BMP-LID Design with EPA SWMM

With Applications to a Site Development

March 8, 2011

IAFSM

Illinois Association for Floodplain and Stormwater Management

Introduction –

Robert Murdock (Michael Baker Jr., Inc.) 8:10 – 8:30

Instructors
•Greg Kacvinsky (Foth)
•Bob Murdock (Baker)
•Shauna Urlacher (Clark Dietz)

Objectives

- Get information about SWMM5 capabilities and features.
- Learn how to prepare SWMM5 input file and interpret SWMM5 output results.
- Learn how to use SWMM5 as a LID/BMP analysis and design tool.

Introduction –

Robert Murdock (Michael Baker Jr., Inc.)

- Schedule:
  - Intro to EPA SWMM Capabilities (8:30 – 8:50)
  - The EPA SWMM Interface (8:50 – 9:15)
  - Tutorial Exercise (9:15 – 10:15)
  - BREAK (10:15-10:30)
  - Site Development: LID Considerations (10:30 – 11:20)
    - Existing Site and Land Use Intent
    - Local Design Standards
    - Site Fingerprinting
    - Discussion of Example Site Layout

Introduction –

Robert Murdock (Michael Baker Jr., Inc.)

- Schedule (cont.):
  - Modeling – Proposed Conditions (11:20 – 12:15)
  - LUNCH (12:15 – 1:00)
  - Continue Proposed Conditions Model (1:00 – 2:00)
  - Existing Conditions Analysis (2:00 – 2:30)
  - Model Output Interpretation (2:30 – 3:00)
  - BREAK (3:00 – 3:15)

Introduction –

Robert Murdock (Michael Baker Jr., Inc.)

- Schedule (cont.):
  - Designing / Maintaining LID Infrastructure (3:15 – 3:45)
  - Overview of WinSLAMM (3:45 – 4:30)
  - Recap and Close (4:30 – 4:45)

Logistics:
Breaks (AM and PM)
Lunch Provided

Introduction to EPA SWMM –

Gregory Kacvinsky (Foth Infrastructure & Environment, LLC)

- Value of EPA SWMM as a design tool for land development
  - EPA SWMM is the basis for most of the comprehensive urban stormwater modeling programs
  - Can model infiltration in storage nodes (bioretention)
  - Can model single event ("design") storms AND continuous simulation
  - Scalability → we can add upstream/downstream hydrologic and hydraulic components with ease
  - Most accessible to design engineers (public domain)

Introduction to EPA SWMM –

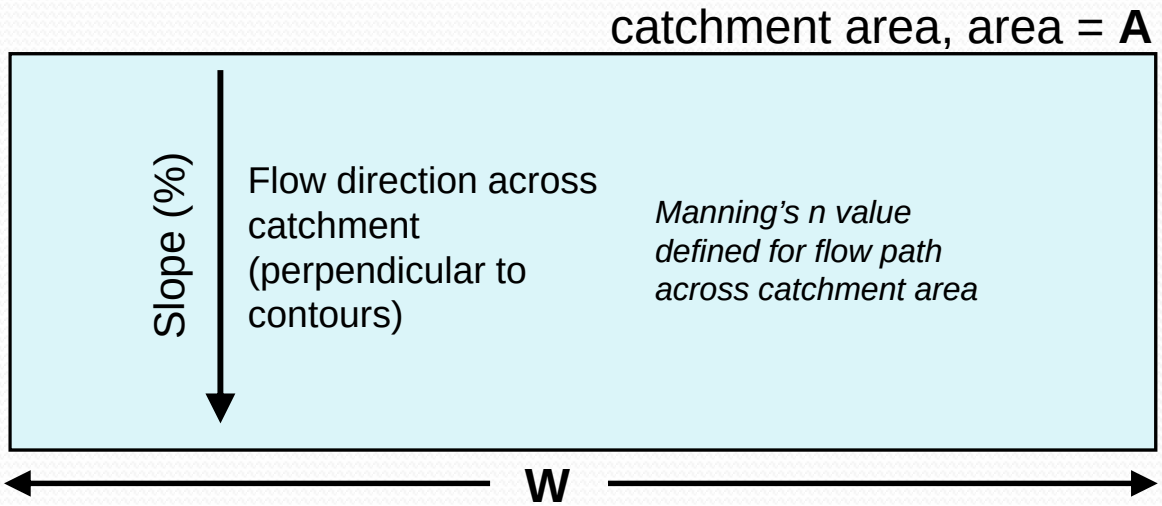
Gregory Kacvinsky (Foth Infrastructure & Environment, LLC)

- SWMM Hydrology
  - More complex than SCS Curve Number method
    - Relies on infiltration parameters for pervious surfaces
      - Decaying infiltration rate
      - Infiltration recovery (extended period simulations)
    - Separates pervious and impervious surfaces
    - Allows for routing of flows from impervious surfaces to pervious surfaces
    - No time of concentration (width/slope parameters)

Introduction to EPA SWMM –

Gregory Kacvinsky (Foth Infrastructure & Environment, LLC)

- SWMM Hydrology



"Time of Concentration" in EPA SWMM is implied by the calculation of travel time across subcatchment

Introduction to EPA SWMM –

Gregory Kacvinsky (Foth Infrastructure & Environment, LLC)

- SWMM Hydraulics
  - Interconnected pipes, storage areas
  - Routing between drainage areas
  - Interaction between distinct hydraulic elements
  - Closed pipe and open channel hydraulics
  - Animation of system profile (output)
  - Dynamic Wave Routing

Introduction to EPA SWMM –

Gregory Kacvinsky (Foth Infrastructure & Environment, LLC)

- SWMM – Advanced Capabilities
  - Pump station and forcemain hydraulics
  - Evaporation
  - **Infiltration in storage nodes (covered today)**
  - Pollutant removal
  - Groundwater / drainage system interflow

Introduction to EPA SWMM –

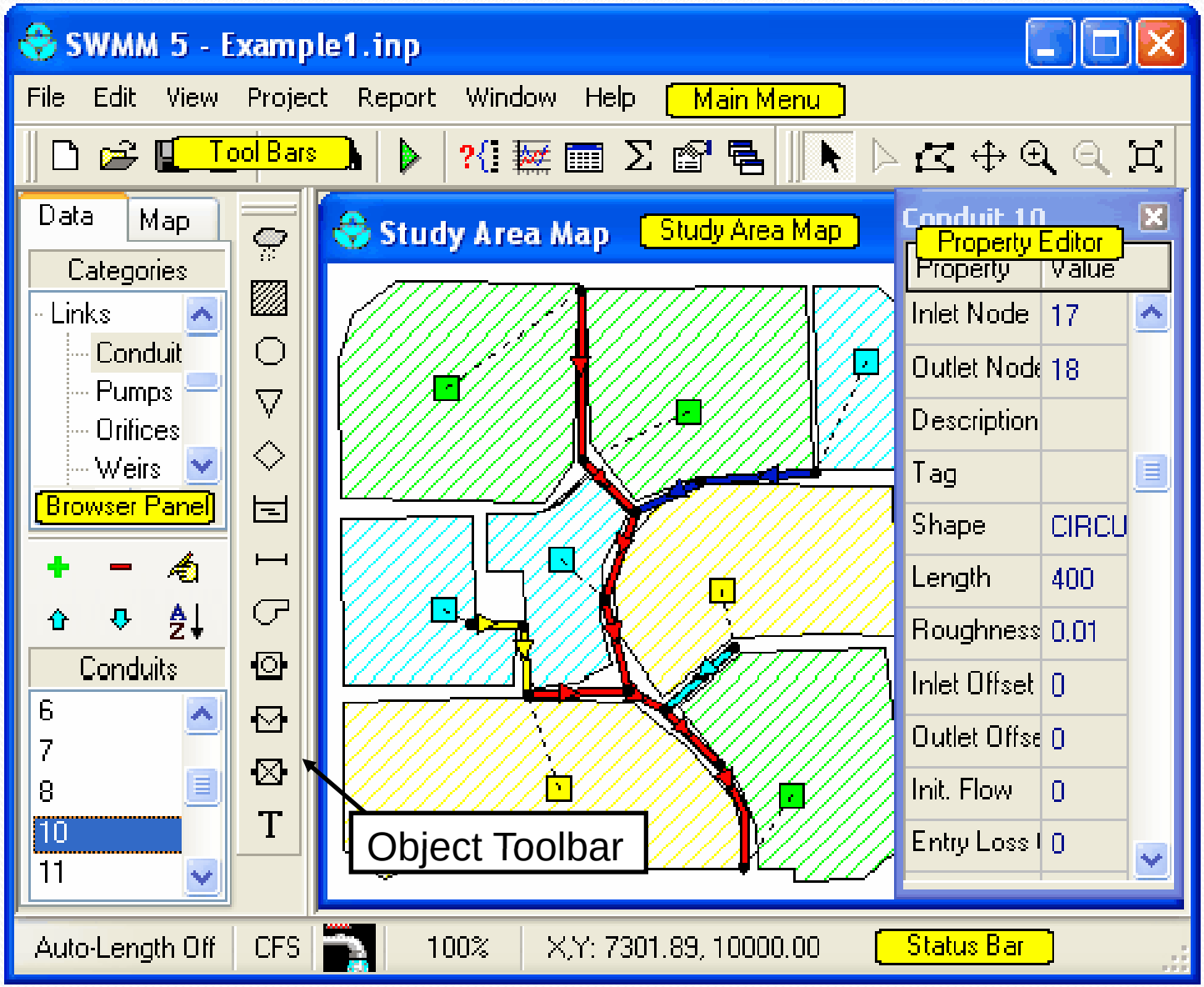
Gregory Kacvinsky (Foth Infrastructure & Environment, LLC)

- SWMM – LID Controls
  - **Bioretention (covered today)**
  - **Rain barrels (covered today)**
  - Pervious pavement
  - Infiltration trench
  - Vegetative swale

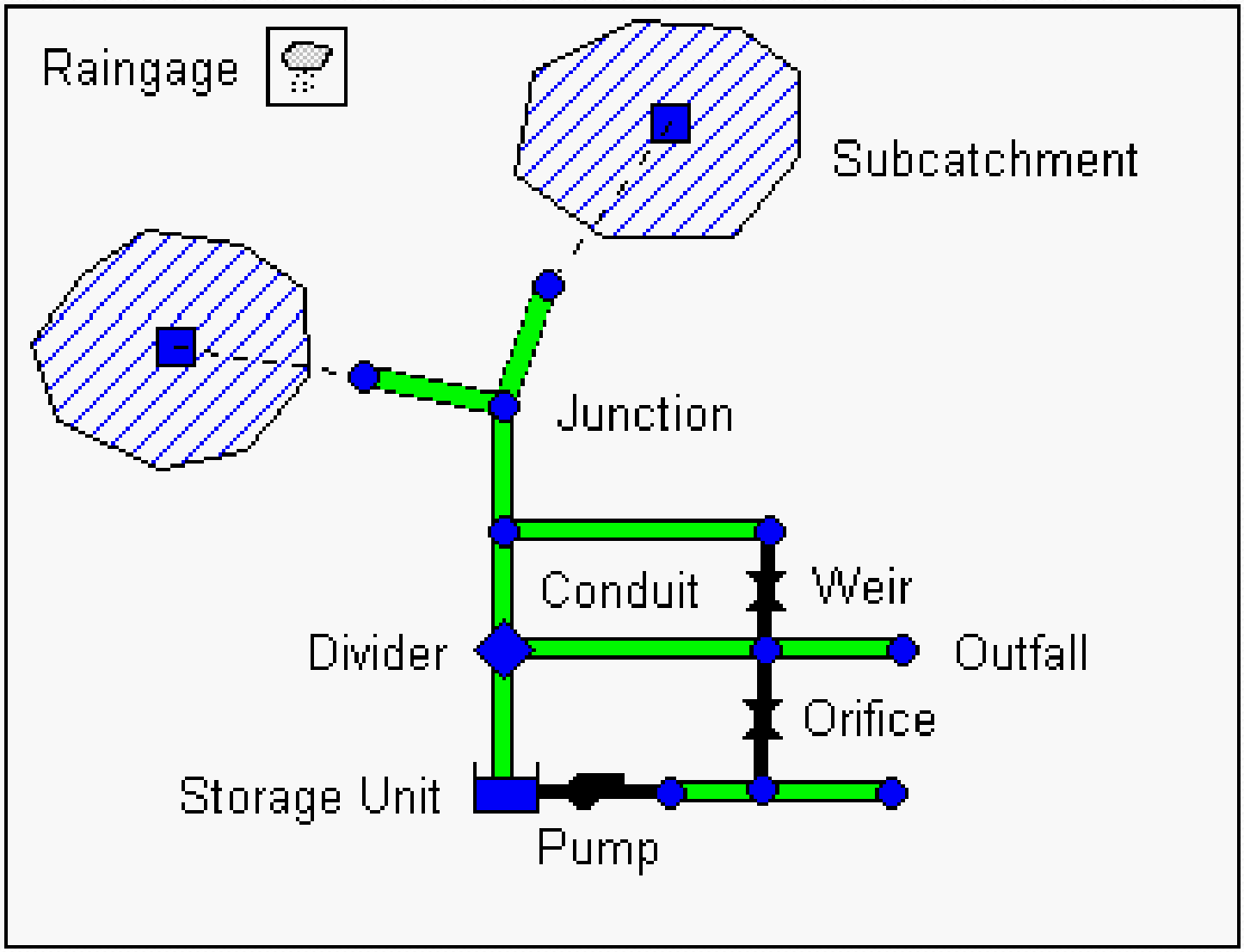
EPA SWMM Interface –

Robert Murdock (Michael Baker Jr., Inc.) 8:50 – 9:15

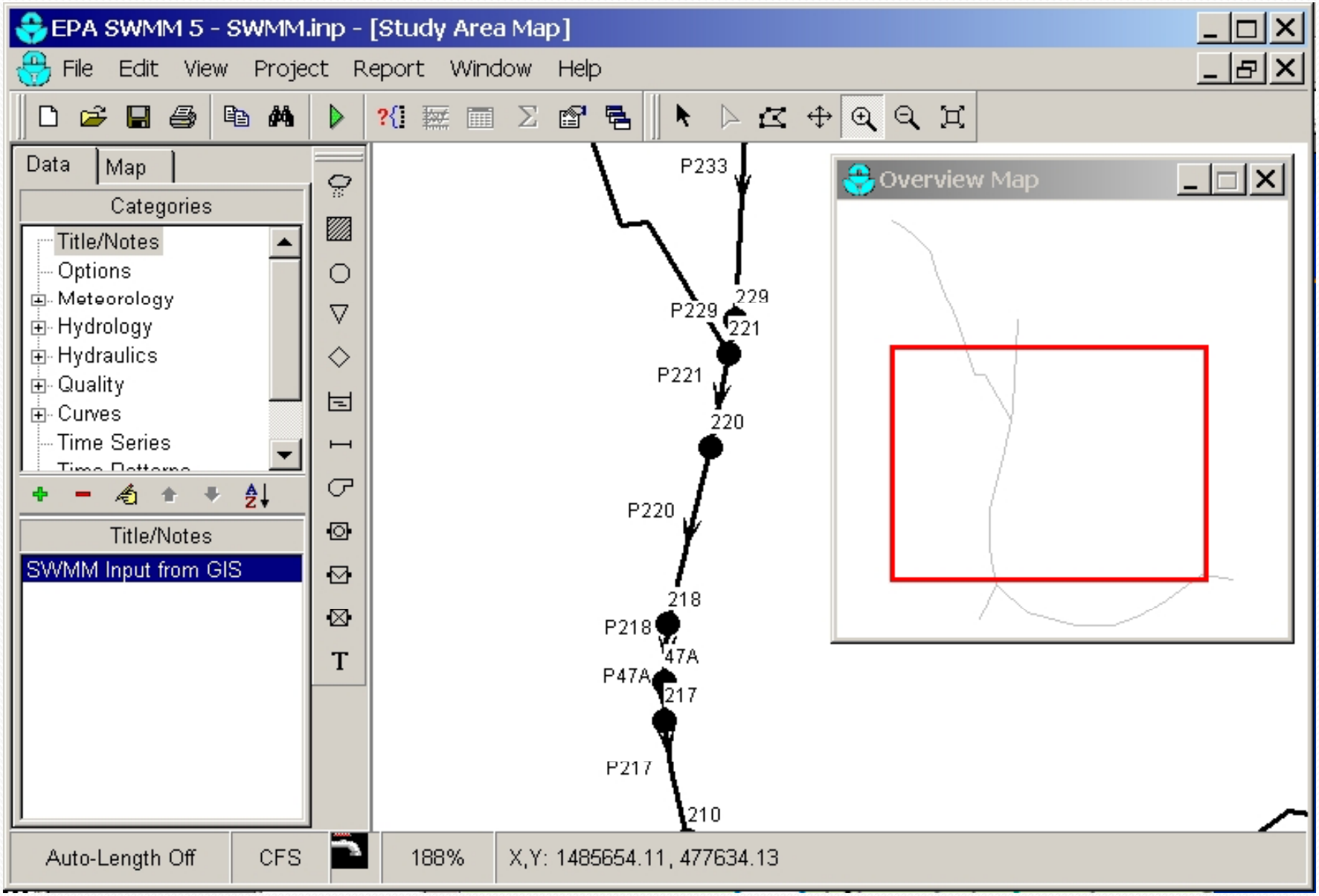
USER INTERFACE (DATA BROWSER)



SWMM'S VISUAL OBJECTS

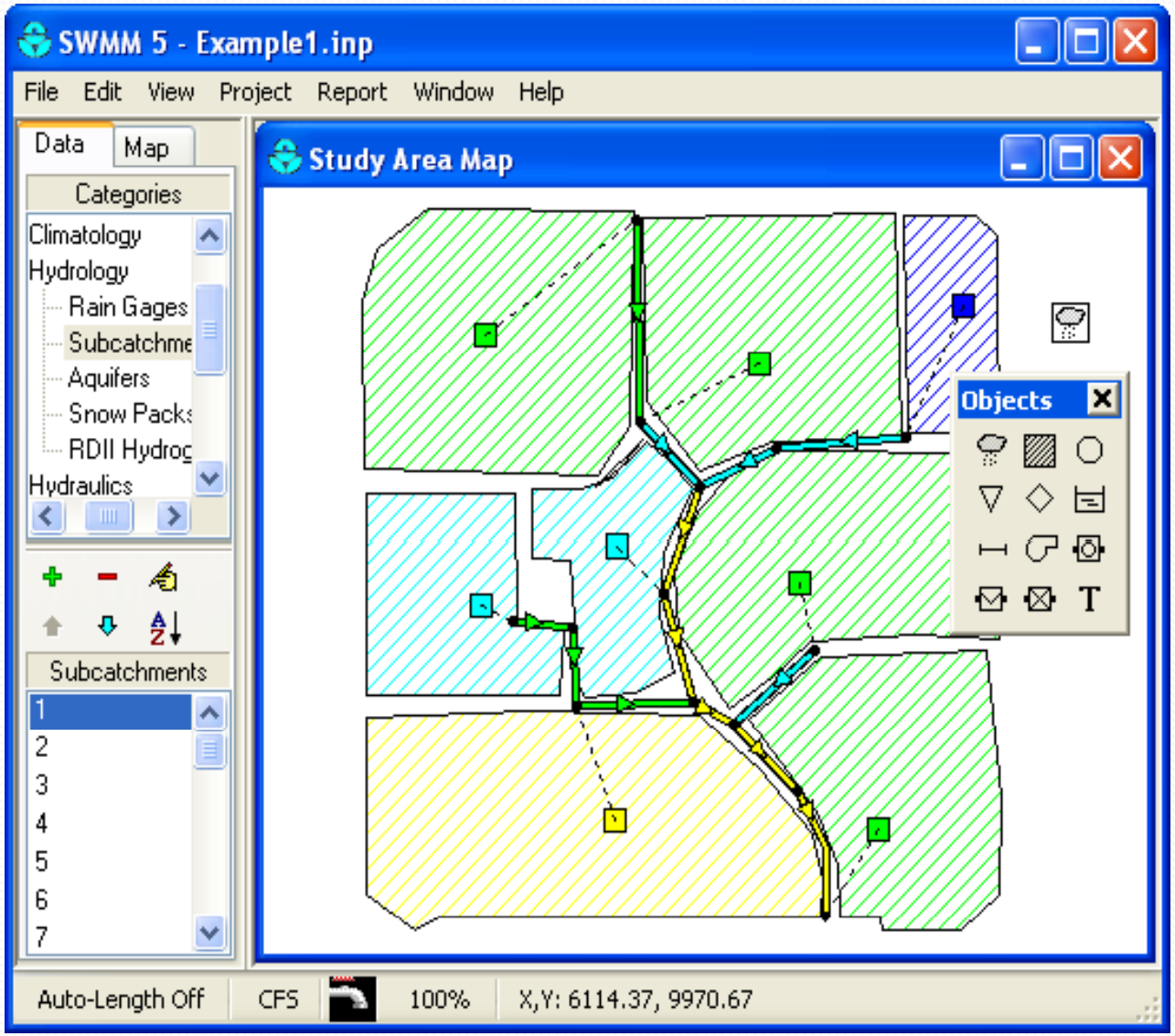


SWMM NETWORK (JUNCTIONS AND CONDUITS



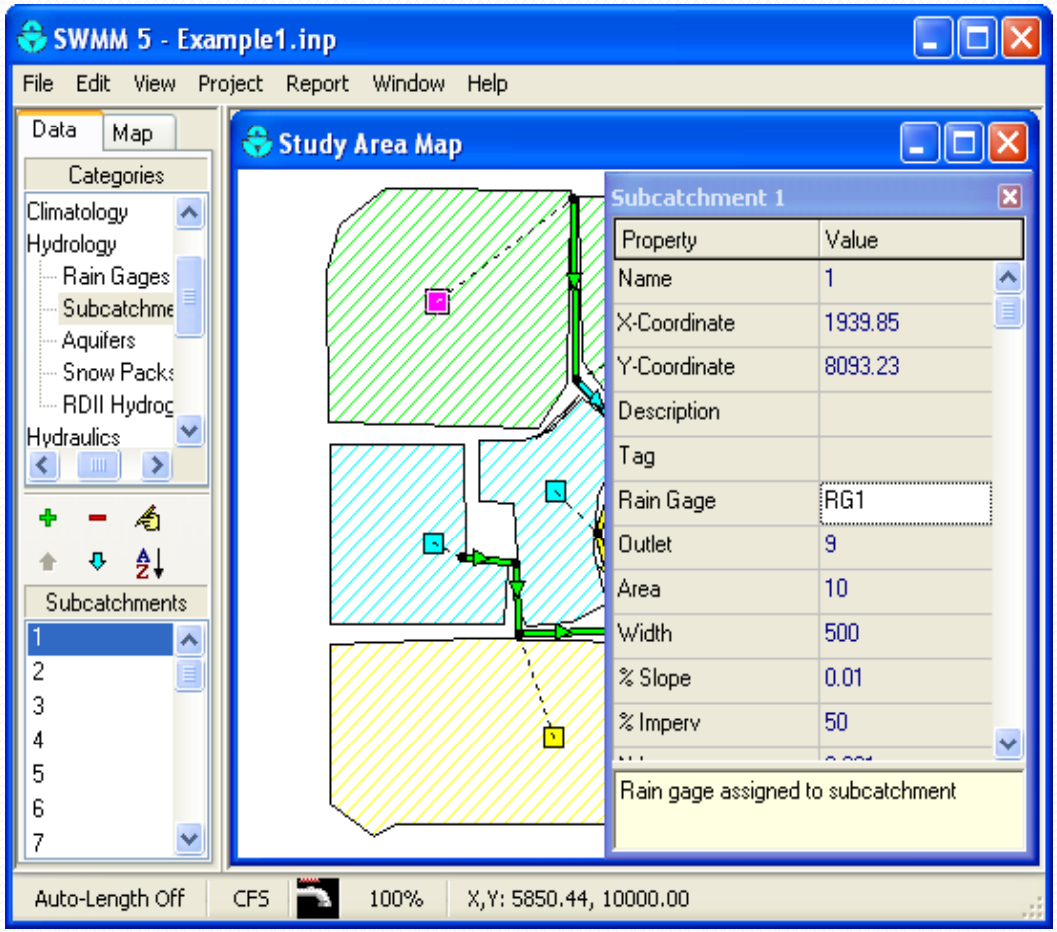
STEPS IN RUNNING SWMM 5

- **Draw drainage system objects**



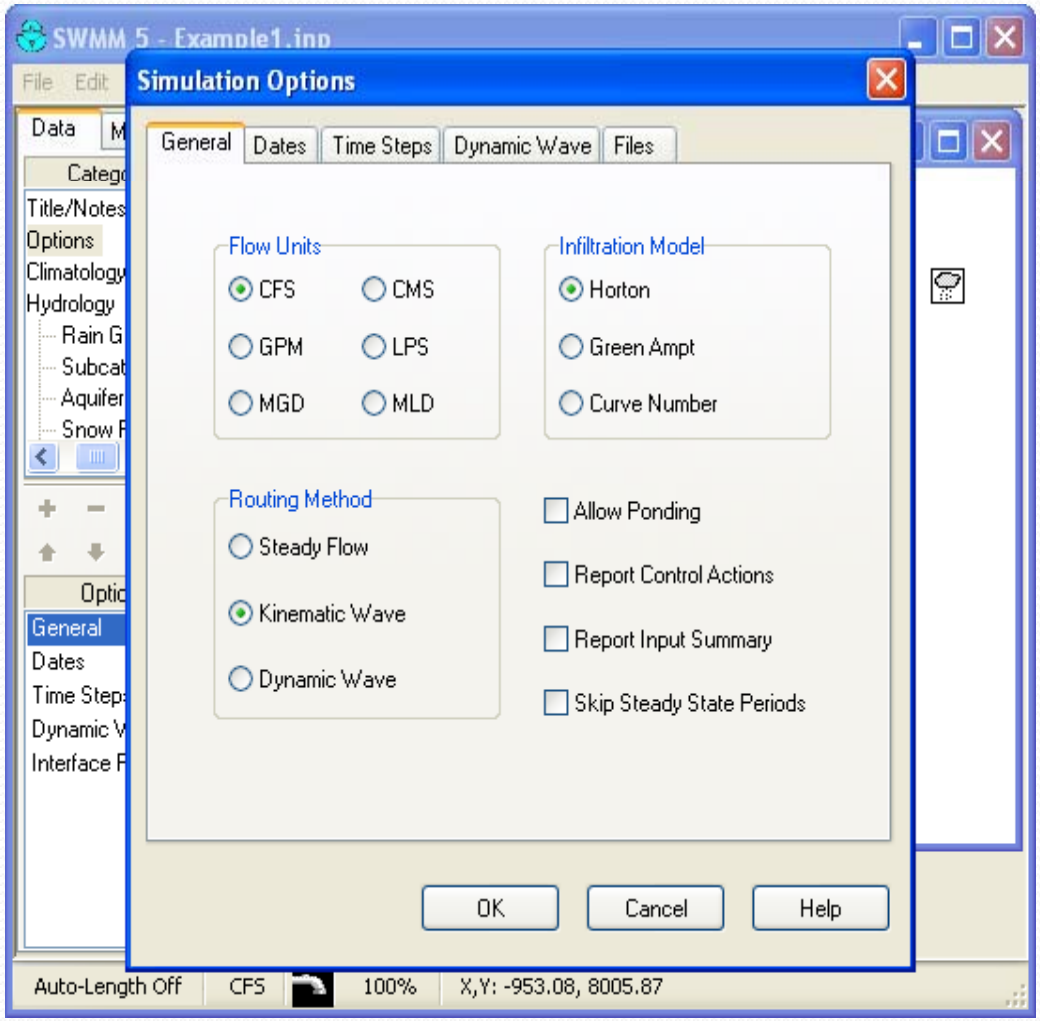
STEPS IN RUNNING SWMM 5

- **Draw drainage system objects**
- **Edit their properties**



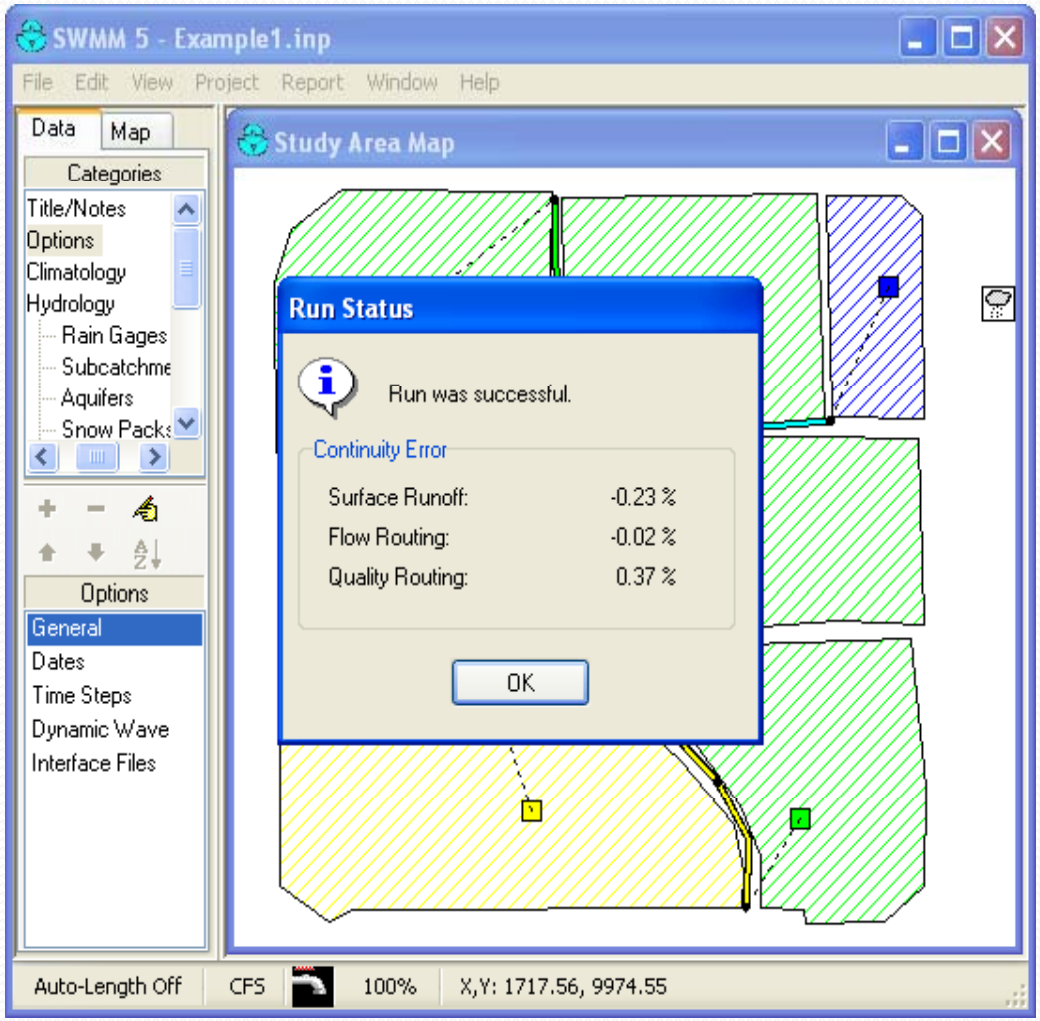
STEPS IN RUNNING SWMM 5

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



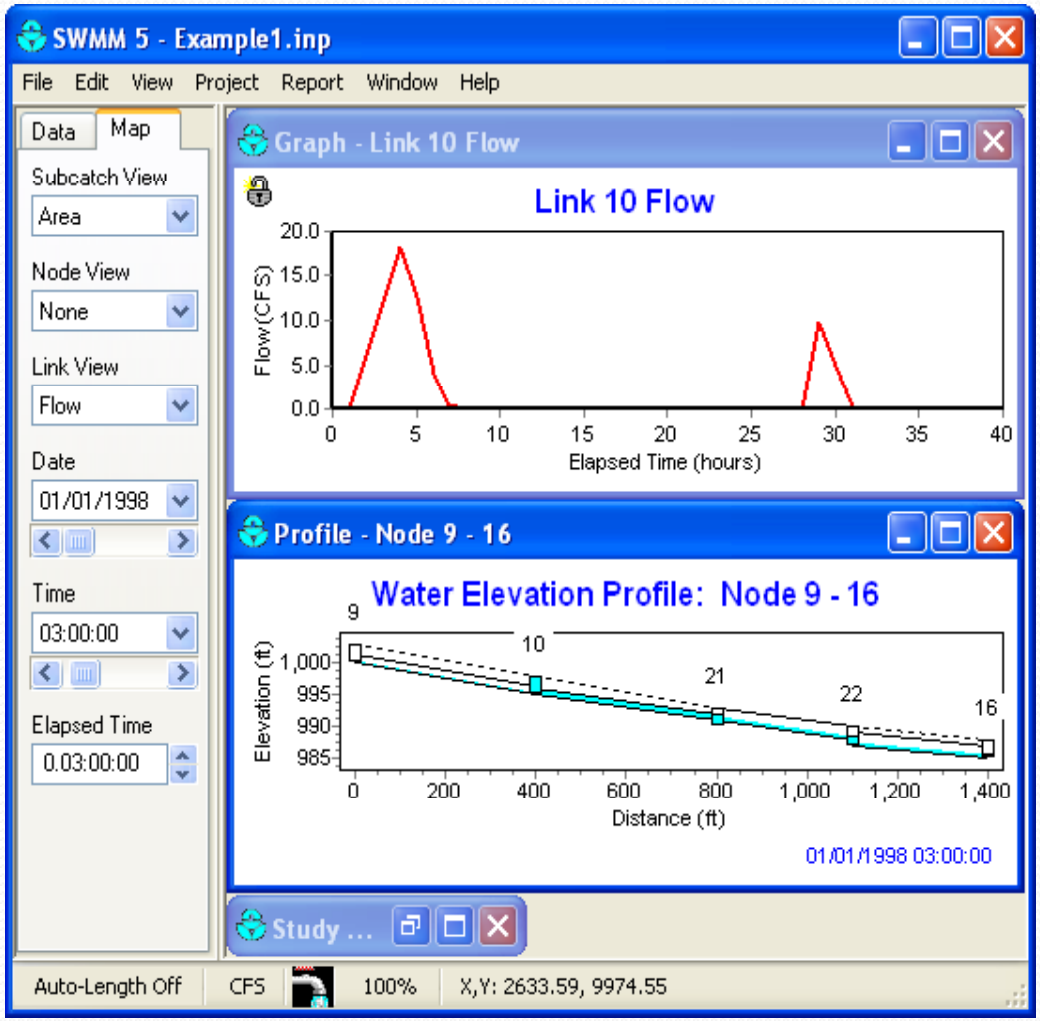
STEPS IN RUNNING SWMM 5

- **Draw drainage system objects**
- **Edit their properties**
- **Set analysis options**
- **Run a simulation**



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**

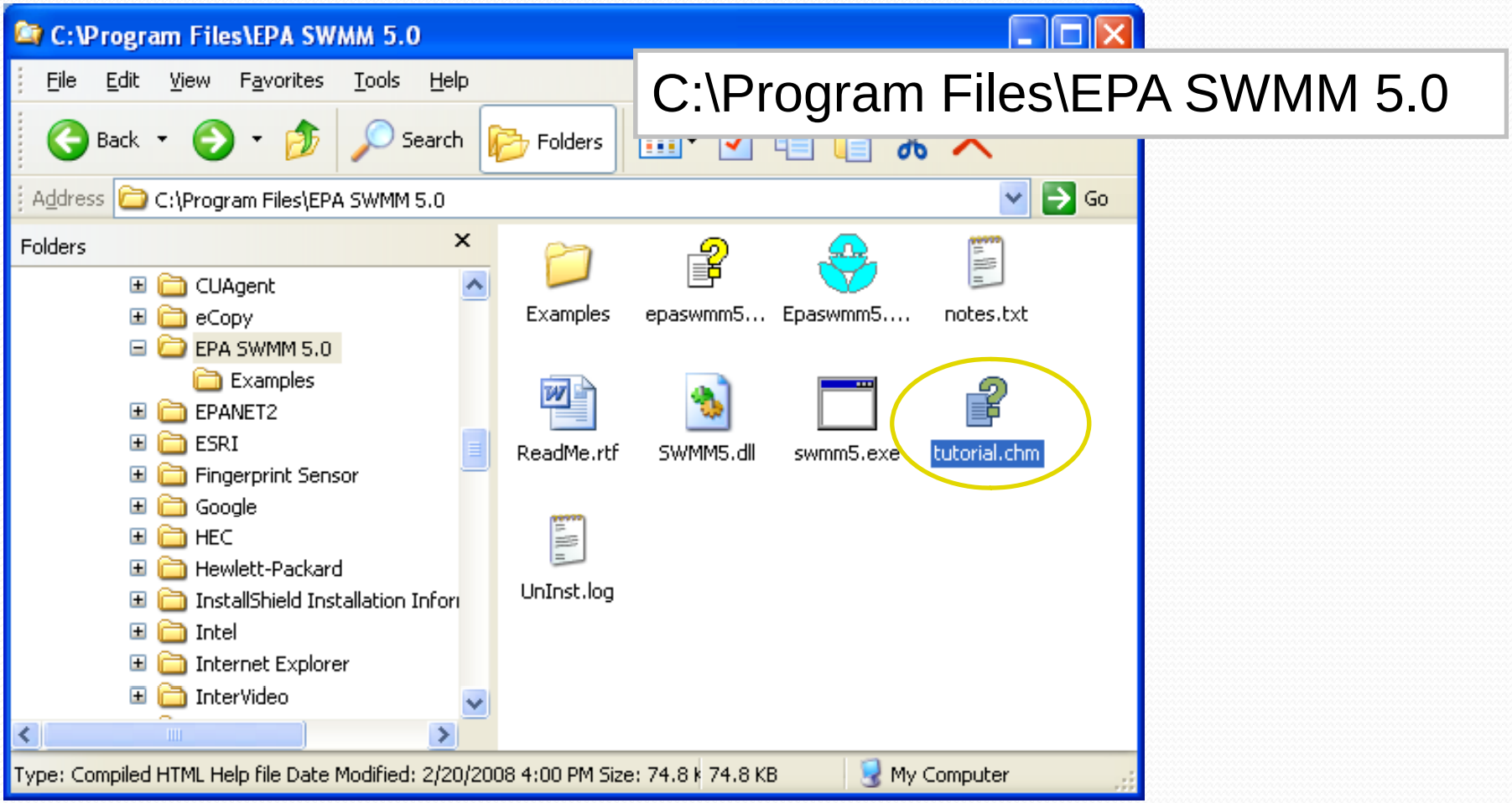


SWMM Tutorial Exercise –

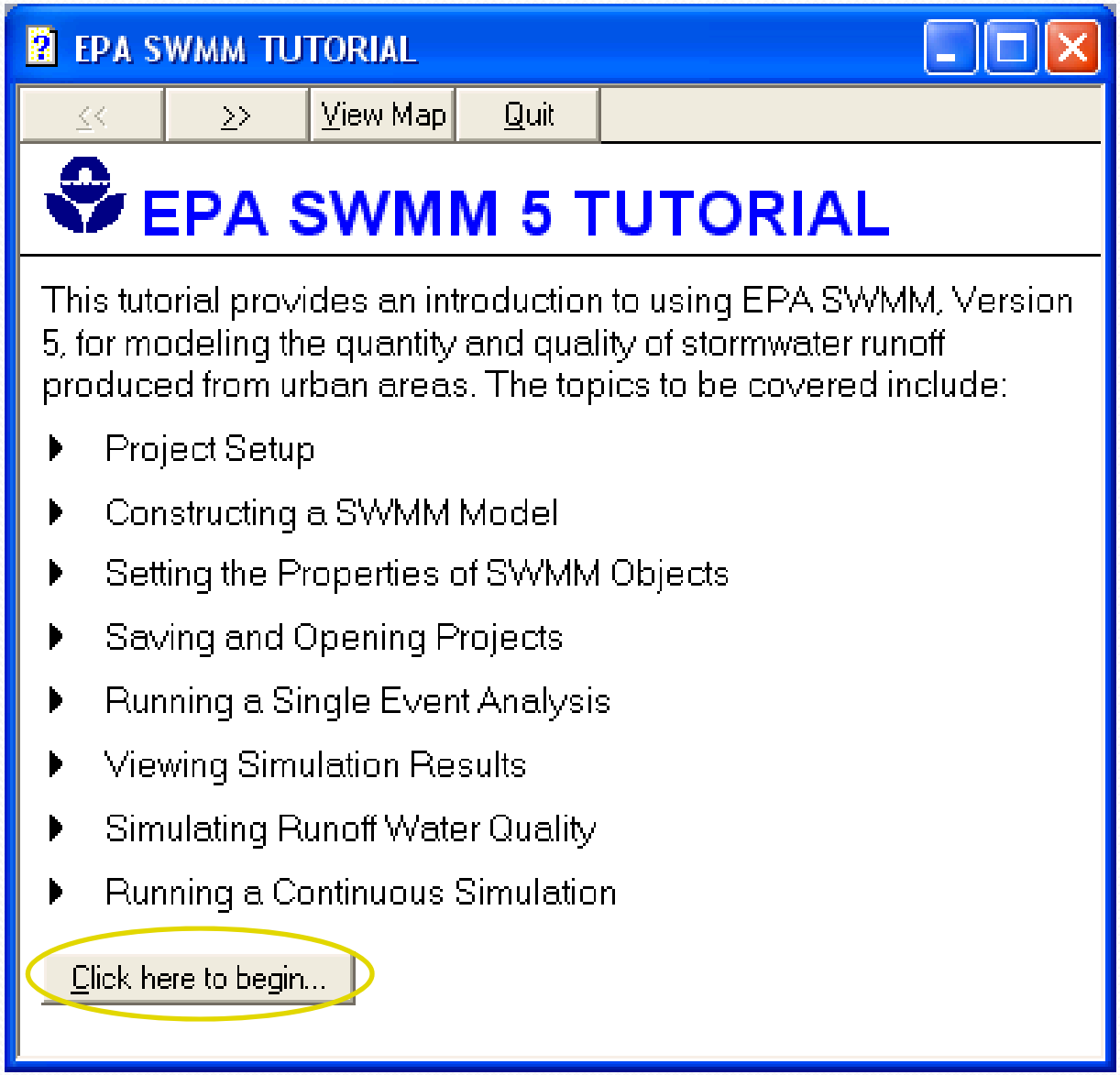
Robert Murdock (Michael Baker Jr., Inc.) 9:15 – 10:15

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



SWMM TUTORIAL



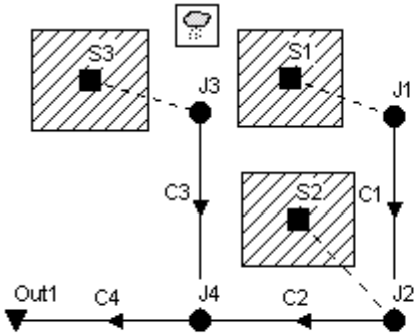
SWMM TUTORIAL

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 Note, 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.

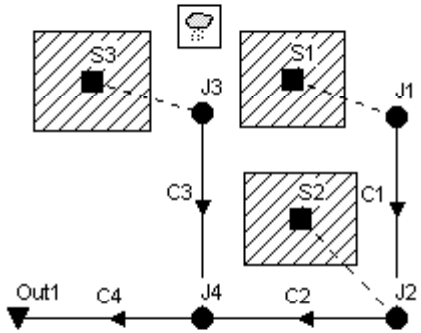


Tutorial Example

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.

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 << 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 the word Note where it appears.

Study Area Map



Tutorial Example

TIPS

- **Caution: To avoid losing your input data due to computer problems, make a habit of repeatedly saving the input (*.inp) file**
- **Create a folder SWMM5_tutorial on your C:drive**
- **After completing step 1 (Project Setup), save using File>Save As menu option. Save as tutorial.inp file in C:\SWMM5 folder**
- **After completing each subsequent step, save using >Save menu option**

Time 9:15 to 10:15

Tutorial Goal: Work through tutorial through “Running a Dynamic Wave Analysis”.

If you finish early, you may proceed through ““Simulating Water Quality”, to the end.

BREAK

Be back in 15 minutes

Site Development Exercise –

Gregory Kacvinsky (Foth Infrastructure & Environment, LLC)
10:30 – 11:20

- Existing Site Characteristics
  - *Developer's Goals*
- Design Standard Overview
  - *What controls will we need to demonstrate with the EPA SWMM model?*
- Site Fingerprinting
  - *Identify and protect onsite environmental features*
  - *Make this a true* ***<u>Low Impact Development</u>***

Existing Site and Land Use Intent –

Gregory Kacvinsky (Foth Infrastructure & Environment, LLC)

- Developer's goals
  - 10-acre parcel (660 feet square)
  - Minimum density of 2.8 units/acre (28 units minimum)
  - Residential
  - Single entrance from road along north side
  - Must include street stubs to south and west to serve future planned developments *(commercial properties planned west and south of development, along south bank of channel)*

Existing Site and Land Use Intent – Continued

- Local Rules
  - Standard R.O.W. width is 60 feet for local roads
  - Standard street width is 30 feet (face-face)
  - Minimum residential lot size is 8,000 sq. ft.
  - Low Impact Development Ordinance (allows variance from street/R.O.W./lot size minimums):
    - 50-foot R.O.W.
    - 24-foot edge-edge (pavement without curb)
    - Minimum 6,000 sq. ft. lots (minimum 50’ frontage)

Existing Site and Land Use Intent – Continued

- Other considerations
  - Pedestrian/bicycle pathway desired to connect developments
  - Offsite drainage (from areas east and south)
  - Existing drainage channel
    - 1.5:1 (horiz:vert) sideslopes

Design Standard Overview –

Robert Murdock (Michael Baker Jr., Inc.)

- What are the local design standards that will impact the development?

Design Standard Overview – Continued

- Local Design Standards
  - Stormwater Quantity:
    - 0.15 cfs/acre (100-year storm)
  - Stormwater Quality:
    - 100% infiltration for 1-year, 1-hour duration storm, AND
    - Maintain 90% of pre-development infiltration under proposed conditions (8-month rainfall series)

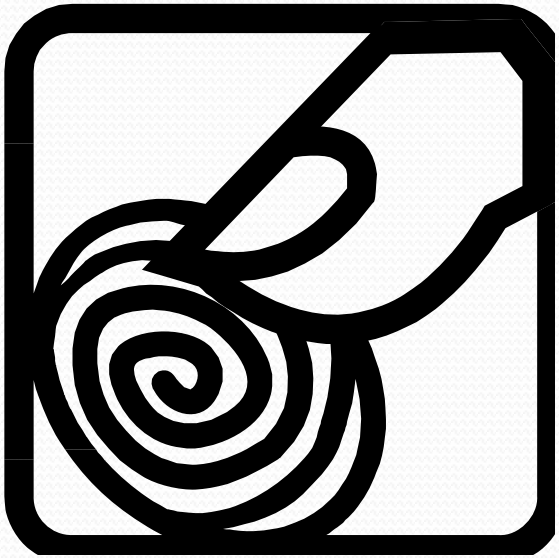
Design Standard Overview – Continued

- Local Design Standards
  - Detention in floodplains
    - Assume 10-yr high-water boundary condition in stream during design (100-year) storm

Site Fingerprinting –

Robert Murdock (Michael Baker Jr., Inc.)

- What is “site fingerprinting”?



Site Fingerprinting – Continued

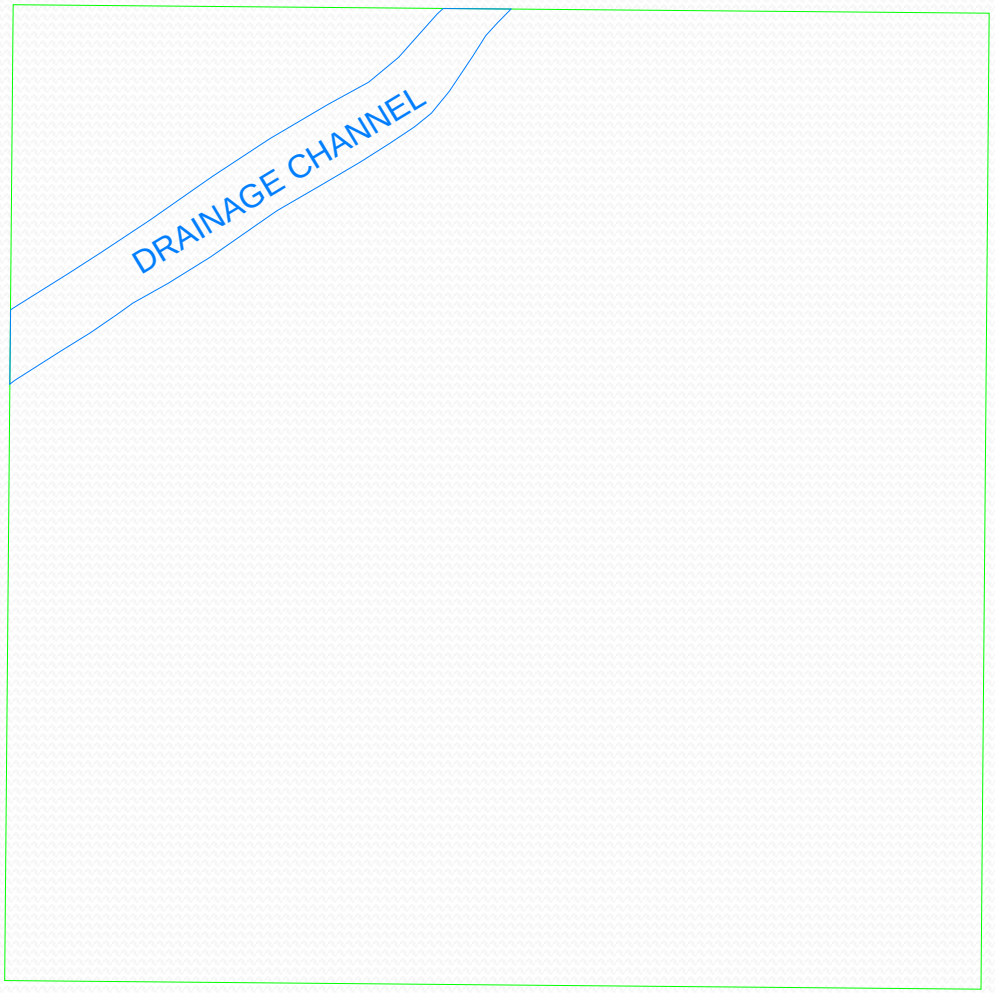
- Identify on-site and nearby environmental features and issues
  - Contamination
  - Floodplain
  - Wetlands
  - Woodlands
  - Endangered Species
  - Archeological

Site Fingerprinting –

Continued

Site Fingerprinting –

Continued

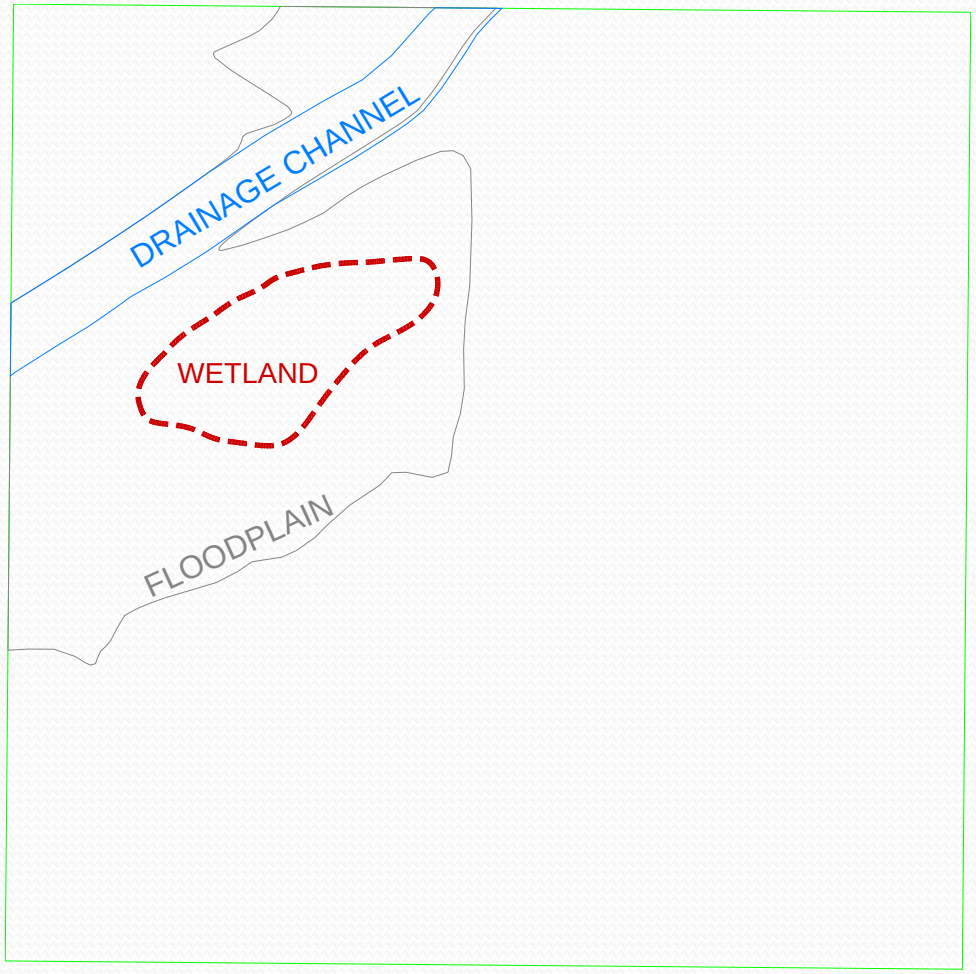


Site Fingerprinting –

Continued

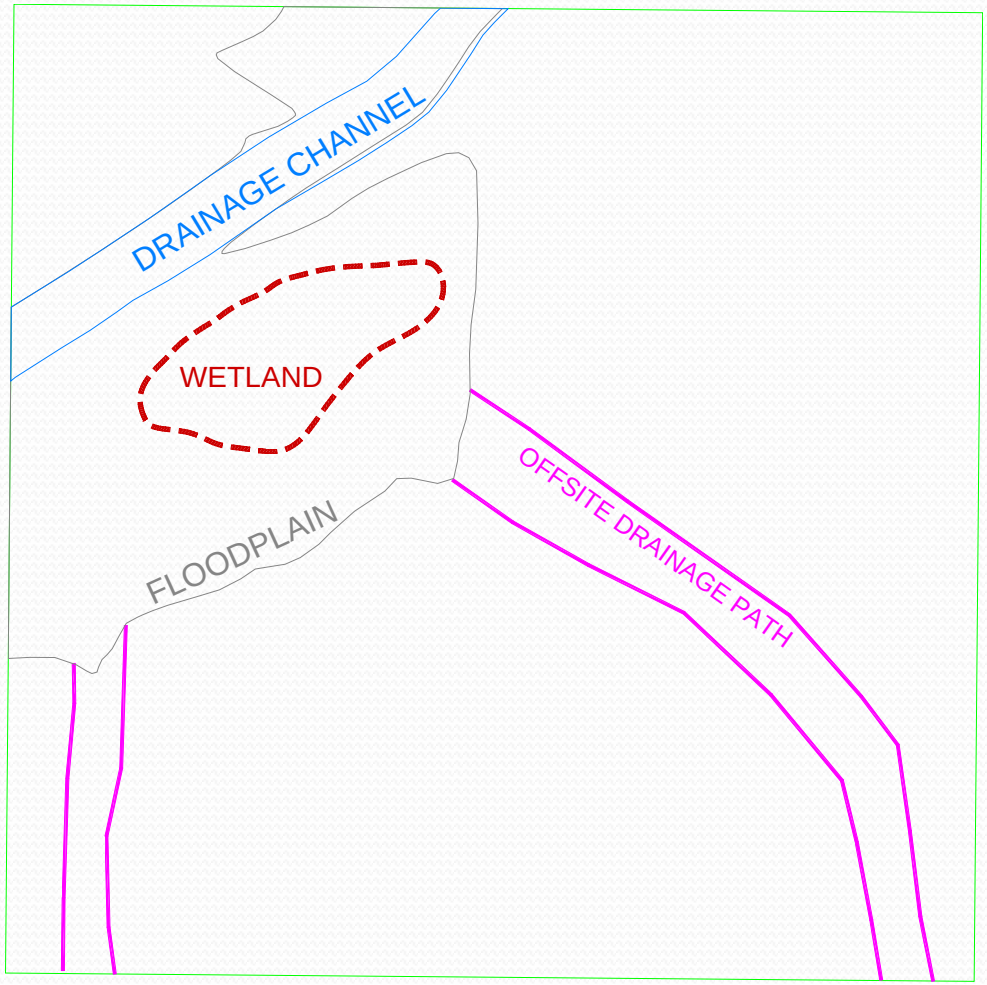
Site Fingerprinting –

Continued



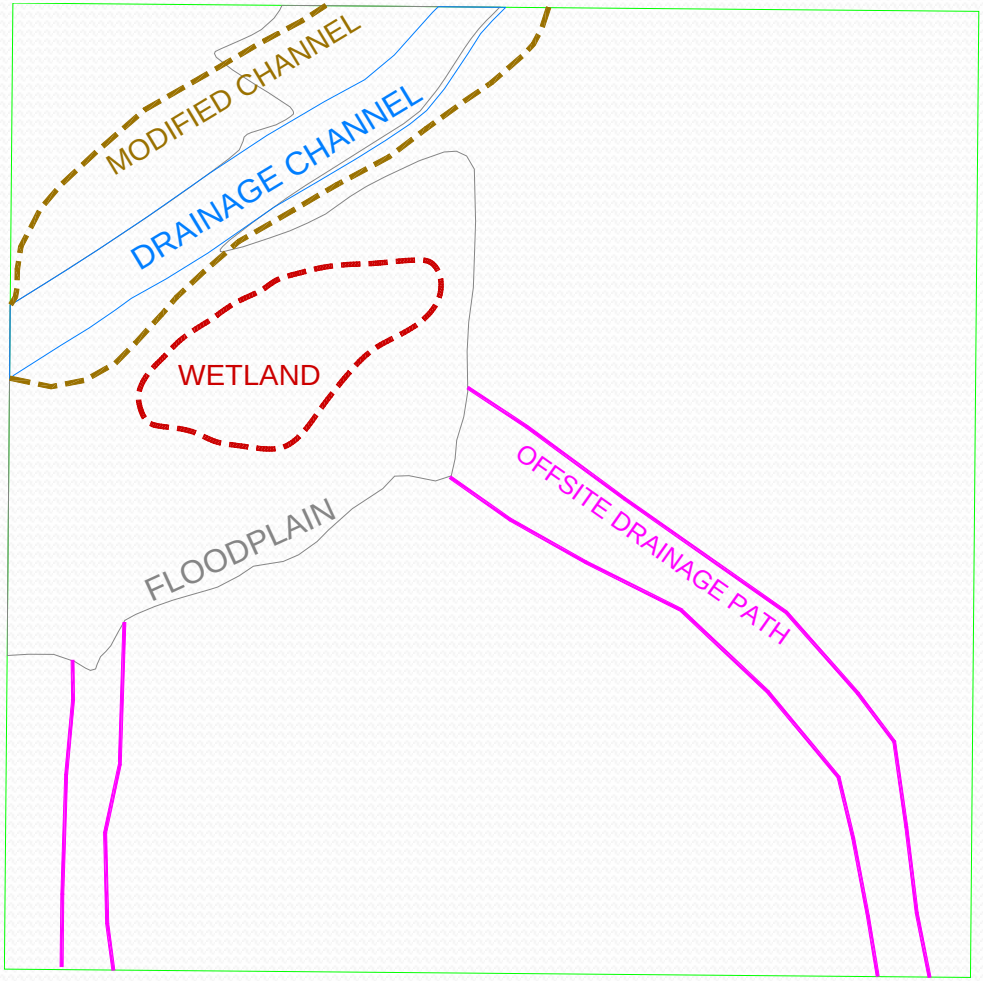
Site Fingerprinting –

Continued



Site Fingerprinting –

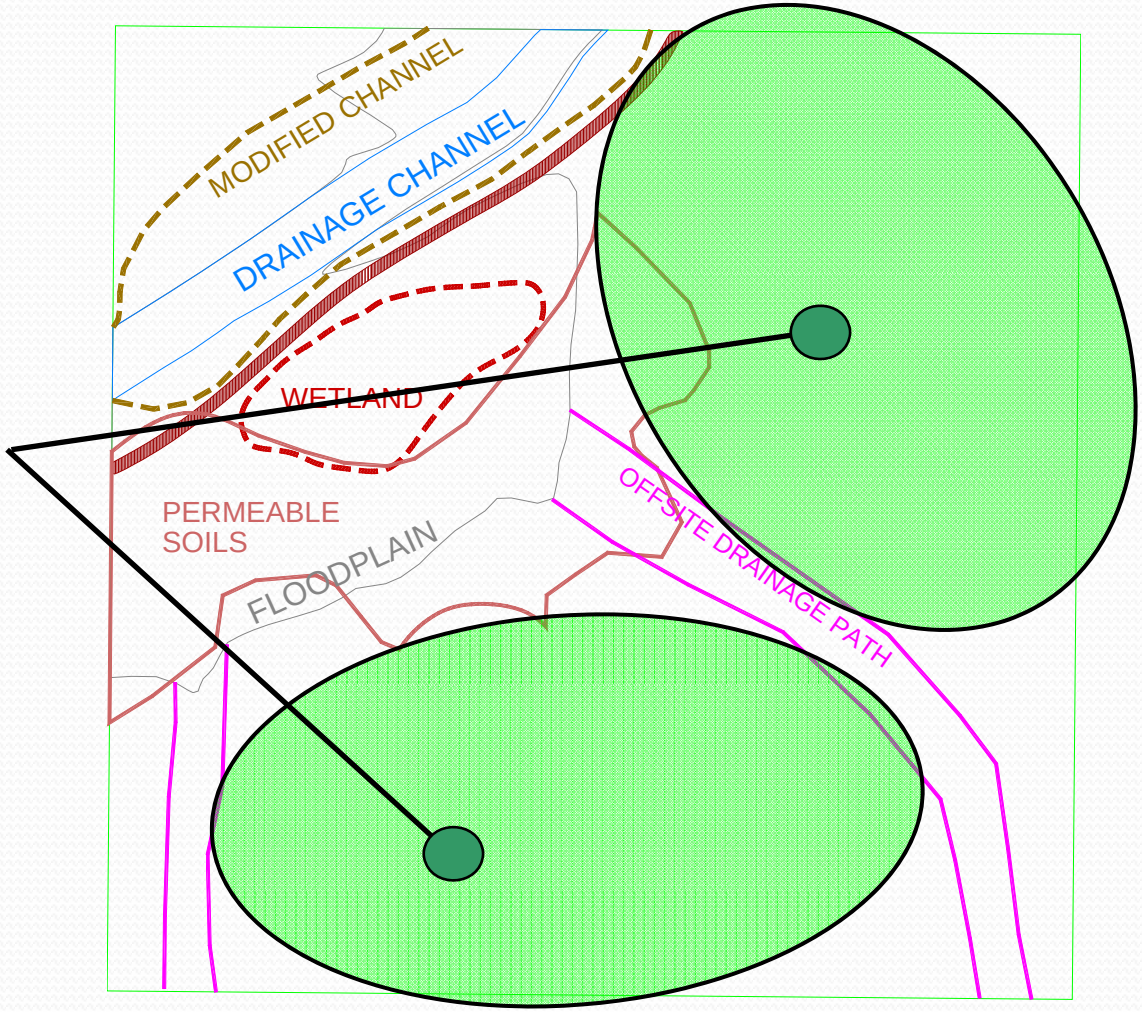
Continued



Site Fingerprinting –

Continued

Focus development outside of sensitive areas



Site Fingerprinting – Continued

- Identify permeable soils
  - USDA/NRCS Soils Maps (available online)
    - A first step only
  - Geotechnical investigation
    - Soil borings (soil type and groundwater level)
    - Permeability tests

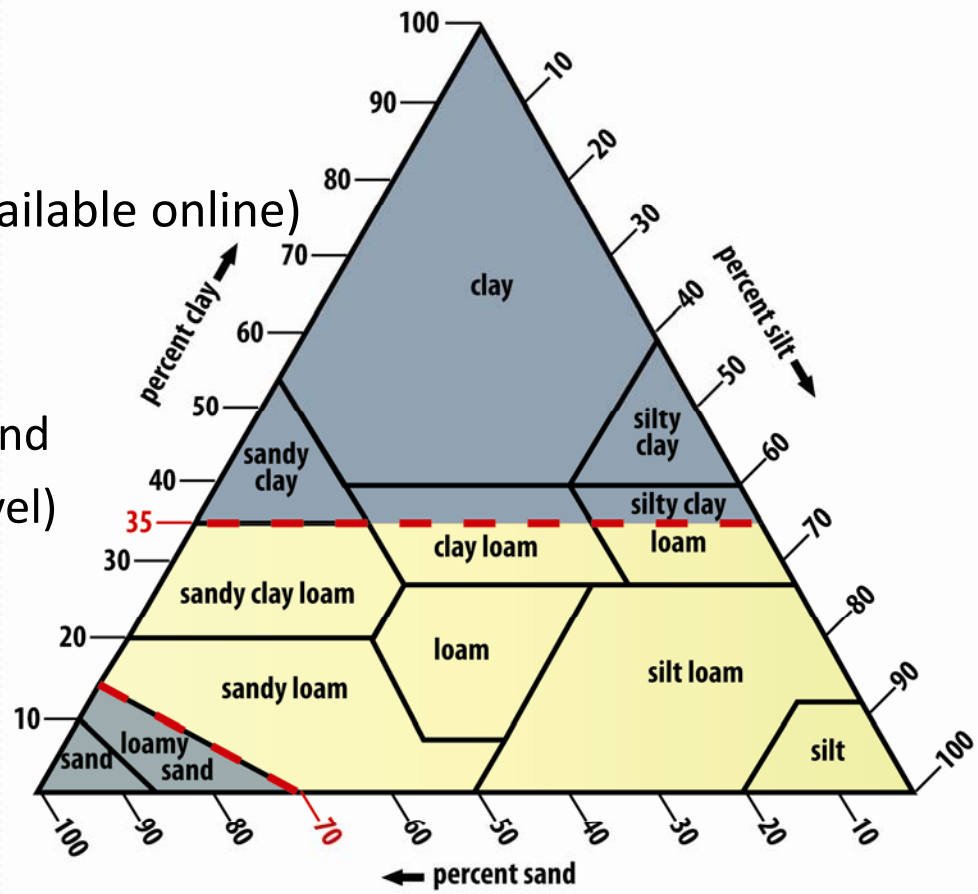
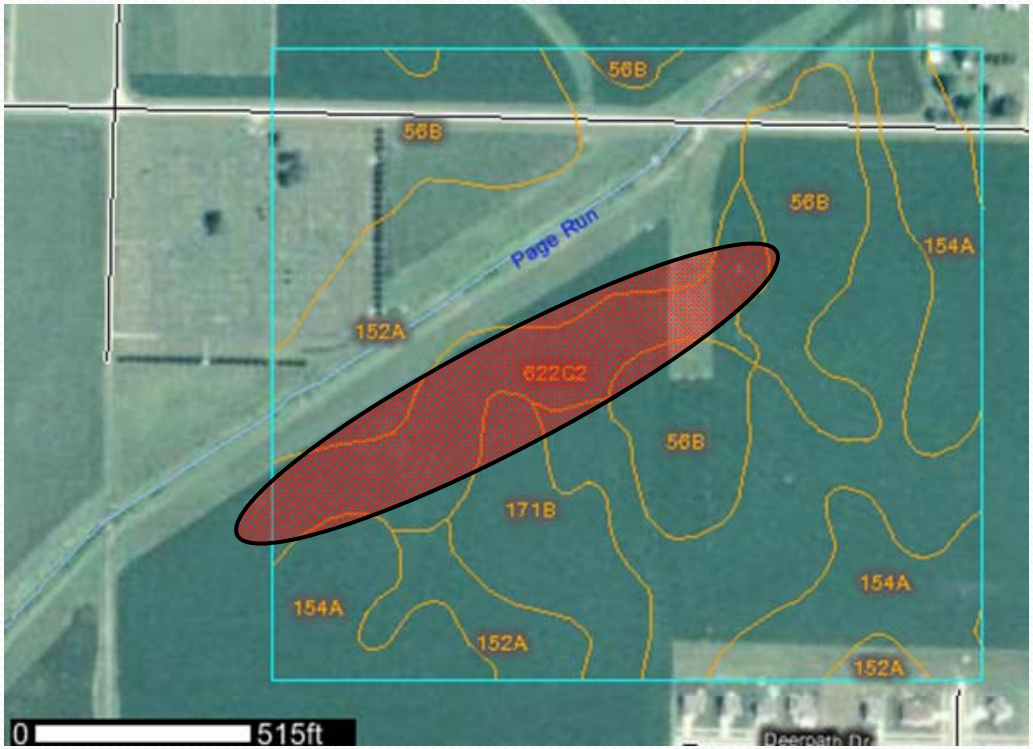


Chart showing the percentages of clay, silt and sand in the basic textural classes.

Site Fingerprinting –
Continued

- USDA-NRCS Soils Map
  - 622G2 is of interest (more permeable)
  - Remaining soil types consist of SILTY CLAYS, poorly- to moderately-drained



Site Fingerprinting – Continued

- USDA-NRCS Soils Data
  - 622G2
    - Wyanet silt loam
    - Depth to restrictive feature: 80 inches
    - Drainage class: well-drained
    - Capacity of the most limiting layer to transmit water (Ksat): Moderately high (0.40 to 0.60 in/hr)
    - Depth to water table: >80 inches
  - Typical Profile:
    - 0-8 inches: silt loam
    - 8-26 inches: clay loam
    - 26-34 inches: loam
    - 34-60 inches: loam

Site Fingerprinting – Continued

- Geotechnical data
  - S-1: Silty loam, Ksat <0.50 in/hr
  - S-2: Clayey Silt, Ksat <0.10 in/hr
  - S-3: Clayey Silt, Ksat <0.20 in/hr
  - S-4: Silty Clay, Ksat <0.05 in/hr
  - S-5: Silty Clay, Ksat <0.1 in/hr
  - *Water table for all samples gener the surface*

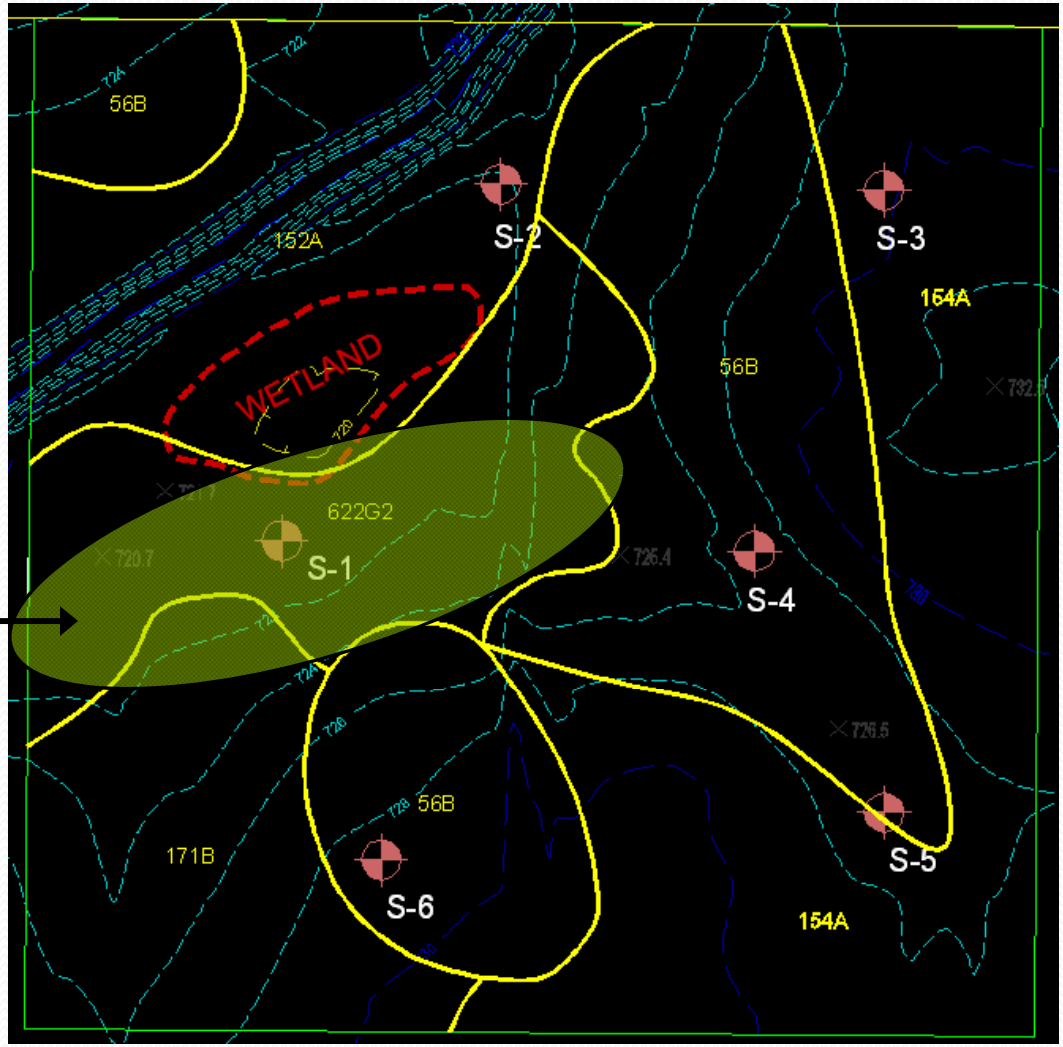
S-4

VISUAL SOIL CLASSIFICATION	FT.	SAMPLE NO.	N	Q_p (tsf)	Q_u (tsf)	MC (%)	Dd (pcf)	REMARKS
7" Topsoil		1-AU	-	-	-	27	-	
Brown silty CLAY (CL)		2-SS	7	2.0	2.2	31	96	
	5	3-SS	5	1.0	1.4	17	95	
Brown silty CLAY with sand and small gravel (ML-CL) Till		4-SS	14	2.5	5.2	15	105	
	10	5-SS	15	2.3	4.2	13	120	
Gray silty CLAY with sand and small gravel (CL) Till		6-SS	18	4.5+	7.4	11	128	
	15	7-SS	18	4.0	5.9	12	128	Completion: 15 ft.
	20	8-SS	16	4.0	4.2	12	109	Drilling: 20 ft.
END OF BORING AT 21.5 FEET								

Site Fingerprinting –

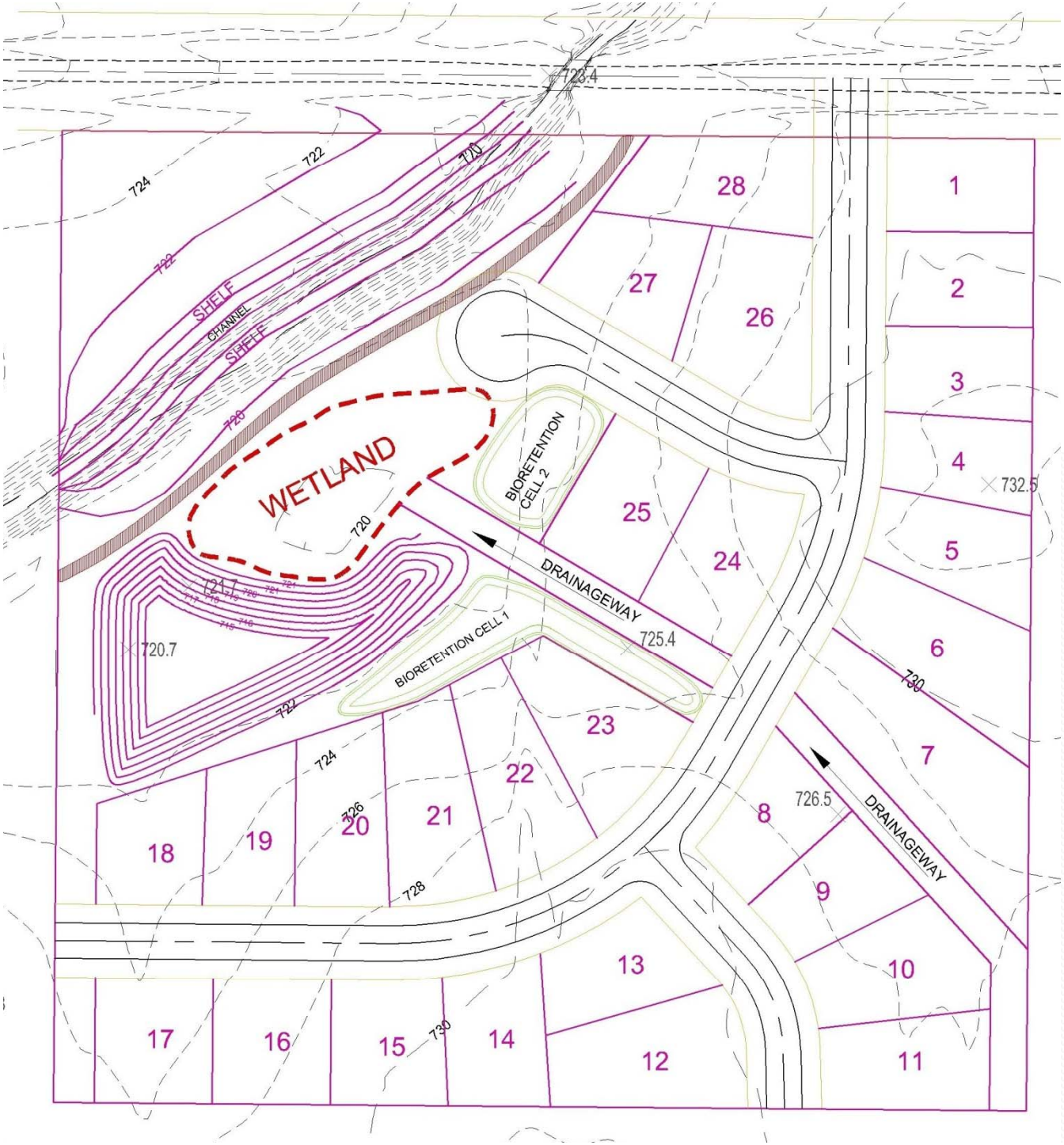
Continued

Ideal location for infiltration BMPs



Proposed Site Layout –

Gregory Kacvinsky (Foth Infrastructure & Environment, LLC)



- Proposed site:
  - About 70% of site developed
  - 30% left as open space
  - Offsite drainage bypasses stormwater management system
  - Wetland hydrology maintained
  - Channel modification (reduced erosion potential)
  - Developer's unit count goal is met

Stormwater Modeling –

Gregory Kacvinsky (Foth Infrastructure & Environment, LLC)

- TIME TO MODEL
  - What do we need to accomplish with modeling effort?
    - Existing conditions (total runoff volume for 8-month rainfall)
    - Proposed conditions
      - 1-year, 1-hour storm → do we have zero runoff?
      - 100-year storm → 0.15 cfs/acre?
      - Long-term rain data set → 90% of predevelopment infiltration?

Stormwater Modeling –

Gregory Kacvinsky (Foth Infrastructure & Environment, LLC)

- What we'll cover today
  - Establish hydrologic components
    - Subbasins and hydrologic variables
  - Establish storage components
    - Detention pond and bioretention storage
  - Establish bioretention characteristics
    - Infiltration variables
  - Establish hydraulic components
    - Pipes, outlet structures

Stormwater Modeling – Continued

- What we'll cover today (cont.)
  - Set up rainfall data and model run parameters
  - Run the EPA-SWMM model
    - Single "design" events (1-yr, 1-hr and 100-yr, 24-hr)
    - Continuous simulation (8 months of rainfall data)
  - Common model pitfalls and debugging strategies
  - Interpreting results
  - Creating figures and processing output data (if time permits)

Stormwater Modeling –
Continued

- PROPOSED CONDITIONS MODEL (before lunch)
  - Create EPA SWMM project file
  - Import background image and set coordinates
  - Review model defaults and adjust as necessary
  - Establish rainfall time series
  - Create subcatchments and begin to define hydrologic variables

Stormwater Modeling – Continued

- **Catchment 1**
- Street, swale runoff to Bioretention Cell 1
- No storm sewers

Stormwater Modeling – Continued

- **Catchment 1 Hydrologic Variables**
  - Width (already measured…550’)
  - Slope (already measured…2%)
  - Percent impervious
    - Typically 30% - 35%, but higher density increases % impervious to 50%
  - N values (per EPA SWMM Help Menu)
    - Impervious: 0.011 to 0.015
    - Pervious: 0.24 to 0.40
  - Depression storage (user preference)
  - Subarea routing (impervious surfaces routed over pervious surfaces)
  - Percent routed (how much impervious surface is “disconnected”?)

Stormwater Modeling – Continued

- **Catchment 1 Hydrologic Variables**
  - Curve Number
    - Represents ONLY pervious surfaces
    - NOT a composite CN
    - Assume Type C soils (developed, compacted) with good stand of grass
      - CN=74

	Hydrologic Soil Group			
	A	B	C	D
Paved parking lots, roofs, driveways	98	98	98	98
Streets and Roads:				
Paved with curbs and storm sewers	98	98	98	98
Gravel	76	85	89	91
Dirt	72	82	87	89
Cultivated (Agricultural Crop) Land*:				
Without conservation treatment (no terraces)	72	81	88	91
With conservation treatment (terraces, contours)	62	71	78	81
Pasture or Range Land:				
Poor (<50% ground cover or heavily grazed)	68	79	86	89
Good (50-75% ground cover; not heavily grazed)	39	61	74	80
Meadow (grass, no grazing, mowed for hay)	30	58	71	78
Brush (good, >75% ground cover)	30	48	65	73
Woods and Forests:				
Poor (small trees/brush destroyed by over-grazing or burning)	45	66	77	83
Fair (grazing but not burned; some brush)	36	60	73	79
Good (no grazing; brush covers ground)	30	55	70	77
Open Spaces (lawns, parks, golf courses, cemeteries, etc.):				
Fair (grass covers 50-75% of area)	49	69	79	84
Good (grass covers >75% of area)	39	61	74	80
Commercial and Business Districts (85% impervious)	89	92	94	95
Industrial Districts (72% impervious)	81	88	91	93
Residential Areas:				
1/8 Acre lots, about 65% impervious	77	85	90	92
1/4 Acre lots, about 38% impervious	61	75	83	87
1/2 Acre lots, about 25% impervious	54	70	80	85

Stormwater Modeling –
Continued

- **EPA SWMM**
  - Hydrology relies on the *Distributed CN Approach*
  - *Composite CN Approach* is not necessarily appropriate for small storm hydrology

Table 1. Example of Runoff Underestimation for a 1.3-Inch (33-mm) Precipitation Event Using Composite CN Versus Distributed CN Approach

Approach	Area, acres *(ha)*	Curve Number	Description	Runoff Depth, in. *(mm)*	Runoff Volume, ac-ft *(ML)*	
Composite CN	20 *(8.1)*	75	¼ ac. *(0.1 ha)* lots, 38% Impervious HSG B	0.1 *(3)*	0.17 *(0.21)*	
Distributed CN	6 *(2.4)*	98	Paved roads, rooftops	1.08 *(27.4)*	0.54 *(0.67)*	0.55 *(0.68)*
	14 *(5.7)*	65	Green spaces with disconnected impervious area interspersed	0.01 *(0.3)*	0.01 *(0.01)*	

Note: HSG = Hydrologic Soil Group

Source: Stormwater Magazine, March-April 2010

LUNCH

Be back by 1:00 ***sharp***

Stormwater Modeling –
Continued (1:00 – 3:00)

- Runoff modeling in SWMM
  - Not the same as TR-20/TR-55/HEC-HMS
  - Pervious and impervious areas treated separately
  - Curve Number in SWMM is NOT the same as in traditional methods
  - More knobs to turn, but more realistic model

Stormwater Modeling –
Continued

- Divide development into two primary subbasins
  - Each draining to a bioretention cell
- Assume offsite flow will bypass bioretention system
  - Will discharge directly to wetland or ditch

Stormwater Modeling –
Continued

- PROPOSED CONDITIONS MODEL (after lunch)
  - Complete subcatchment data calculations
  - Create storage nodes (detention and bioretention)
  - Define storage volumes
  - Define infiltration parameters for bioretention
  - Create hydraulic links between storage areas
    - Overflows
  - Create detention pond outlet pipe
    - Define outfall characteristics

Stormwater Modeling – Continued

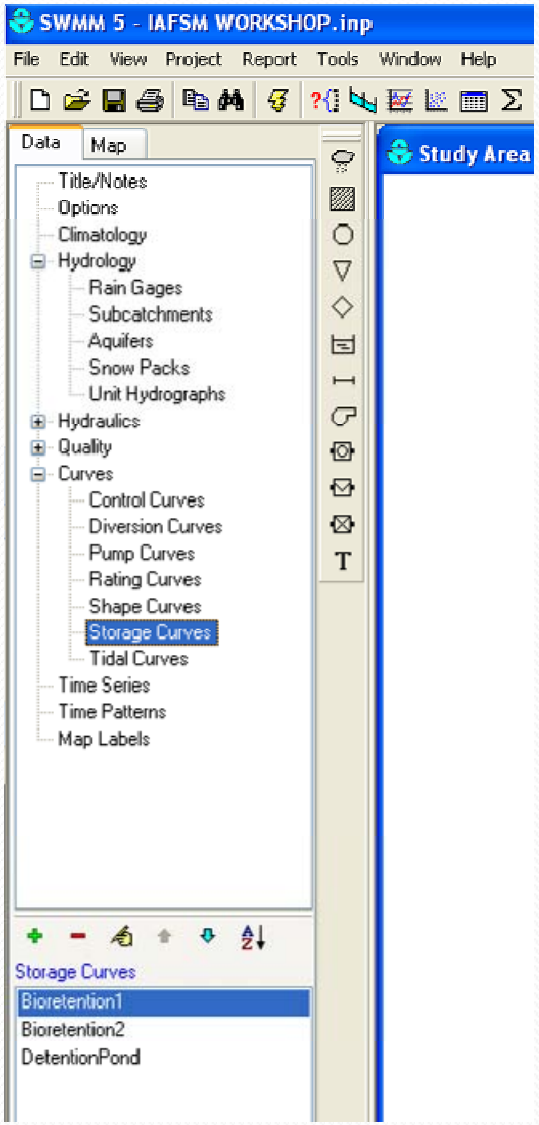
- Define Storage for Detention Basin and Bioretention
  - Build Storage Curves for each storage node

Bioretention Cell 1

Depth (ft)	Area (sq. ft.)
0	2800
1	4800
1.3	5300

Bioretention Cell 2

Depth (ft)	Area (sq. ft.)
0	2800
1	3800
1.3	4100

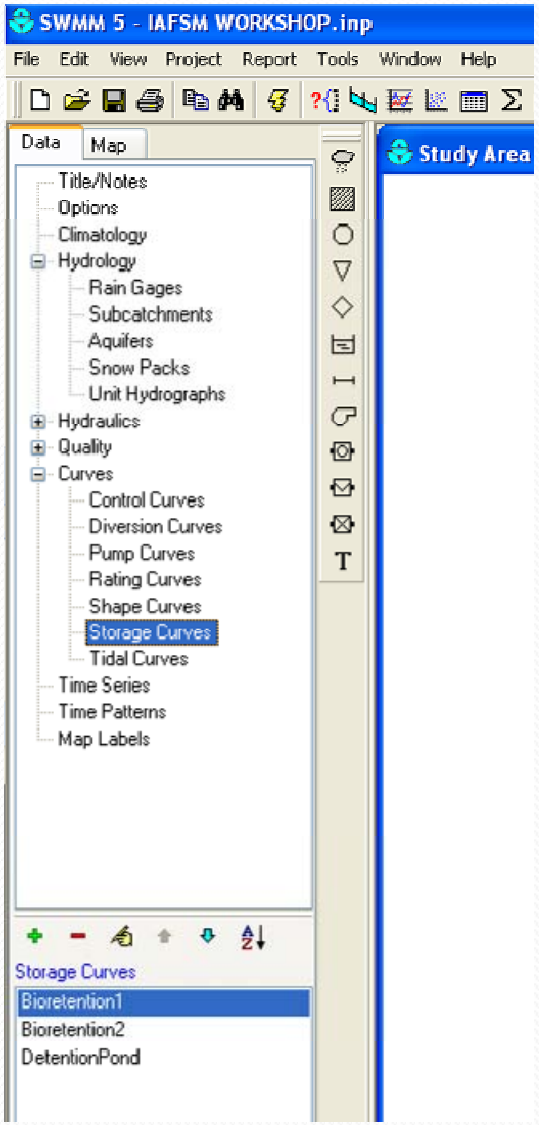


Stormwater Modeling – Continued

- Define Storage for Detention Basin and Bioretention
  - Build Storage Curves for each storage node

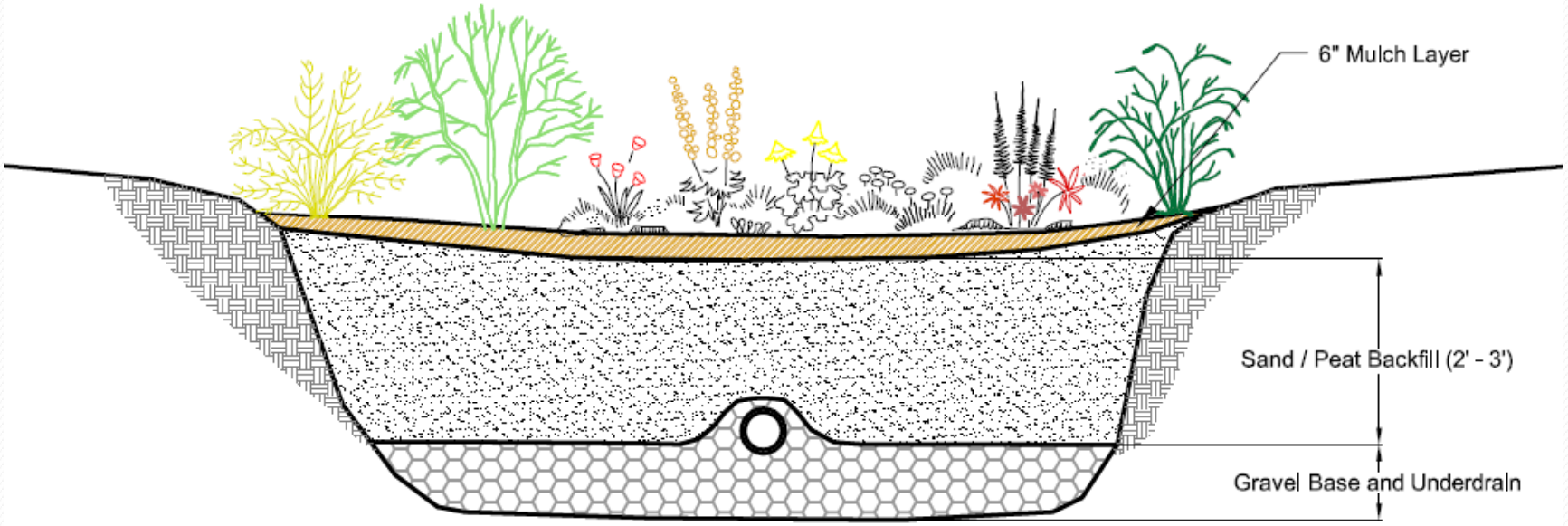
Detention Pond

Depth (ft)	Area (sq. ft.)
0	5500
1	8000
3	13000
5	18000
7	23500

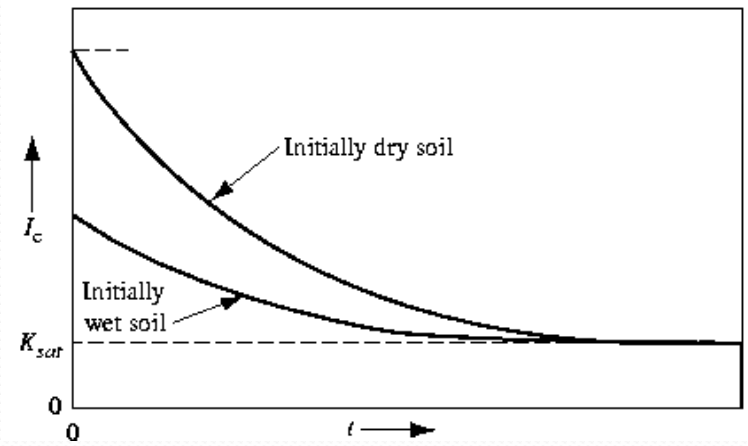


Stormwater Modeling –

Continued



Stormwater Modeling – Continued



- Bioretention modeling:
  - Establishing infiltration criteria
    - Green-Ampt method
      - **Conductivity (in/hr): Ksat (saturated soil conductivity)**
        - MOST IMPORTANT VARIABLE
        - Should be at least 0.3-0.4 in/hr for effective infiltration
      - Suction Head (ft): capillary suction
        - Higher for fine-grained soils
      - Initial deficit (fraction): lower for saturated soils
        - Typically 0.2 – 0.5 (lower for wet soils)

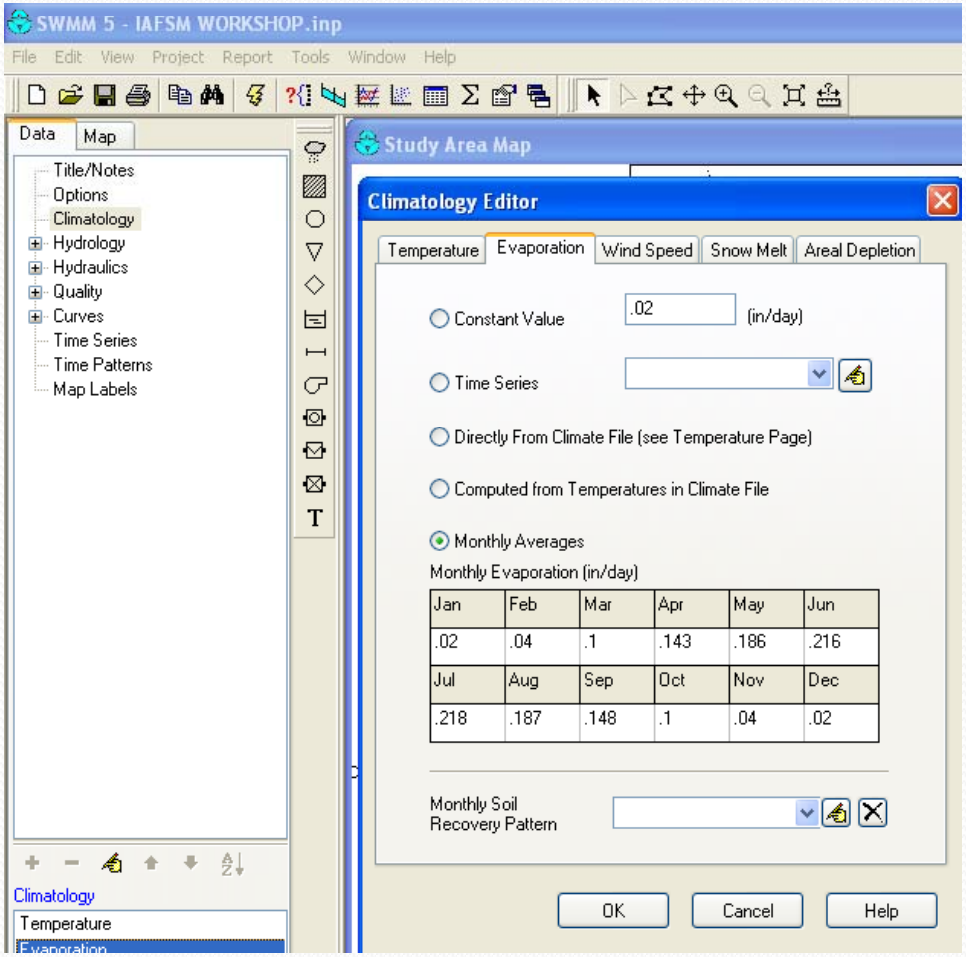
Stormwater Modeling – Continued

- Evaporation
  - Not insignificant when modeling long-term rainfall
    - Summer months, daily evaporation can exceed 0.2 inches per day (in Illinois)
    - After bioretention area fills, evaporation can account for up to 2% of drawdown rate
  - Insert monthly average evaporation rates

Stormwater Modeling –

Continued

- Evaporation



Stormwater Modeling – Continued

- Bioretention Modeling – Elevations
  - Perch above hydraulic influence of detention pond
  - Bioretention elevation = 720 to 721
    - Detention pond elevation range: 714 - 721
- Bioretention Modeling – Overflow
  - Bioretention designed for 12 inches of vertical storage
  - Any additional depth overflows to detention pond
    - Bioretention Cell 1 via overland flow
    - Bioretention Cell 2 via pipe (need to bypass drainageway)

Stormwater Modeling – Continued

- Detention Pond
  - Dual outlet (orifice and overflow weir)
  - Both orifice and overflow weir drain through main outlet pipe
  - Additional considerations:
    - Wet vs. Dry
    - If dry, model infiltration?

Stormwater Modeling –
Continued

- EXISTING CONDITIONS MODEL
  - Add catchment representing pre-developed area
  - Add separate outlet to receive and calculate runoff volume
  - Assign appropriate Curve Number
  - Run model under 8-month rainfall scenario
    - Review output for total infiltration

Stormwater Modeling – Continued

- Running EPA SWMM and Data Analysis
  - Event-based analysis
    - Meet local flood control criteria?
    - Meet infiltration criteria?
  - Continuous simulation
    - Are we infiltrating 90% of pre-developed infiltration?

Stormwater Modeling – Continued

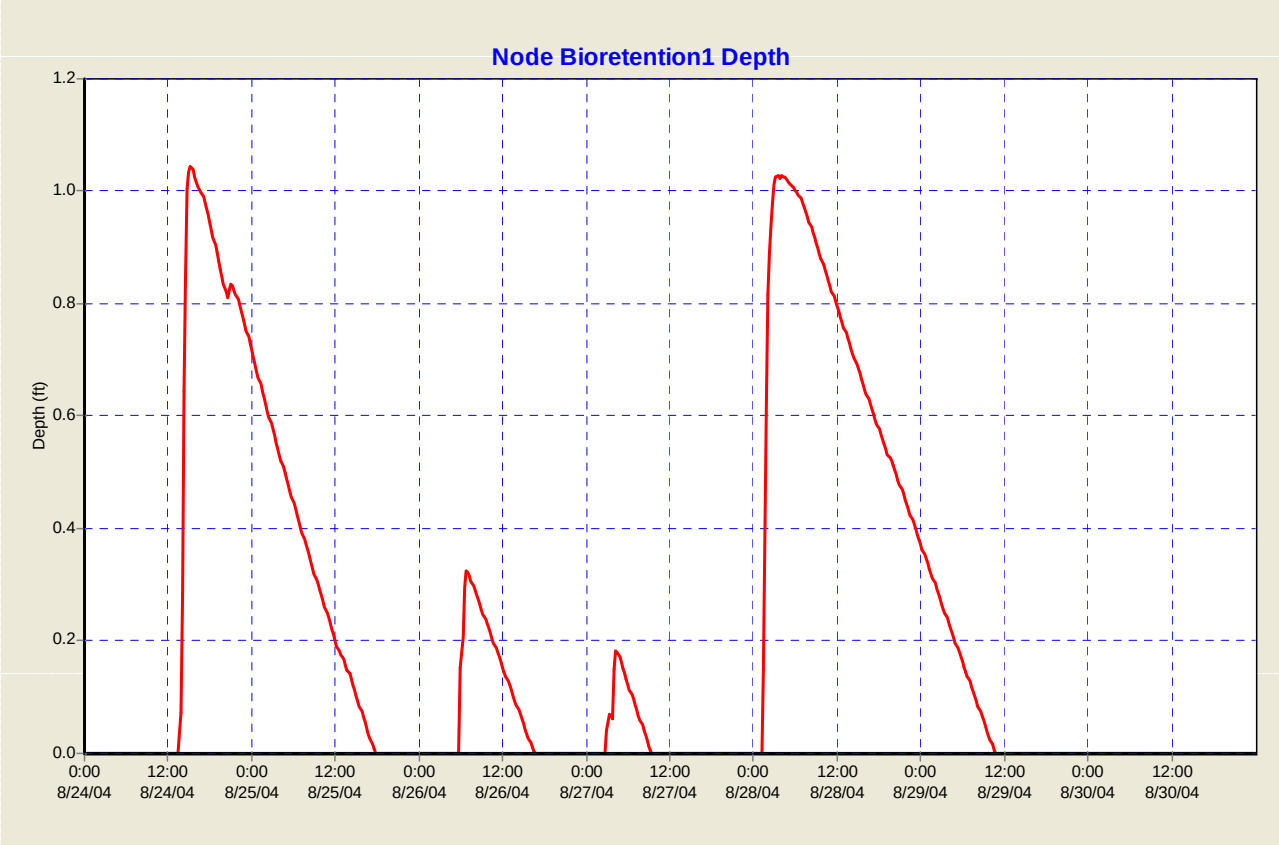
- Bioretention modeling:
  - Quantify infiltration volume using EPA-SWMM output data

Stormwater Modeling – Continued

- Bioretention modeling:
  - Quantify infiltration volume using EPA SWMM output data
    - Existing Conditions infiltration volume = 17.1 ac-ft
    - Proposed Conditions:
      - Total rainfall volume – Total Discharge to Outlet
      - 18.2 ac-ft – 2.5 ac-ft = 15.7 ac-ft
        - *(1 MG = 3.069 ac-ft)*
      - 15.7 / 17.1 = 91.8% of existing infiltration

Stormwater Modeling – Continued

- Viewing Results



Stormwater Modeling – Continued

- Infiltration Calculations:
  - Existing conditions infiltration…many ways to calculate
    - What infiltration method do you use?
      - CN?
      - Horton?
      - Green-Ampt?
    - CN = 75, Infiltration = 17.1 ac-ft (we score 91.8%)
    - CN = 72, Infiltration = 17.4 ac-ft (we score 90.2%)
    - Horton, Infiltration = ?
    - Green-Ampt, Infiltration = ?

Stormwater Modeling – Continued

- Not meeting water quality (infiltration) criteria?
  - Consider the following (TAKE-HOME EXERCISE):
    - Overestimating existing infiltration? Is your curve number high enough?
    - Increase % of "disconnected" impervious areas (25% in our model)
    - Design (and model) the main detention pond to accept infiltration (requires dry pond)
    - Add rain barrels to subdivision (assume 1 rain barrel per house)
      - Even 1 rain barrel per home can treat up to 15%-20% of impervious surfaces

Stormwater Modeling – Continued

- Other Take-Home Exercises
  - Export (copy) runoff/depth data to Excel and manipulate data as desired
  - Review impact of tweaking infiltration parameters on bioretention performance:
    - Capillary suction
    - Initial deficit
    - Saturated soil conductivity
  - Attempt to model other LID Controls (porous pavement)
  - Practice on your own designs

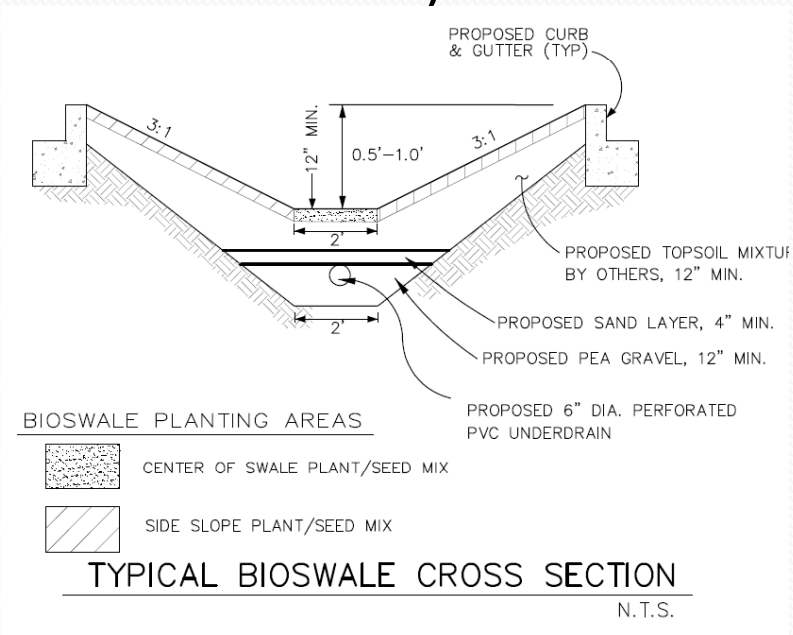
BREAK

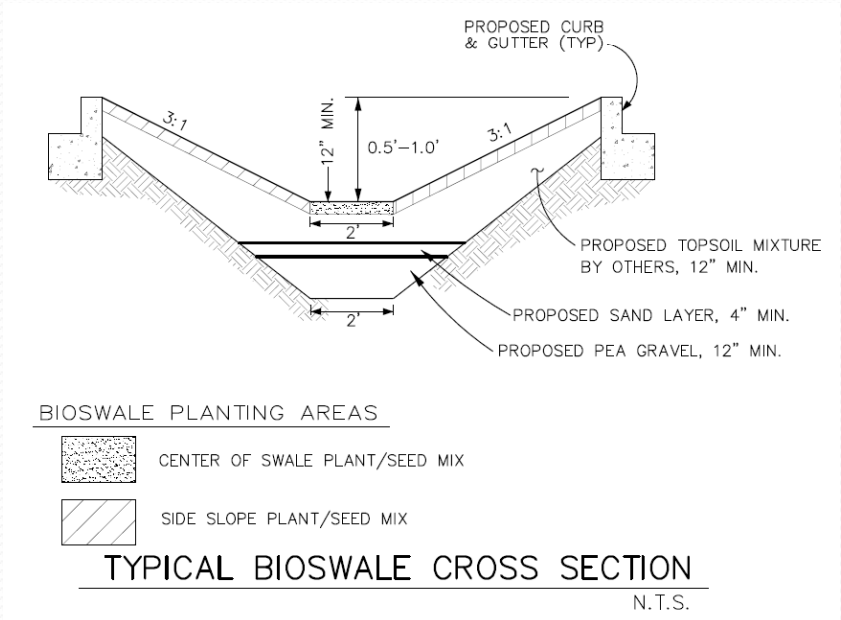
Be back in 15 minutes

Plans, Specs & Long-Term Maintenance

Greg Kacvinsky / Bob Murdock (3:15 – 3:45)

- Key design considerations for final plan development
  - Bioretention plans and cross sections (underdrain or no underdrain?)

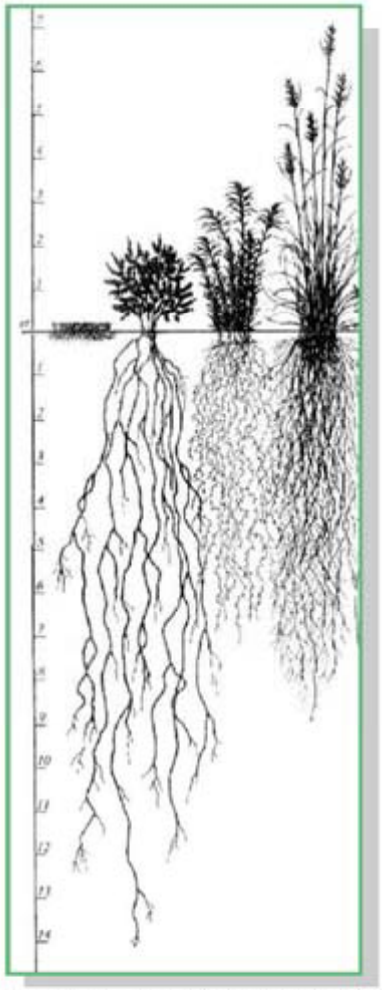




Plans, Specs & Long-Term Maintenance

Continued

- Key design considerations for final plan development
  - Specifications for excavation, backfill, and plant schedule
  - Upon excavation disc sub-soil
  - Do not compact backfill
  - Backfill to consist of combination sand, peat and mulch
  - Use deep rooted vegetation to increase permeability and evapotranspiration
  - Construct bioretention AFTER establishment of permanent vegetation on site



Root length of conventional turf grass (left)as compared to native plant roots (right).

Plans, Specs & Long-Term Maintenance

Continued

- Key design considerations for final plan development
  - Choose plants that will tolerate the proposed hydrology.
  - Choose salt tolerant plants.
  - Provide an alternate area to plow snow. Don't plow snow on top of bioretention areas.

Table 1
Plant/Seed Mix

Scientific Name	Common Name	Lbs/Ac	Plugs/Ac
Cover Crop:			
Avena sativa	Oats	32.000	
Lolium multiflorum	Annual	10.000	
	TOTAL w/ Cover Crop:	**42.000**	
Permanent Matrix:			
Aster novae-angliae	Aster	0.250	
Bidens cernua	Nodding Bur Marigold	0.250	
Carex hystericina	Porcupine Sedge	0.063	600
Carex scoparia	Lanced Fruited Oval Sedge	0.125	600
Carex stipata	Awl-friuted Sedge	0.125	600
Carex vulpinoidea	Brown Fox Sedge	0.500	1500
Helenium autumnale	Sneezeweed	0.125	
Iris virginica shrevei	Blue Flag Iris		500
Juncus balticus littoralis	Rush		500
Juncus torreyi	Torrey's Rush	0.063	250
Panicum virgatum	Switch Grass	2.000	1000
Physostegia virginiana	Obedient Plant	0.125	
Scirpus atrovirens	Dark Green Rush	0.250	807
Scirpus pendulus	Red Bulrush	0.125	675
Solidago riddelli	Riddell's Goldenrod		600
Verbena hastata	Blue Vervain	0.250	250

Plans, Specs & Long-Term Maintenance

Continued

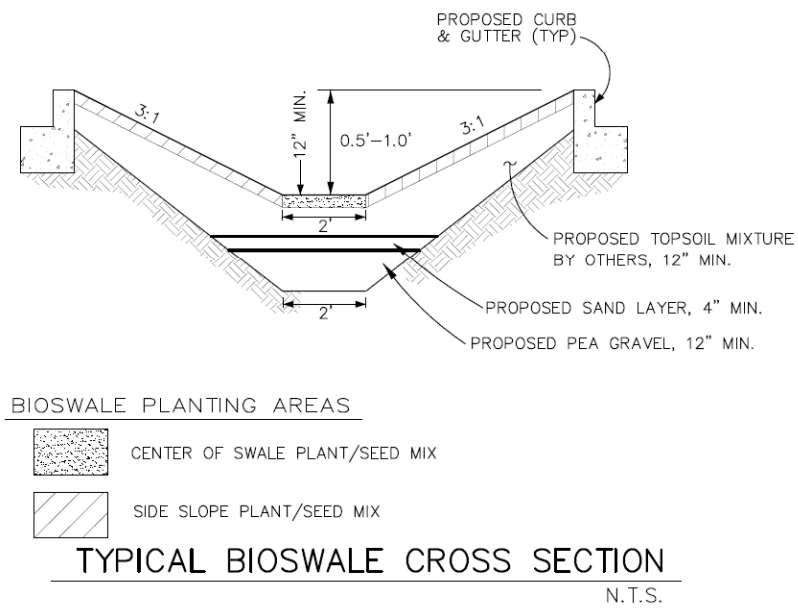


Table 2
Bioswale Side-Slope Plant/Seed Mix

Scientific Name	Common Name	Lbs/Ac	Plugs/Ac
Cover Crop:			
Avena sativa	Seed Oats	32	
Lolium multiflorum	Annual	10	
	TOTAL w/ Cover Crop:	**42**	
Permanent Matrix:			
Andropogon scoparius	Little Bluestem	3.500	500
Aster laevis	Sky Blue Aster	0.125	
Aster nova-angliae	Aster	0.125	500
Baptisia leucantha	Wild White Indigo	0.063	500
Coreopsis tripteris	Tall Coreopsis	0.125	
Echinacea pallida	Pale Purple Coneflower	0.250	500
Elymus canadensis	Wild Rye	2.500	500
Eryngium yuccifolium	Rattlesnake Master	0.125	250
Juncus dudleyi	's Rush	0.125	
Liatris spicata	Marsh Blazing Star	0.125	500
Monarda fistulosa	Wild Bergamot	0.250	500
Panicum virgatum	Switch Grass	2.000	1000
Penstemon digitalis	Foxglove Beardstongue	0.125	500
Petalostemum purpureum	Purple Prairie Clover	0.250	
Ratibida pinnata	Yellow Coneflower	0.125	
Rudbeckia hirta	Black-eyed Susan	0.500	
Solidago rigida	Stiff Goldenrod	0.250	
Sporobolis heterolepis	Prairie Dropseed	2.000	1000
Tradescantia ohiensis	Spiderwort	0.125	500

Plans, Specs & Long-Term Maintenance

Continued

- Key design considerations for final plan development
  - Performance specifications for bioretention plantings.

Sample Performance Standards (3-growing season monitoring period)

1. By the end of the third growing season, at least 50% of the vegetative coverage (as measured by aerial coverage) will consist of seeded/planted species. The planted area shall exhibit at least the following at the end of each growing season: Year 1- 10% and Year 2- 25%
2. By the end of the third growing season, at least 75% of the planted areas must contain native, non-invasive perennial species as measured by aerial coverage. The planted area shall exhibit at least the following at the end of each growing season: Year 1- 10% and Year 2- 25%.
3. None of the three most dominant species within the planted areas shall be nonnative or invasive species, including but not limited to: Cattail *(Typha spp.), Reed* Canary Grass *(Phalaris arundinacea), Purple Loosestrife (Lythrum salicaria),* Common Reed *(Phragmites australis), Canada Thistle (Cirsium arvense),* Sandbar Willow *(Salix exigua), Kentucky Blue Grass (Poa pratensis), and White* Sweet Clover *(Melilotus alba).*
4. No more than 0.5 square meters in size shall be devoid of vegetation at any time.
5. 100% of the planted trees and shrubs shall be alive, in healthy condition, and representative of the individual species at the end of each growing season.

Plans, Specs & Long-Term Maintenance
Continued

- Maintenance Plan
  - Frequency and type of maintenance
  - Treat non-native invasive species yearly
  - Remove/replace mulch every 4-5 years (residential)
  - Potentially more frequent removal in high density developments
  - Installing bioretention does not reduce the need for other non-structural BMPs such as street sweeping

WinSLAMM

Shauna Urlacher, Clark Dietz (3:45 – 4:30)

Source Loading and Management Model (WinSLAMM)

- Intensive Data Collection Began in Wisconsin in Early 1990's
- Development began in mid 1970's
- First Windows Version Developed in 1995

EPA SWMM vs. WinSLAMM

EPA SWMM	WinSLAMM
Hydraulic Modeling	Water Quality Modeling
Stormwater Routing	Applies BMPs to a Selected Area
Based on Equations	Calibrated from 30-years of Field Data
Storm Events	Continuous Simulation

Purpose of WinSLAMM

- Quantify runoff volumes and pollutant loads
- Identify critical sources of runoff and pollutants
- Determine effectiveness of BMPs
- Compare costs and efficiency of BMPs

Applications

Large Scale

- City-wide Analysis
- Watershed Analysis

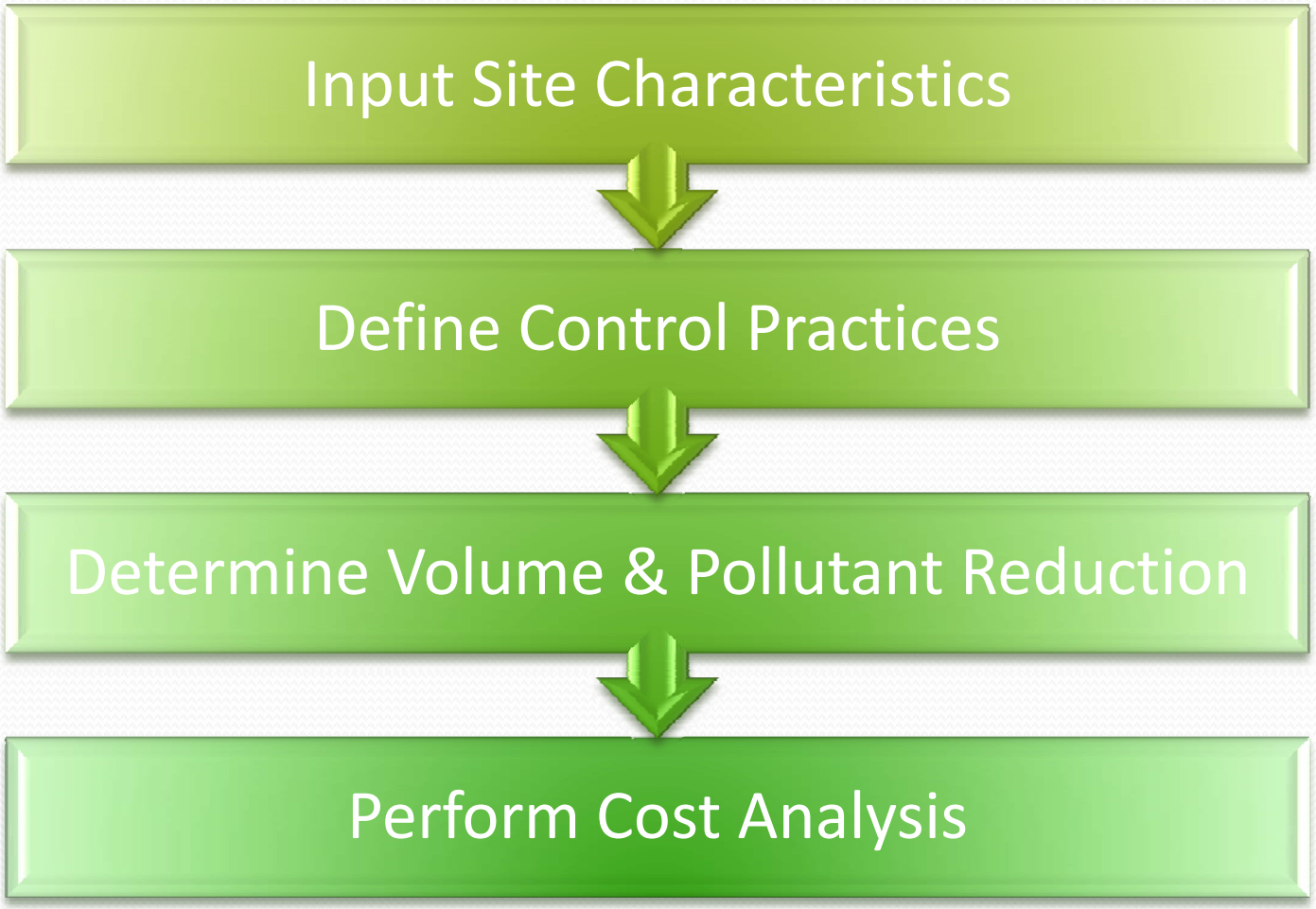
Site Development

- Propose BMPs to Meet Regulations
- Consider Green Approach

Single Practice

- Determine Effectiveness of a BMP
- Compare BMPs

Program Flow Chart



Site Characteristics

Soil Type

- Silty
- Clayey
- Sandy

Land Use

- Residential
- Commercial
- Industrial

Rainfall

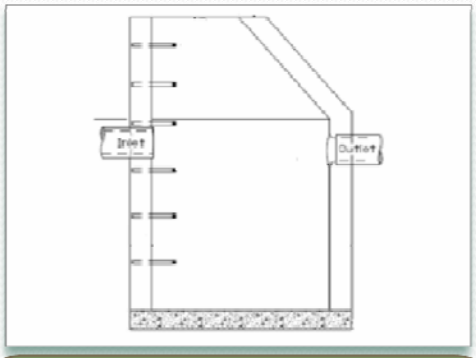
- Continuous Simulation
- Storm Event*

Development Characteristics

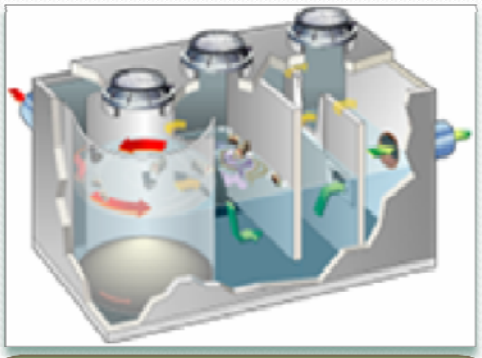
- Roofs
- Driveways
- Streets
- Landscape Areas
- Others

Control Practices (Settling)

Wet Detention Ponds



Catch Basins



Hydrodynamic Devices

Street Cleaning

Rain Barrels/ Cisterns

Control Practices
(Infiltration/Filtration)

Biofiltration/ Infiltration

Grass Swales

Porous Pavement

Filter Strips

Results

Runoff

- **Infiltration**
- **Evapo-transporation**
- **Runoff Reduction**

Pollutant Loads

- **Solids,** Phosphorus, Nitrates, TKN, COD, Fecal Coliform, Chromium, Copper, Lead, Zinc, Cadmium, Pyrene, Other

Results

File View

Runoff Volume | Particulate Solids | Pollutants | **Output Summary**

File Name: \\Ken-1\projects\R0670010\WinSLAMM\Taylor Avenue HDS Model-STC2400-96-in.dat

Drainage System and Outfall Output Summary

	Runoff Volume (cu. ft.)	Percent Runoff Reduction	Runoff Coefficient (Rv)	Particulate Solids Conc. (mg/L)	Particulate Solids Yield (lbs)	Percent Particulate Solids Reduction
Source Area Total without Controls	65302 <== Percent Reduction Basis Value		0.73	129.8		
Outfall Total without Controls					529.2 <== Basis Value	Percent Reduction
Current File Output: Total Before Drainage System	65301	0.00 %	0.73	99.77	406.7	
Current File Output: Total After Drainage System	65301	0.00 %	0.73	99.77	406.7	
Current File Output: Total After Outfall Controls	65301	0.00 %	0.73	99.77	406.7	23.15 %
Current File Output: Annualized Total After Outfall Controls	98085				610.9	

Total Area Modeled (ac) 0.85 Years in Model Run: 0.67

Print Output Summary to Text File

Total Control Practice Costs

Capital Cost	N/A
Land Cost	N/A
Annual Maintenance Cost	N/A
Present Value of All Costs	N/A
Annualized Value of All Costs	N/A

Perform Flow Duration Curve Calculations

Receiving Water Impacts Due To Stormwater Runoff

(CWP Impervious Cover Model)

	Calculated Rv	Approximate Urban Stream Classification
Without Controls	0.73	Poor
With Controls	0.73	Poor

Recap and Close – Q&A