00:00	11.92
0	04:15:00	6.12
0	04:30:00	3.36
0	04:45:00	2.03
0	05:00:00	1.37
0	05:15:00	0.97
0	05:30:00	0.71
0	05:45:00	0.54
0	06:00:00	0.44
0	06:15:00	0.38
0	06:30:00	0.35

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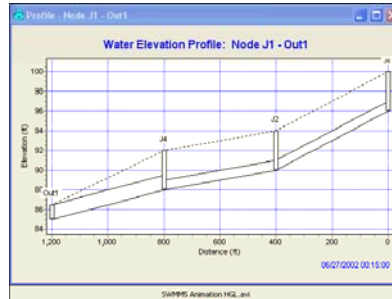
GRAPHICAL OUTPUT



ANIMATED OUTPUT



PLAN AND HGL ANIMATION

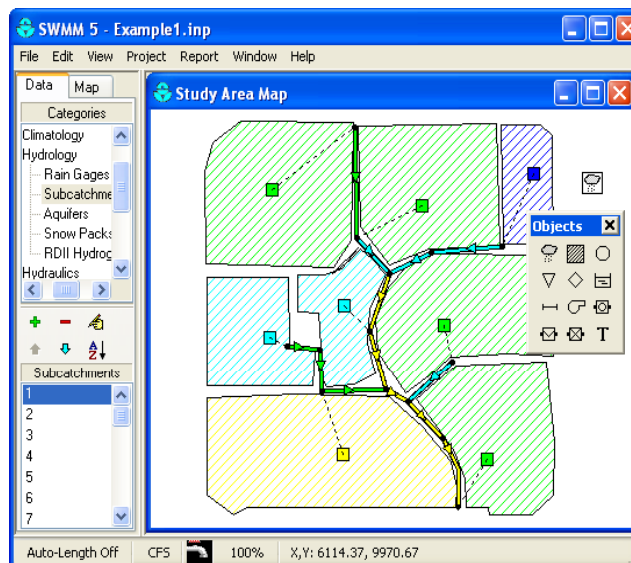


<..\\..\\..\\2008\\YSUGIS08\\Lectures\\11-SWMM\\Support\\SWMM5 Animation Plan and HGL.avi>

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STEPS IN RUNNING SWMM 5

- ◆ Draw drainage system objects

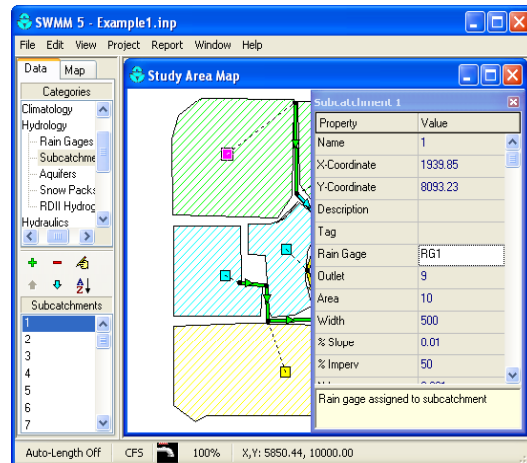


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STEPS IN RUNNING SWMM 5

- ◆ Draw drainage system objects

- ◆ Edit their properties



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STEPS IN RUNNING SWMM 5

- ◆ Draw drainage system objects

- ◆ Edit their properties

- ◆ Alternatively, create and edit a SWMM 5 input file using the format described in the Users Manual.

```

Example1.inp - Notepad
File Edit Format View Help

[TITLE]
Example 1

[OPTIONS]
FLOW_UNITS          CFS
INFILTRATION        HORTON
FLOW_ROUTING        KW
START_DATE          01/01/1998
START_TIME          00:00:00
REPORT_START_DATE   01/01/1998
REPORT_START_TIME   00:00:00
END_DATE            01/02/1998
END_TIME            12:00:00
DRY_DAYS            5
WET_STEP            00:15:00
DRY_STEP            01:00:00
ROUTING_STEP        00:01:00
REPORT_STEP         01:00:00

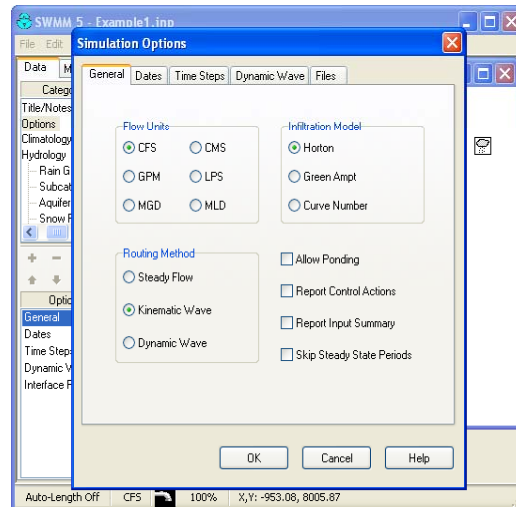
[RAINGAGES]
::
::Name      Rain      Recd.  Snow  Data
::          Type      Freq.   Catch Source
::-----
RG1         INTENSITY 1:00   1.0   TIMESERIES

[SUBCATCHMENTS]
::
::Name      Raingage      Outlet
::-----
1          RG1            9
2          RG1            10
3          RG1            13
    
```

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STEPS IN RUNNING SWMM 5

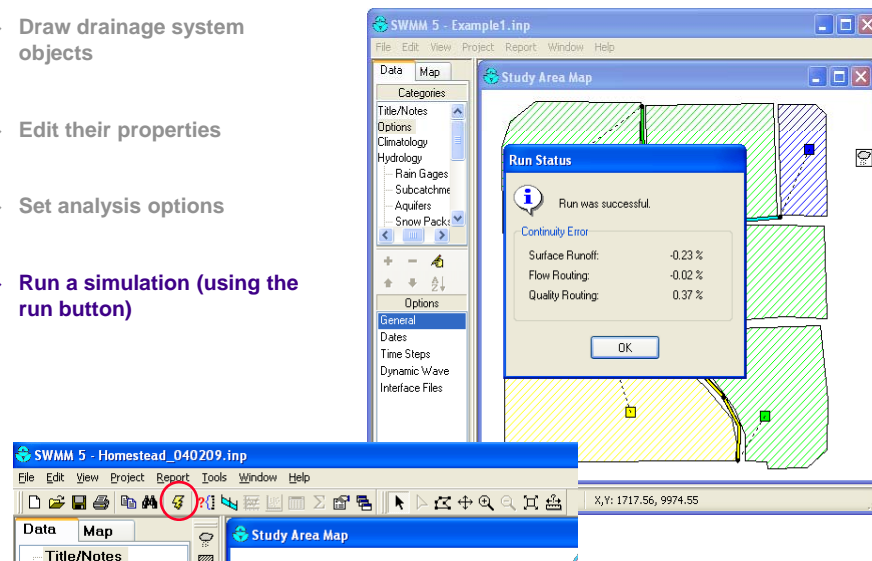
- ◆ Draw drainage system objects
- ◆ Edit their properties
- ◆ Set analysis options



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STEPS IN RUNNING SWMM 5

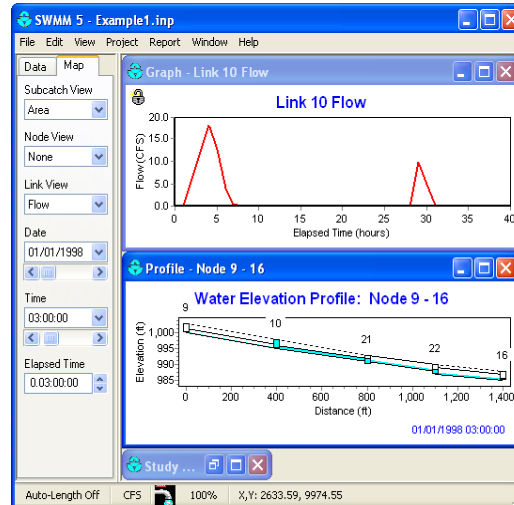
- ◆ Draw drainage system objects
- ◆ Edit their properties
- ◆ Set analysis options
- ◆ Run a simulation (using the run button)



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STEPS IN RUNNING SWMM 5

- ◆ Draw drainage system objects
- ◆ Edit their properties
- ◆ Set analysis options
- ◆ Run a simulation
- ◆ View a variety of ad hoc reports



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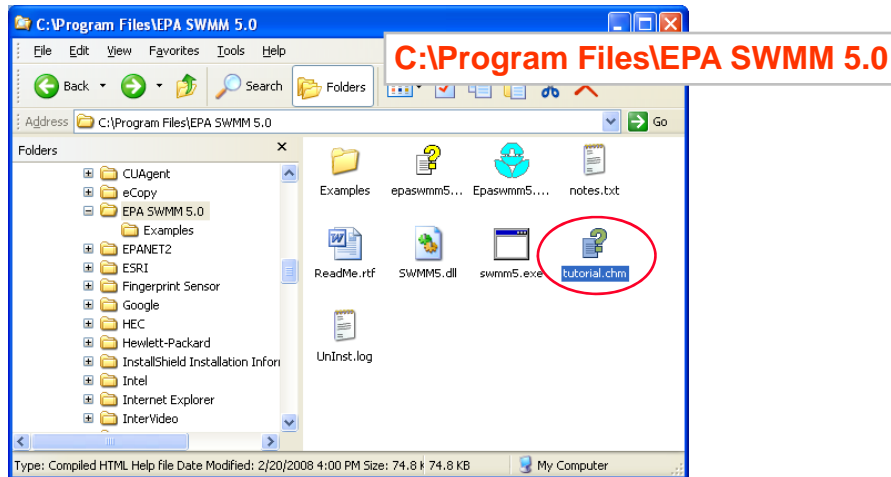
SWMM EXAMPLES

- ◆ SWMM5 comes with three examples to help one become familiar with the program.
- ◆ The example input files are installed in the “Examples” folder of the SWMM5 installation directory
 - ◆ C:\Program Files\EPA SWMM 5.0\Examples
- ◆ Each example consists of a .INP file which holds the model data and a .TXT file which includes suggestions on running it.
- ◆ Examples include:
 - ◆ EXAMPLE1.INP models runoff quantity and quality from a small watershed and its routing through a network of storm sewers. It can be run in either single event mode or in continuous mode using the companion rainfall file.
 - ◆ EXAMPLE2.INP is Example 1 of the 1988 EXTRAN Users Manual. It illustrates how SWMM5 can graphically compare its results to observed data stored in a text file.
 - ◆ EXAMPLE3.INP illustrates the use of the rule-based controls feature in SWMM5 for simulating real-time control.

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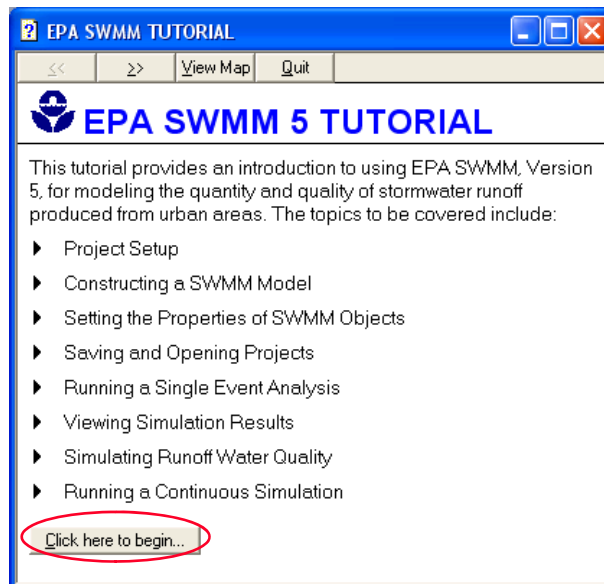
SWMM TUTORIAL

1. Open [tutorial.chm](#) file from C:\Program Files\EPA SWMM 5.0, or
2. Open Chapter 2 (Quick Start Tutorial) of the Users Manual, or
3. Select Tutorial from SWMM Help menu



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SWMM TUTORIAL



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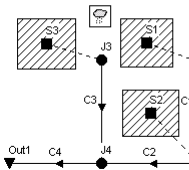
SWMM TUTORIAL

EPA SWMM TUTORIAL

<<
>>
View Map
Quit

Example Study Area

In this tutorial we will model the drainage system serving a 12 acre residential area. The system layout is shown below and consists of subcatchment areas 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.

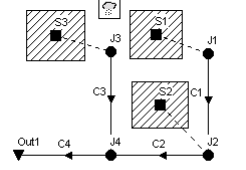


Tutorial Example

You can click the **View Map** button on the Navigation bar above to refer to this drawing at any time. Use to move to the **next topic** and the **back** button to return to the previous topic. Side notes have been added to topics that describe additional features of EPA SWMM. These can be viewed in a pop-up window by clicking word **Note** where it appears.

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.

Study Area Map



Tutorial Example

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LAB EXERCISE: SWMM TUTORIAL



- ◆ Download and print the exercise from the Course Web site
 - ◆ SWMM Exercise (SWMMExercise.pdf)
- ◆ Same as the above tutorial example up to "Viewing a Profile Plot" step (about 75% of the tutorial).

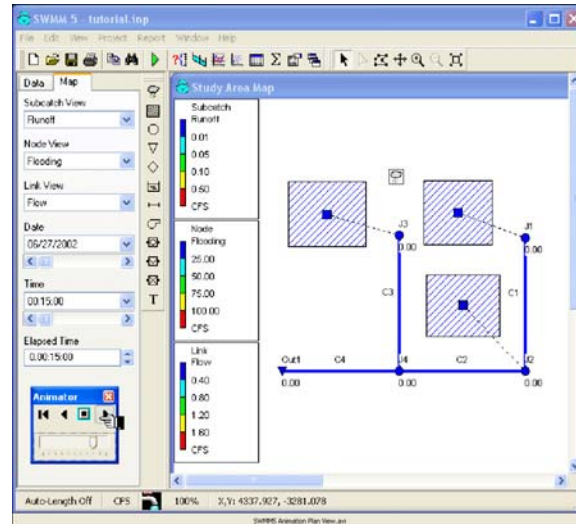
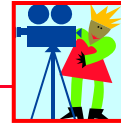
This exercise is the initial part of the tutorial example included with SWMM 5 up to "Viewing a Profile Plot" step of the tutorial. Thus, you can also do this exercise by following the steps in the tutorial which can be accessed using one of the following methods:

- ▶ Select Tutorial from SWMM Help menu
- ▶ Open Tutorial.hlp file from C:\Program Files\EPA SWMM 5.0, or
- ▶ Open Chapter 2 (Quick Start Tutorial) of the Users Manual

Several steps (depending on available time) will be done by students in the class on the projector. Remaining steps should be completed as homework. After completing the following exercise steps, submit the following items as homework:

- ▶ Screenshot of Figure 2-12. Example of viewing color-coded results on the Study Area Map
- ▶ Screenshot of Figure 2-15. Time Series plot of results from initial simulation run
- ▶ Screenshot of Figure 2-17. Example of a Profile plot

SWMM EXERCISE



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ACKNOWLEDGEMENTS

- ◆ Lewis Rossman
Environmental Scientist
Water Supply and Water Resources Division
U.S Environmental Protection Agency
- ◆ Many thanks to Lew for proving some slides
used in this lecture and tutorial files

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