

CE 3354 ENGINEERING HYDROLOGY

LECTURE 14: UNIT HYDROGRAPHS

OUTLINE

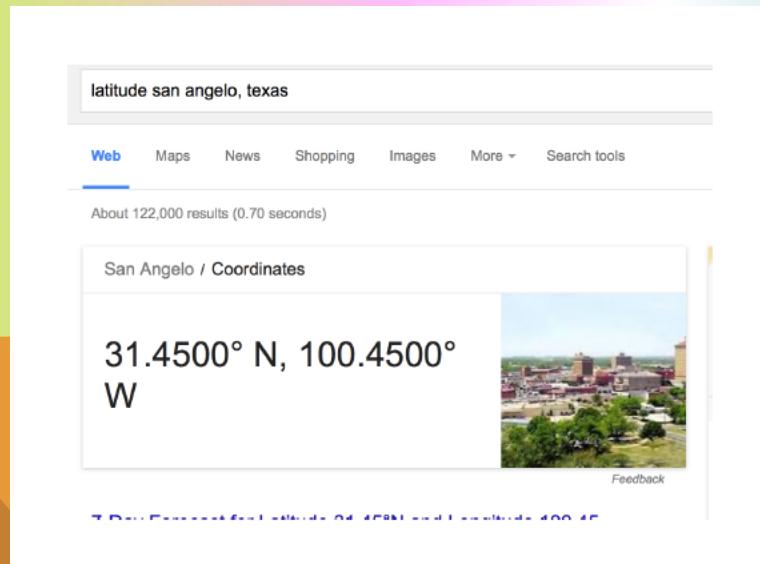
- ES6 Solution Sketch
- Unit Hydrographs/HMS Workshop
 - CMM pp. 201-223
- HMS Workshop

ES-6 SOLUTION SKETCH

ES 6 was application of two different evaporation models

1. Estimate the monthly evapotranspiration depths for the San Angelo (Concho County) area using the Blaney-Criddle method.¹

- **The Blaney-Criddle method uses location (latitude) and mean monthly temperatures in Celsius**
- Google search <Latitude and Longitude for San Angelo, Texas>



ES-6 SOLUTION SKETCH

- The Blaney-Criddle method uses location (latitude) and mean monthly temperatures in Celsius
- Google search <Mean Monthly Temperature for San Angelo, Texas>

U.S. climate data
Temperature - Precipitation - Sunshine - Snowfall

Home United States Texas

Monthly Daily History Geo & Map Weather Forecast

Climate San Angelo - Texas

°C °F

	Jan	Feb	Mar	Apr	May	Jun
Average high in °F:	60	64	71	80	87	92
Average low in °F:	33	37	44	52	62	69
Av. precipitation in inch:	0.94	1.34	1.5	1.42	2.83	2.6
Days with precipitation:	-	-	-	-	-	-
Hours of sunshine:	-	-	-	-	-	-
Average snowfall in inch:	1	0	0	0	0	0

	Jul	Aug	Sep	Oct	Nov	Dec
Average high in °F:	95	95	88	79	68	60
Average low in °F:	71	71	64	54	42	34
Av. precipitation in inch:	1.18	2.24	2.44	2.72	1.14	0.87
Days with precipitation:	-	-	-	-	-	-
Hours of sunshine:	-	-	-	-	-	-

Need in Celsius,
So either convert or
select Celsius

ES-6 SOLUTION SKETCH

Put these results into Blaney-Criddle equation

The screenshot shows a Microsoft Excel spreadsheet titled "BlaneyCriddle.xlsx". The ribbon at the top has tabs for Home, Insert, Page Layout, Formulas, Data, Page Break Preview, and Help. The Home tab is selected. The font size is set to 12pt Calibri (Body). The table below contains data for the Blaney-Criddle ET Estimator.

	A	B	C	D	E	F	G	H
1	Blaney-Criddle ET Estimator							
2	North Latitude							
3								
4	Latitude	30	<=Degrees Latitude (0-60, increments of 5)					
5								
6	Month	T_mean	p-Value	ET_o		T-high	T-low	
7	Jan	8	0.24	2.8032		15.3	0.7	
8	Feb	10.15	0.25	3.16725		17.5	2.8	
9	Mar	14.3	0.27	3.93606		21.7	6.9	
10	Apr	18.9	0.29	4.84126		26.7	11.1	
11	May	23.65	0.31	5.85249		30.7	16.6	
12	Jun	26.9	0.32	6.51968		33.4	20.4	
13	Jul	28.45	0.31	6.53697		35.1	21.8	
14	Aug	28.15	0.3	6.2847		34.8	21.5	
15	Sep	24.25	0.28	5.3634		31	17.5	
16	Oct	19	0.26	4.3524		26	12	
17	Nov	12.95	0.24	3.34968		20.2	5.7	
18	Dec	8.2	0.23	2.70756		15.5	0.9	
19								
20								

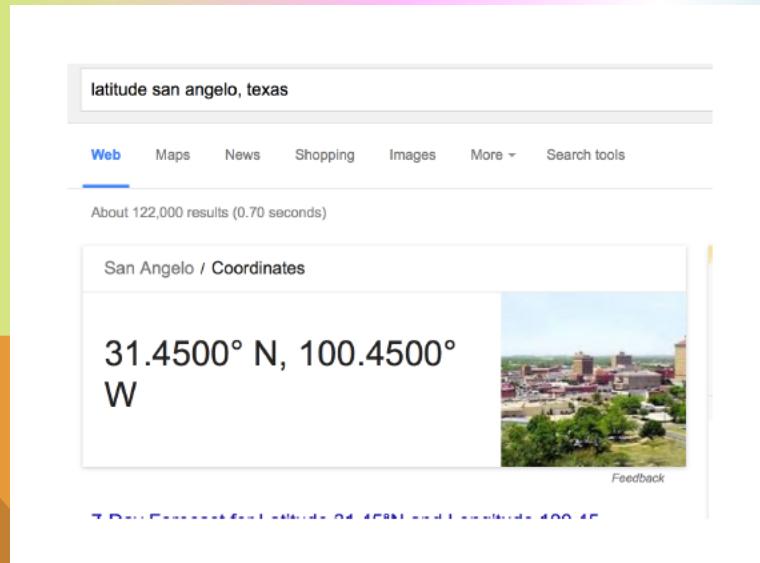
At the bottom of the table, there are tabs for "North-Latitude", "South-Latitude", "p-factor", and a plus sign (+).

ES-6 SOLUTION SKETCH

ES 6 was application of two different evaporation models

2. Estimate the monthly evapotranspiration depths for the San Angelo (Concho County) area using the Thornwaite method.²

- **The Thornwaite method uses location (latitude) and mean monthly temperatures in Celsius**
- Google search <Latitude and Longitude for San Angelo, Texas>



ES-6 SOLUTION SKETCH

- The Thornwaite method uses location (latitude) and mean monthly temperatures in Celsius
- Google search <Mean Monthly Temperature for San Angelo, Texas>

U.S. climate data
Temperature - Precipitation - Sunshine - Snowfall

Home United States Texas

Monthly Daily History Geo & Map Weather Forecast

Climate San Angelo - Texas

°C | °F

	Jan	Feb	Mar	Apr	May	Jun
Average high in °F:	60	64	71	80	87	92
Average low in °F:	33	37	44	52	62	69
Av. precipitation in inch:	0.94	1.34	1.5	1.42	2.83	2.6
Days with precipitation:	-	-	-	-	-	-
Hours of sunshine:	-	-	-	-	-	-
Average snowfall in inch:	1	0	0	0	0	0

	Jul	Aug	Sep	Oct	Nov	Dec
Average high in °F:	95	95	88	79	68	60
Average low in °F:	71	71	64	54	42	34
Av. precipitation in inch:	1.18	2.24	2.44	2.72	1.14	0.87
Days with precipitation:	-	-	-	-	-	-
Hours of sunshine:	-	-	-	-	-	-

Need in Celsius,
So either convert or
select Celsius

ES-6 SOLUTION SKETCH

Put these results into Thornwaite method

Thornwaite Method Worksheet														
Instructions:														
(1) Enter mean monthly air temperature in data field														
(2) Enter nearest latitude of study area (see data table to see latitudes available)														
5	Required Data		January	February	March	April	May	June	July	August	September	October	November	December
6	Mean Monthly Air Temperature (°C)		8	10.15	14.3	18.9	23.65	26.9	28.45	28.15	24.25	19	12.95	8.2
7	Station Latitude (°North)		30											
8	Computed Values													
9	Monthly Thermal Index (i)		2.03722	2.92112	4.90838	7.48725	10.5133	12.7763	13.9072	13.6858	10.9198	7.54731	4.22412	2.11482
10	Monthly Correction Coefficient (F(λ))		0.9	0.87	1.03	1.08	1.18	1.17	1.2	1.14	1.03	0.98	0.89	0.88
11	Annual Thermal Index (I)		93.0426											
12	Exponent (a)		2.03	6.75E-07	7.71E-05	1.79E-02	0.49239							
13	Monthly Potential ET (mm)		10.6	16.6	39.5	73.0	125.9	162.2	186.5	173.4	115.7	67.0	27.9	10.9
15	Latitude North		January	February	March	April	May	June	July	August	September	October	November	December
16	50	0.74	0.78	1.02	1.15	1.33	1.36	1.37	1.25	1.06	0.92	0.76	0.7	
17	49	0.75	0.79	1.02	1.14	1.32	1.34	1.35	1.24	1.05	0.93	0.76	0.71	
18	48	0.76	0.8	1.02	1.14	1.31	1.33	1.34	1.23	1.05	0.93	0.77	0.72	
19	47	0.77	0.8	1.02	1.14	1.3	1.32	1.33	1.22	1.04	0.93	0.78	0.73	
20	46	0.79	0.81	1.02	1.13	1.29	1.31	1.32	1.22	1.04	0.94	0.79	0.74	
21	45	0.8	0.81	1.02	1.13	1.28	1.29	1.31	1.21	1.04	0.94	0.79	0.75	
22	44	0.81	0.82	1.02	1.13	1.27	1.29	1.3	1.2	1.04	0.95	0.8	0.76	
23	43	0.81	0.82	1.02	1.12	1.26	1.28	1.29	1.2	1.04	0.95	0.81	0.77	
24	42	0.82	0.83	1.03	1.12	1.26	1.27	1.28	1.19	1.04	0.95	0.82	0.79	
25	41	0.83	0.83	1.03	1.11	1.25	1.26	1.27	1.19	1.04	0.96	0.82	0.8	
26	40	0.84	0.83	1.03	1.11	1.24	1.25	1.27	1.18	1.04	0.96	0.83	0.81	

ES6 SOLUTION SKETCH

Blaney-Criddle Results:

The results indicate a high value of about $1/4$ inch/day during the summer months, and about $1/10$ inch per day in the winter months.

Thornwaite Results:

The results indicate a daily rate of about $1/4$ inch/day per day in the summer months and about 0.01 inches per day in the winter months.

Is evaporation for a 24-hour storm?

3. How important are these estimates in the drainage analysis project for a storm lasting 24-48 hours? Probably not terribly important for rainfall rates in excess of 1 inches per hour.

WHAT IS A UNIT HYDROGRAPH?

Streamflow from Rainfall by Unit-Graph Method

Observed runoff following isolated one-day rainfall forms basis of computation—Method applicable to rainfalls of any intensity or duration

By L. K. Sherman
Consulting Engineer, Randolph-Perkins Co.,
Chicago, Ill.

BY MAKING USE of a single observed hydrograph, one due to a storm lasting one day, it is possible to compute for the same watershed the runoff history corresponding to a rainfall of any duration or degree of intensity. From the known hydrograph the "unit" graph must be determined, representing 1 in. of runoff from a 24-hour rainfall. The daily ordinates of the unit graph can then be combined in accordance with the variation in daily precipitation figures to obtain the runoff from a sum of any length.

Following a storm, the hydrograph representing the flow in the main-stream channel shows the runoff increasing to a maximum point and then subsiding to the value it had before the storm. For a single storm the graph is generally of a triangular shape with the falling stage taking never less and usually two or more times as long as the rising stage. For the same drainage area, however, there is a definite total flood period corresponding to a given rainfall, and all one-day rainfalls

or 2 in., and the observed graph represents a 2-in. runoff applied in 24 hours. The unit graph for this area, then, is one having the same base but ordinates one-half as great as those on the observed graph. This is the procedure for determining a unit graph for any drainage area. The graph is a constant for any particular drainage area, but drainage areas of different physical characteristics give radically different forms.

A topography with steep slopes and few pondage pockets gives a graph with a high sharp peak and a short time period. A flat country with large pondage pockets gives a graph with a flat rounded peak and a long time period.

Application of unit graph

After a unit graph has been constructed for a particular area it may be used to compute a hydrograph of runoff for this area for any individual storm or sequence of storms of any duration or intensity over any period of time. The principle to use in applying the unit graph is to follow the summation process of nature. For example, consider a case where the unit graph

OPO. A continued rain with the same daily depth of runoff produces successively the additional dotted graphs. At the end of the fifth day of such continuous rain, with uniform depths of runoff for each day, the runoff graph ORS will be formed. The peak at R will be the maximum rate of runoff. Further

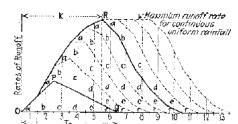


Fig. 1—Simple hydrograph of runoff from a continuous uniform rain, when the unit graph is triangular.

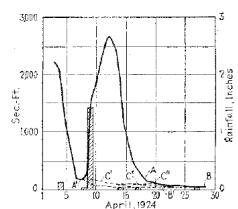
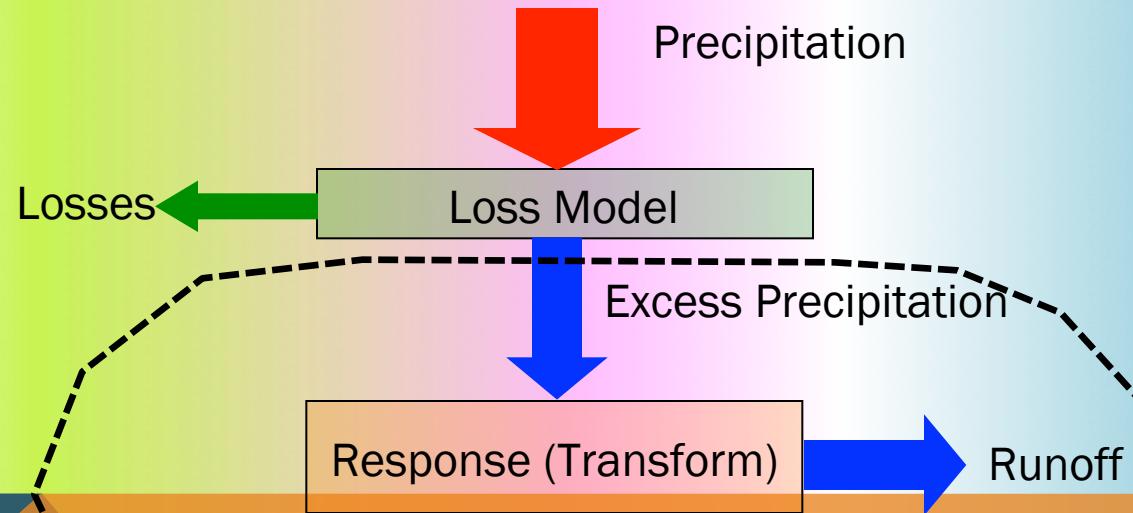


Fig. 2—At Plumfield, Ill., on the Big Muddy River, there was a fairly well-isolated rain of 1.42 in. on April 9, 1934, yielding a hydrograph with ordinates proportional to those of the unit graph.

- Used to explain the time re-distribution of excess precipitation on a watershed
- Represents the response of the watershed at the outlet to a unit depth of EXCESS precipitation
 - EXCESS implies some kind of loss model is applied to the raw precipitation
 - Time re-distribution implies some kind of transfer behavior is applied
- L. K. Sherman 1932 is credited with seminal publication of the concept
 - Read the document in AdditionalReadings

RESPONSE MODEL

Response models convert the excess precipitation signal into a direct runoff hydrograph at the point of interest



CE 3354 ENGINEERING HYDROLOGY

LECTURE 15: HEC-HMS WORKSHOP - ASH CREEK EXAMPLE

PURPOSE

Illustrate the steps to create a functioning precipitation-runoff model in HEC-HMS

- Only a small set of HEC-HMS capabilities are employed
 - Basin Model
 - Sub-Basin: IaCI Loss Model; DUH Transform Model
 - Meteorological Model
 - Control Specifications
 - Time-Series: Rain Gage
 - Time-Series: Discharge Gage
- Realistic parameter values are employed from class references

LEARNING OBJECTIVES

Familiarize students with the HEC-HMS Graphical User Interface.

- Reinforce the concepts of “Projects” as a data-storage paradigm.

Simulate the rainfall-runoff response of a single sub-basin Texas watershed using:

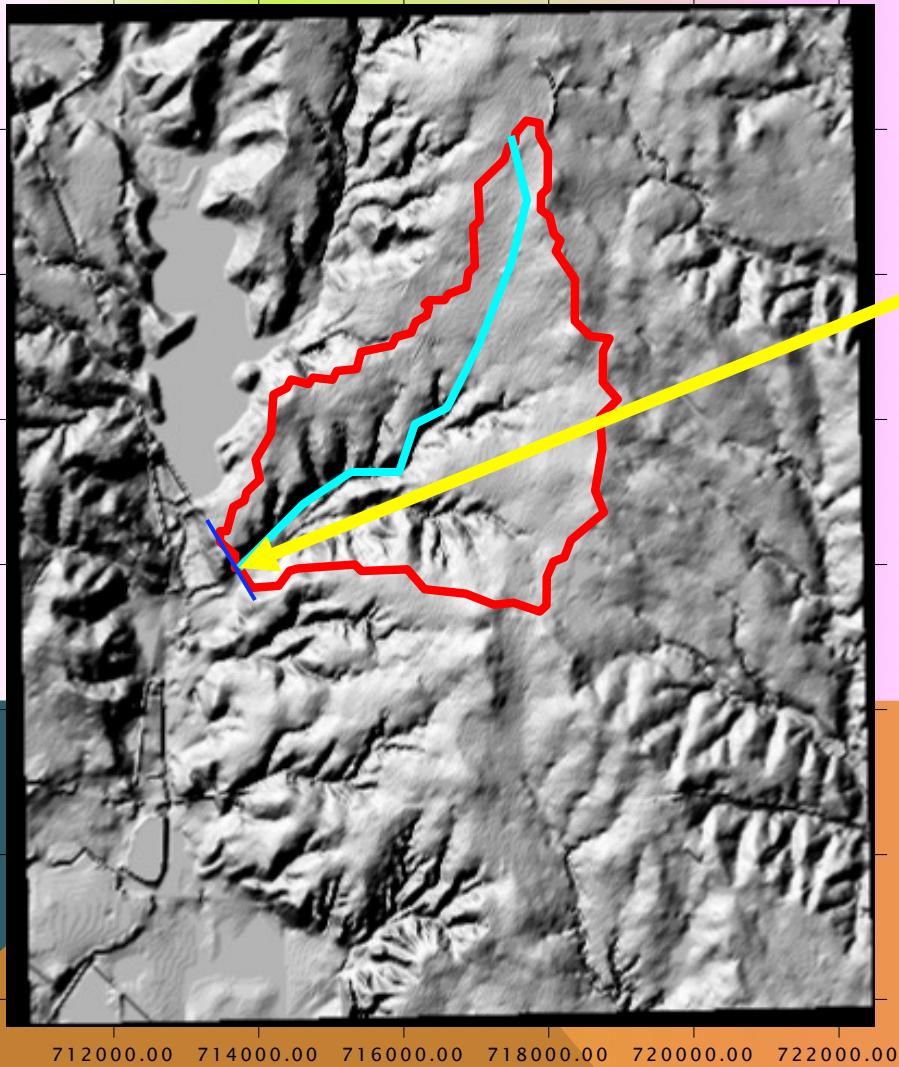
- Initial loss and constant rate loss model
- SCS Unit Hydrograph transformation model
- User-specified hyetograph.

PROBLEM STATEMENT

Simulate the response of the Ash Creek watershed at Highland Road for a 5-year, 3-hour storm, under current development conditions.

- Treat the entire watershed as a single sub-basin.

PROBLEM STATEMENT



Watershed Outlet

- Highland Road and Ash Creek, Dallas, TX.
- Area is residential subdivisions, light industrial parks, and some open parkland.
- White Rock Lake is water body to the North-West

PRECIPITATION ESTIMATION

Precipitation

- Estimate 5-year, 3-hour storm depth using the DDF Atlas



In cooperation with the Texas Department of Transportation

Atlas of Depth-Duration Frequency of Precipitation Annual Maxima for Texas



Scientific Investigations Report 2004-5041
(TxDOT Implementation Report 5-1301-01-1)

U.S. Department of the Interior
U.S. Geological Survey

PRECIPITATION ESTIMATION



In cooperation with the Texas Department of Transportation

Empirical, Dimensionless, Cumulative-Rainfall Hyetographs Developed From 1959–86 Storm Data for Selected Small Watersheds in Texas



Scientific Investigations Report 2004–5075
(TxDOT Research Report 0–4194–3)

U.S. Department of the Interior
U.S. Geological Survey

Precipitation

- Approximate the storm temporal distribution using dimensionless hyetograph.

LOSS MODEL ESTIMATION

Runoff Generation (Loss)

- Estimate the initial loss and constant rate loss using TxDOT 0-4193-7



In cooperation with the Texas Department of Transportation

An Initial-Abstraction, Constant-Loss Model for Unit Hydrograph Modeling for Applicable Watersheds in Texas



Scientific Investigations Report 2007-5243
(Texas Department of Transportation Research Report 0-4193-7)

TRANSFORMATION MODEL ESTIMATION

Unit Hydrograph Timing Parameters

- Example will use the SCS DUH, but will parameterize assuming GUHAS regression is appropriate.



U.S. Geological Survey;
Texas Tech University, Center for
Multidisciplinary Research in Transportation;
University of Houston;
Lamar University

UNIT HYDROGRAPH ESTIMATION FOR
APPLICABLE TEXAS WATERSHEDS



Research Report 0-4193-4

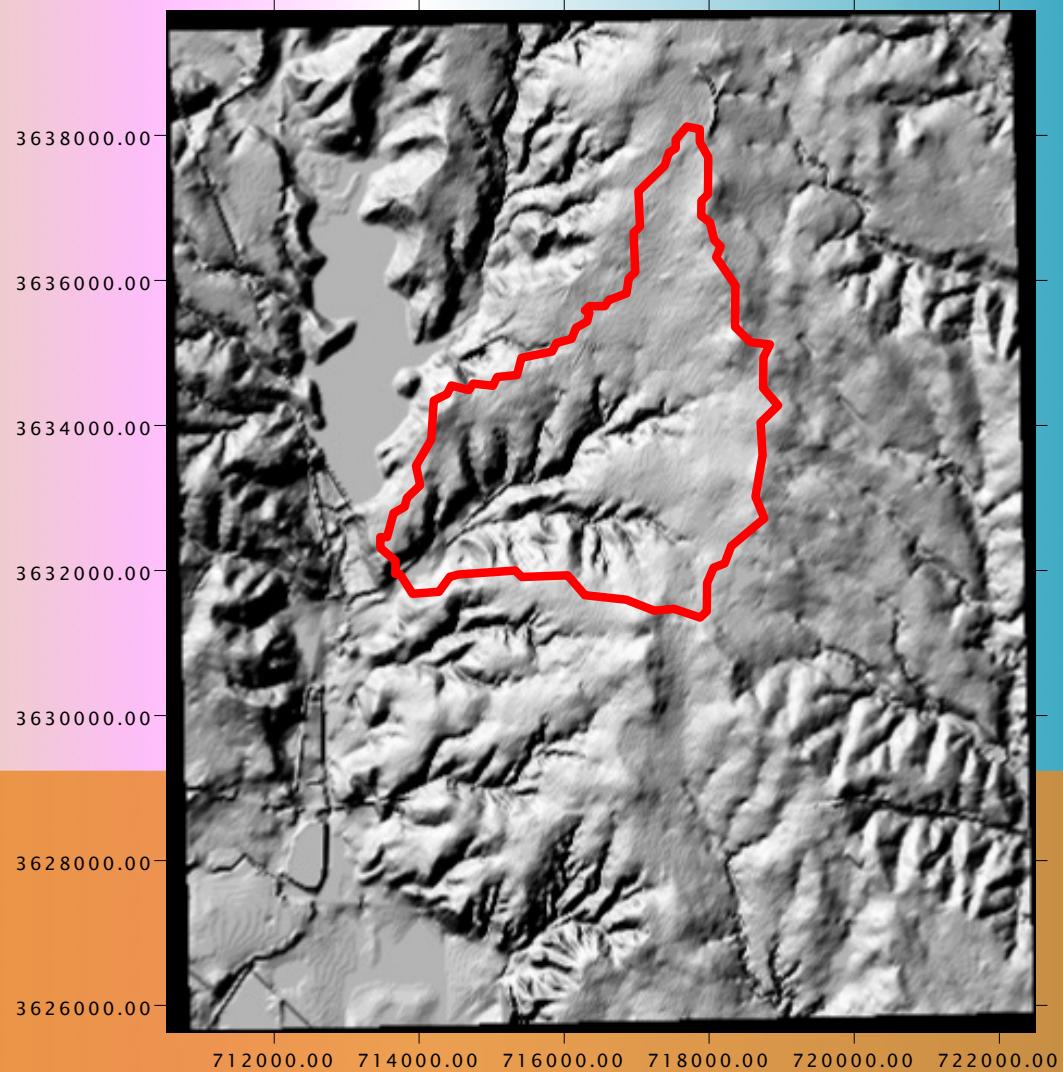


Texas Department of Transportation
Research Project 0-4193

PHYSICAL PROPERTIES

Watershed Properties

- AREA=6.92 mi²
- MCL=5.416 mi
- MCS=0.005595
- CN=86
- R=0



BUILDING THE MODEL – DATA PREPARATION

HEC-HMS will require us to construct, external to HMS the following:

- A Hyetograph (rainfall)
- Loss model parameters
- Transform model parameters

In this example will use Excel to build some input data required by the program.

RAINFALL DEPTH

Figure 20 27

Use the DDF atlas to find the 5-year, 3-hour storm depth for Dallas Texas.

- About 2.8 in.

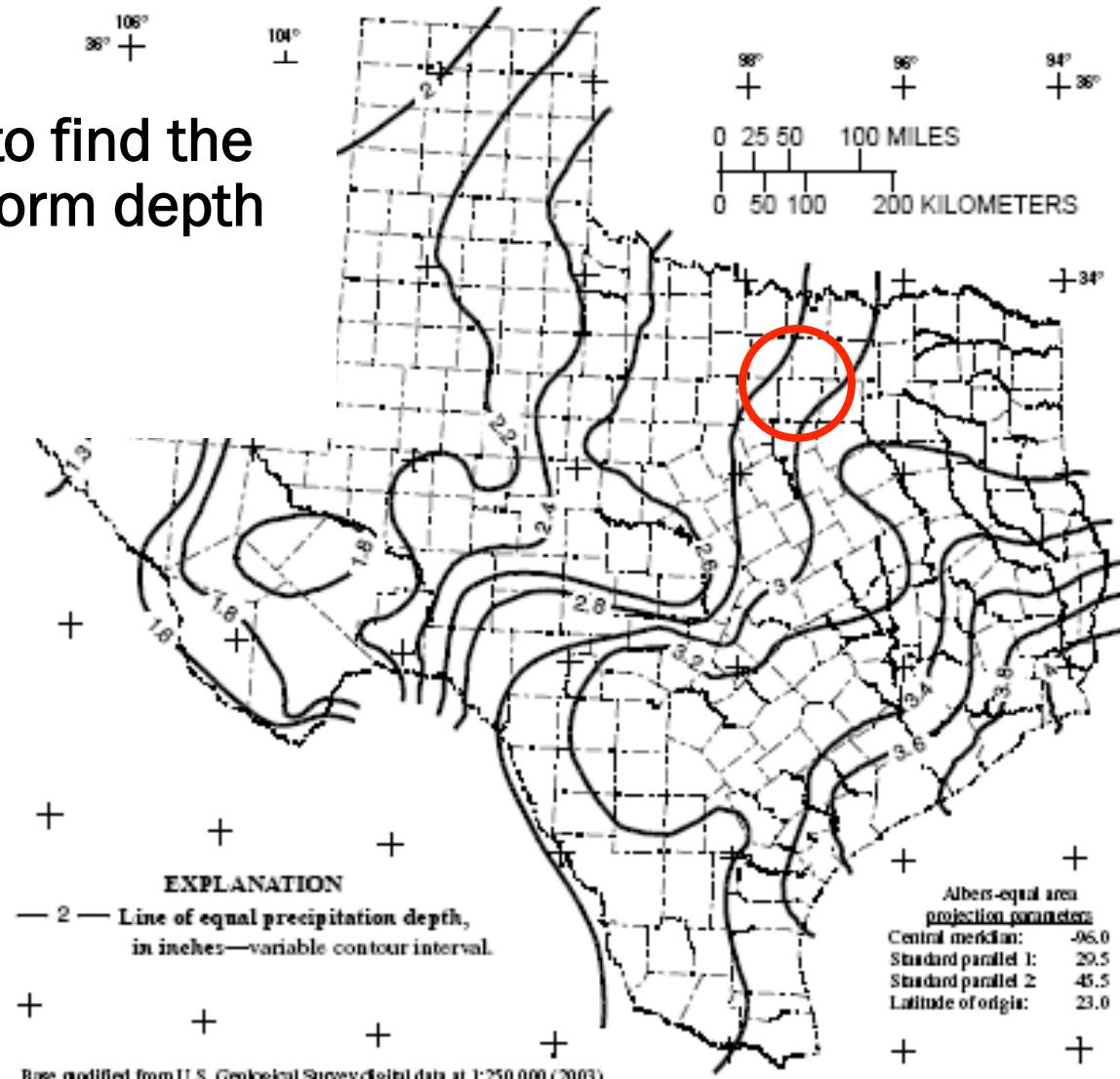


Figure 20. Depth of precipitation for 5-year storm for 3-hour duration in Texas.

GENERATE A HYETOGRAPH – USE TXHYETO

TXHYETO-2015-PreRelease.xlsx

Search in Sheet

B17 Home Layout Tables Charts SmartArt Formulas Data

A B C D E F G H I

TxHYETO-2015 Pre-Release

Texas Hyetographs for 50-th Percentile Storm

(Revised: July 30, 2015)

1. Enter a Storm Duration
(from DDF Atlas, TP40, or equivalent)
 hours

2. Enter a Storm Depth
(from TxDOT Hydraulic Design Manual, EBDLKUP-NEW.xlsx,
DDF Atlas, TP40, or equivalent)
 inches

3. Enter a desired Time Interval
(recommend intervals perfectly divisible by storm duration)
 minutes

Mixture Model Parameters (50th)

w ₁	1.038977
a	0.795463
b	3.485892
w ₂	0.248833
m	0.471874
s	0.283391

50TH PERCENTILE (2-YEAR) HYETOGRAPH

Time (min)	Time (hrs)	Depth (in)
0	0	0.000
5	0.08	0.176
10	0.17	0.446
15	0.25	0.660
20	0.33	0.835
25	0.42	0.980
30	0.50	1.100
35	0.58	1.200
40	0.67	1.282
45	0.75	1.351
50	0.83	1.409
55	0.92	1.459
60	1.00	1.503
65	1.08	1.543
70	1.17	1.581
75	1.25	1.620
80	1.33	1.659
85	1.42	1.701
90	1.50	1.747
95	1.58	1.796
100	1.67	1.848
105	1.75	1.905
110	1.83	1.964
115	1.92	2.027
120	2.00	2.091
125	2.08	2.157
130	2.17	2.222
135	2.25	2.287
140	2.33	2.351
145	2.42	2.412

50th Percentile 90th Percentile

DATA PREPARATION

HEC-HMS will require us to construct, external to HMS the following:

- A *Hyetograph (rainfall)*
- Loss model parameters
- Transform model parameters

In this example will use Excel to build some input data required by the program.

LOSS MODEL PARAMETERS

$I_a C_i$ model in TxDOT 0-4193-7

Estimation of Initial Abstraction

The regression equation¹⁵ for estimation of I_A has $\varphi^{[I_A]} = -0.9041$ and is

$$I_A = 2.045 - 0.5497L^{-0.9041} - 0.1943D + 0.2414R - 0.01354CN, \quad (23)$$

where I_A is initial abstraction in watershed inches, L is main-channel length of the watershed in miles, $D = 0$ for undeveloped watersheds and $D = 1$ for developed watersheds, $R = 0$ for non-rocky watersheds and $R = 1$ for rocky watersheds, and CN is the curve number.

LOSS MODEL PARAMETERS

$I_a C_I$ model in TxDOT 0-4193-7

The screenshot shows a Microsoft Excel window titled "Microsoft Excel - Dimensionless2Dimen...". The spreadsheet contains data related to loss model parameter estimation. Row 1 is labeled "Loss Model Parameter Estimation". Row 2 is labeled "Initial Abstraction". Row 3 has two columns: "Input Values" and "Regression Coefficients". Rows 4 through 8 show specific regression coefficients for different conditions. Row 9 highlights the value "0.567 inches" under the heading "Ia".

Loss Model Parameter Estimation					
Initial Abstraction					
Input Values		Regression Coefficients			
			2.045		
5.416 <=MCL (Miles)			-0.5497	-0.9041	
1 <=D (0 or 1)			-0.1943		
0 <=R (0 or 1)			0.2414		
86 <= CN			-0.01354		
Ia	0.567 inches				

LOSS MODEL PARAMETERS

I_aC_l model in TxDOT 0-4193-7

Estimation of Constant Loss

The regression equation¹⁶ for estimation of C_L has $\varphi^{[C_L]} = 0.2312$ and is

$$C_L = 2.535 - 0.4820L^{0.2312} + 0.2271R - 0.01676CN, \quad (29)$$

where C_L is constant loss in watershed inches per hour, L is main-channel length of the watershed in miles, $R = 0$ for non-rocky watersheds and $R = 1$ for rocky watersheds, and CN is curve number. The equation has

LOSS MODEL PARAMETERS

$I_a C_l$ model in TxDOT 0-4193-7

Microsoft Excel - Dimensionless2Dimen...

Loss Model Parameter Estimation					
Initial Abstraction					
Input Values		Regression Coefficients			
			2.045		
5.416 <=MCL (Miles)		-0.5497	-0.9041		
1 <=D (0 or 1)		-0.1943			
0 <=R (0 or 1)		0.2414			
86 <= CN		-0.01354			
la	0.567 inches				

Microsoft Excel - Dimensionless2Dimen...

Constant Loss					
Input Values			Regression Coefficients		
			2.535		
5.416 <=MCL (Miles)		-0.482	0.2312		
1 <=D (0 or 1)		0			
0 <=R (0 or 1)		0.2271			
86 <= CN		-0.01676			
CI	0.381 inches/hour				

DATA PREPARATION

HEC-HMS will require us to construct, external to HMS the following:

- A *Hyetograph (rainfall)*
- *Loss model parameters*
- Transform model parameters

In this example will use Excel to build some input data required by the program.

UNIT HYDROGRAPH MODEL

SCS Dimensionless Unit Hydrograph

- Related to a gamma distribution with shape K=3.77
- HEC-HMS requires a time constant, T_lag

For this example, will assume 0-4193-4 method is sufficient

UNIT HYDROGRAPH MODEL

Estimate T_p

$$T_p = 10^{(-1.41 - 0.313D)} L^{0.612} S^{-0.633},$$

The screenshot shows a Microsoft Excel window with the title bar "Microsoft Excel - Dimensionless2Dimensi...". The spreadsheet contains the following data:

A	B	C	D	E	F
1	Time to Peak				
2	Input Values			Regression Coefficients	
3			0		
4	5.416 <=MCL (Miles)		2.812	0.612	
5	1 <=D (0 or 1)		0.0191		
6	0.005595 <=Slope		-0.633		
7					
8	T _p	1.428 hours	85.665 minutes		
9	Hydrograph Shape	IaC/I	T _p -K		

UNIT HYDROGRAPH MODEL

Estimate K

$$K = 10^{(0.481 - 0.0782D)} L^{0.140},$$

Microsoft Excel - Dimensionless2Dimensi...					
	A	B	C	D	E
9	Hydrograph Shape				
10	Input Values		Regression Coefficients		
11			0		
12	5.416 <=MCL (Miles)		1.2668	0.14	
13	1 <=D (0 or 1)		2.5281		
14			1		
15			1		
16					
17	K	3.203			

UNIT HYDROGRAPH MODEL

SCS Dimensionless Unit Hydrograph

- Related to a gamma distribution with shape K=3.77

For this example

- Assume that K=3.77 is close enough in shape to K=3.2 to use without modification.
- A later example will illustrate how to employ a user-specified hydrograph.
- Basin lag time is $0.6 \times 80\text{min} = 48\text{ min}$

(e) Relation between lag and time of concentration

Various researchers (Mockus 1957; Simas 1996) found that for average natural watershed conditions and an approximately uniform distribution of runoff:

$$L = 0.6T_c \quad (\text{eq. 15-3})$$

where:

L = lag, h

T_c = time of concentration, h

DATA PREPARATION

HEC-HMS will require us to construct, external to HMS the following:

- A *Hyetograph (rainfall)*
- *Loss model parameters*
- *Transform model parameters*

Now ready to build the HEC-HMS model.

HEC-HMS

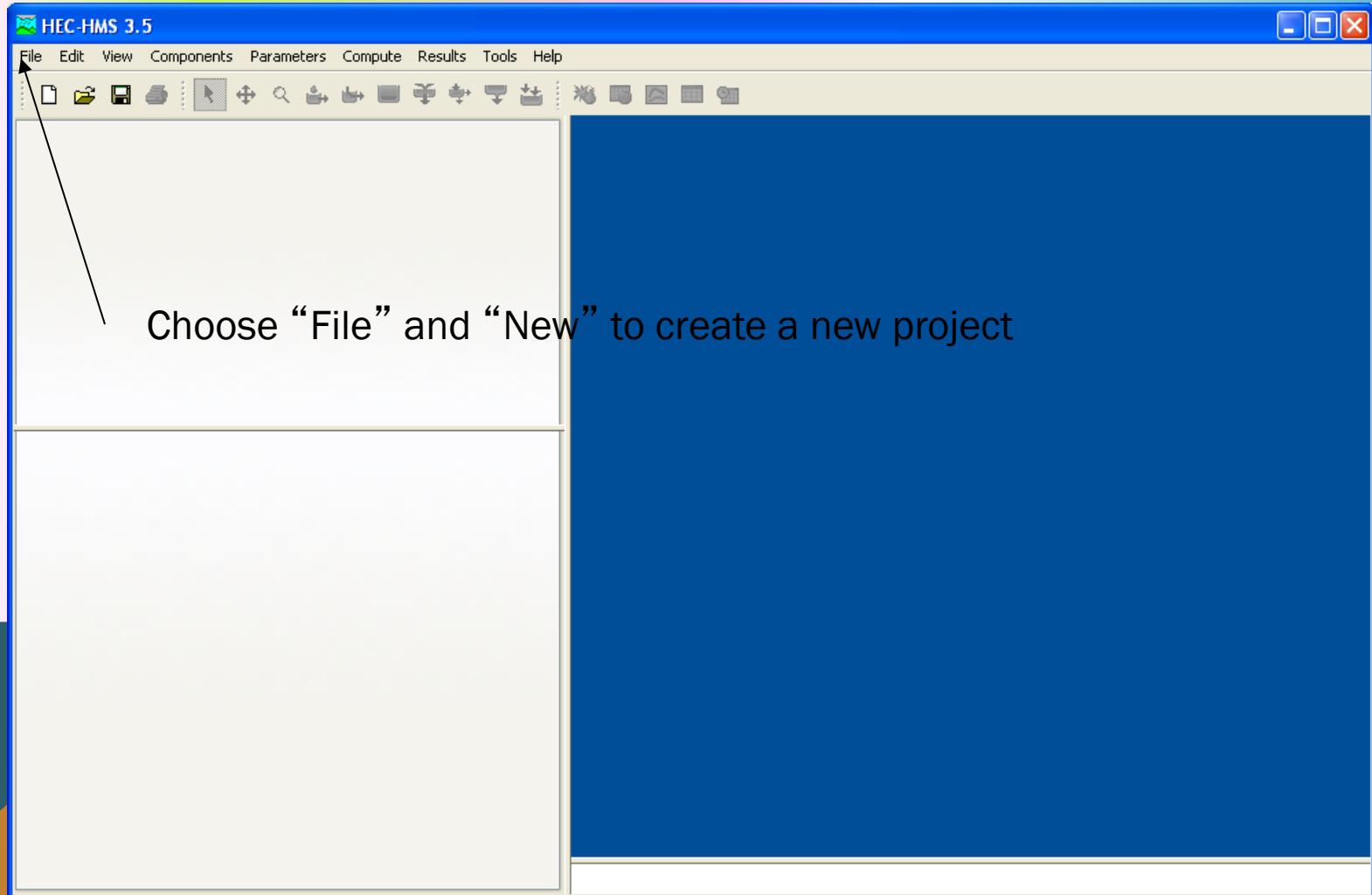
Start the program

Create a project

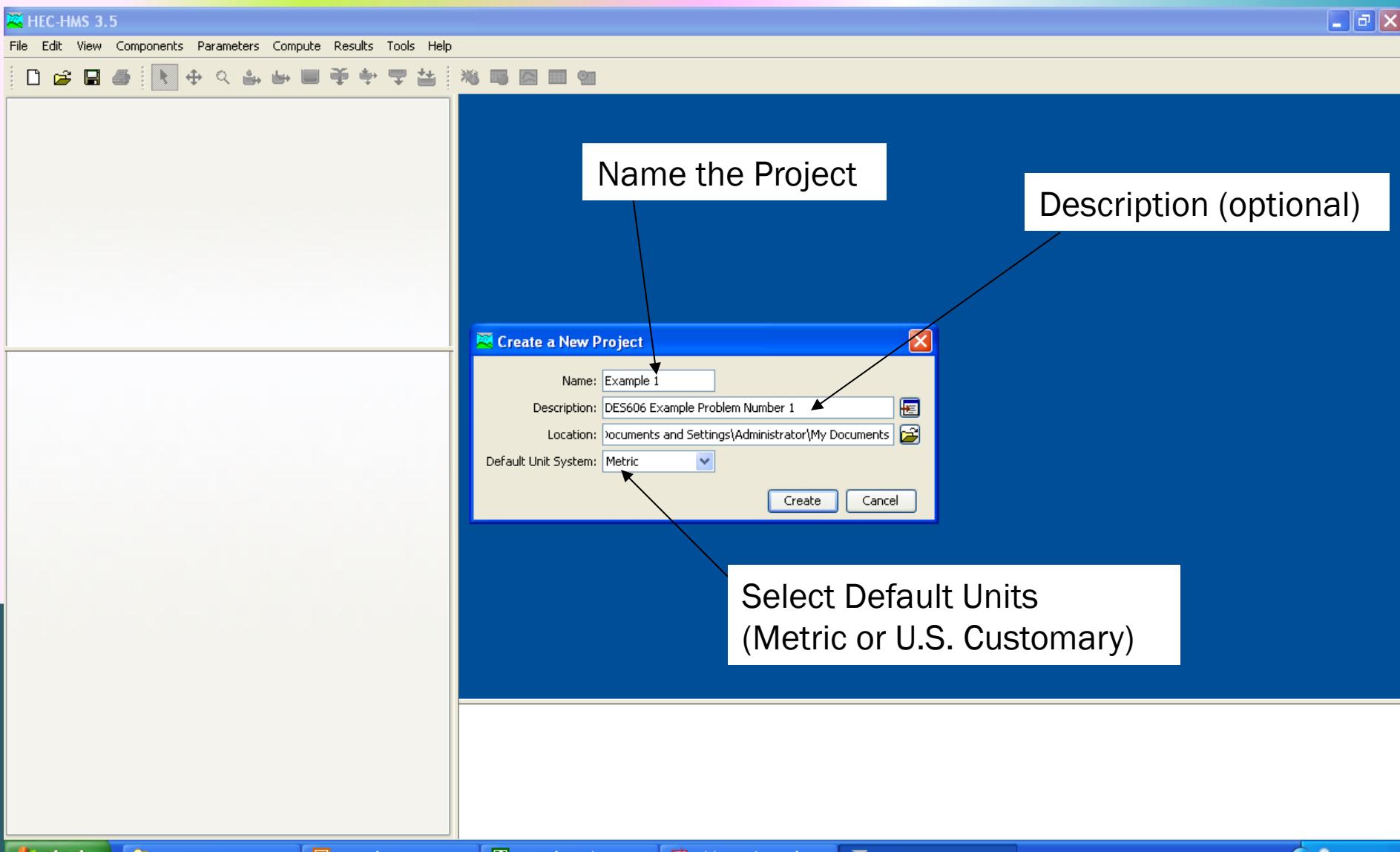
- Project is a directory where all data are stored for a particular model.
- Can share files between projects, but an advanced technique.

HEC-HMS

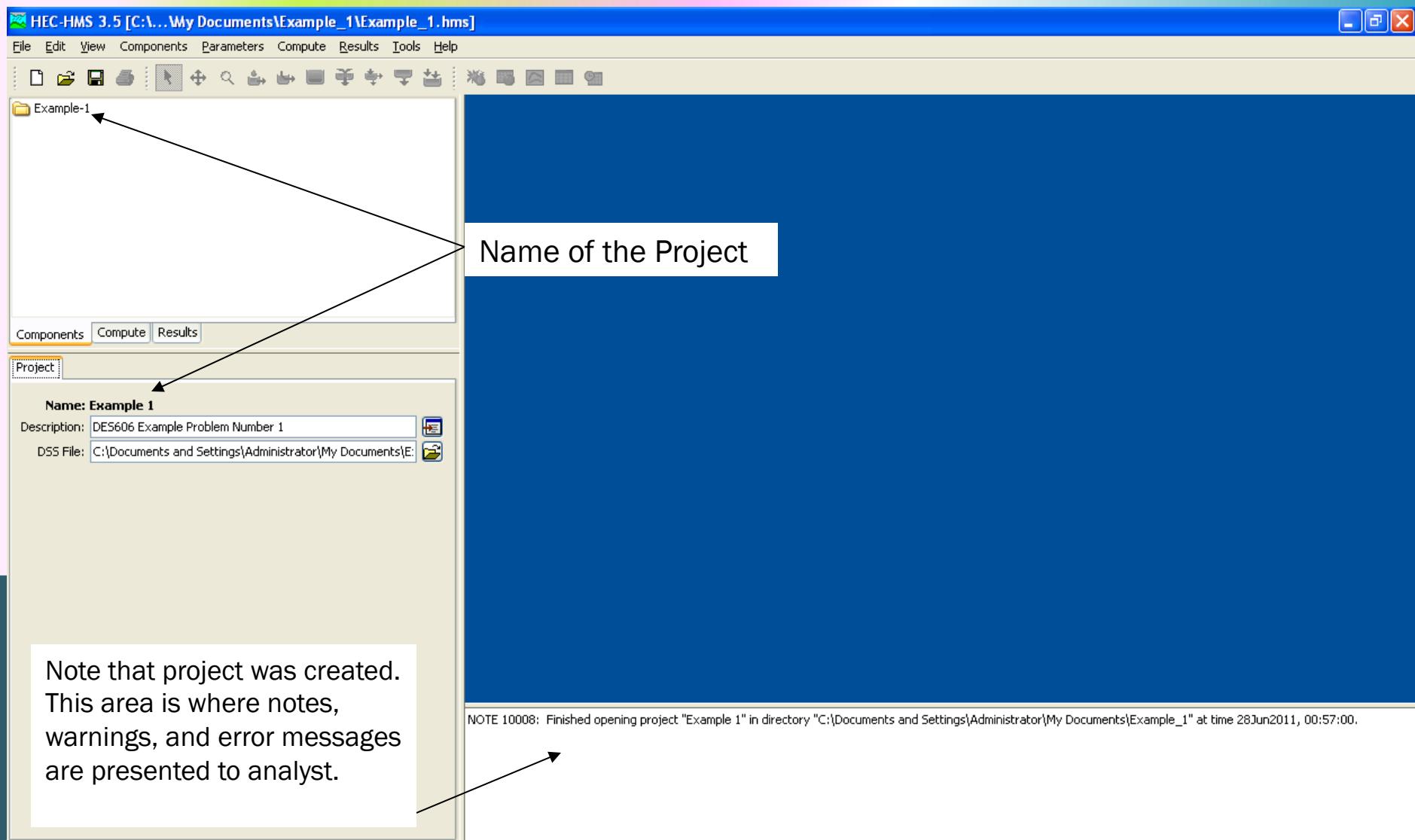
Start the program



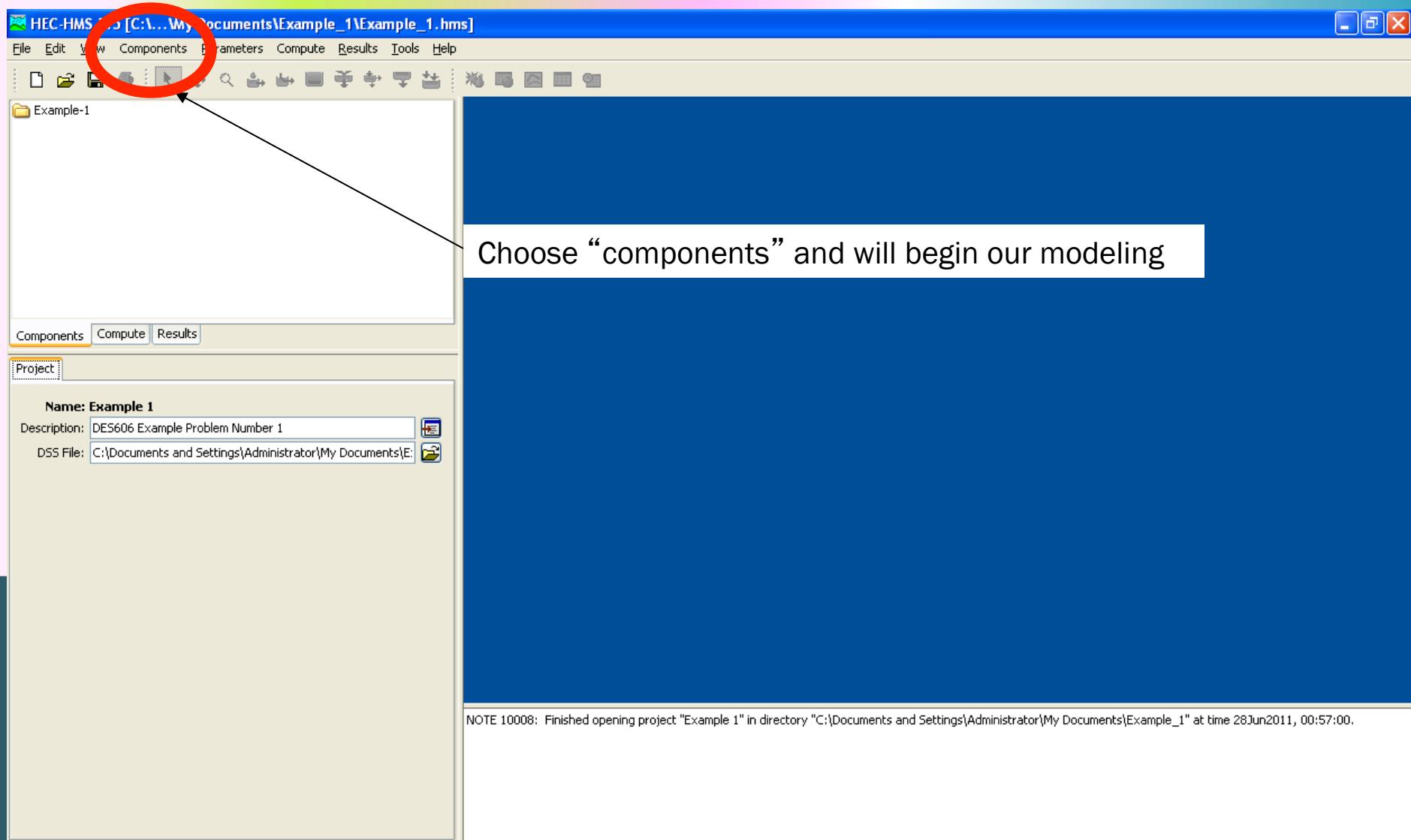
CREATE PROJECT



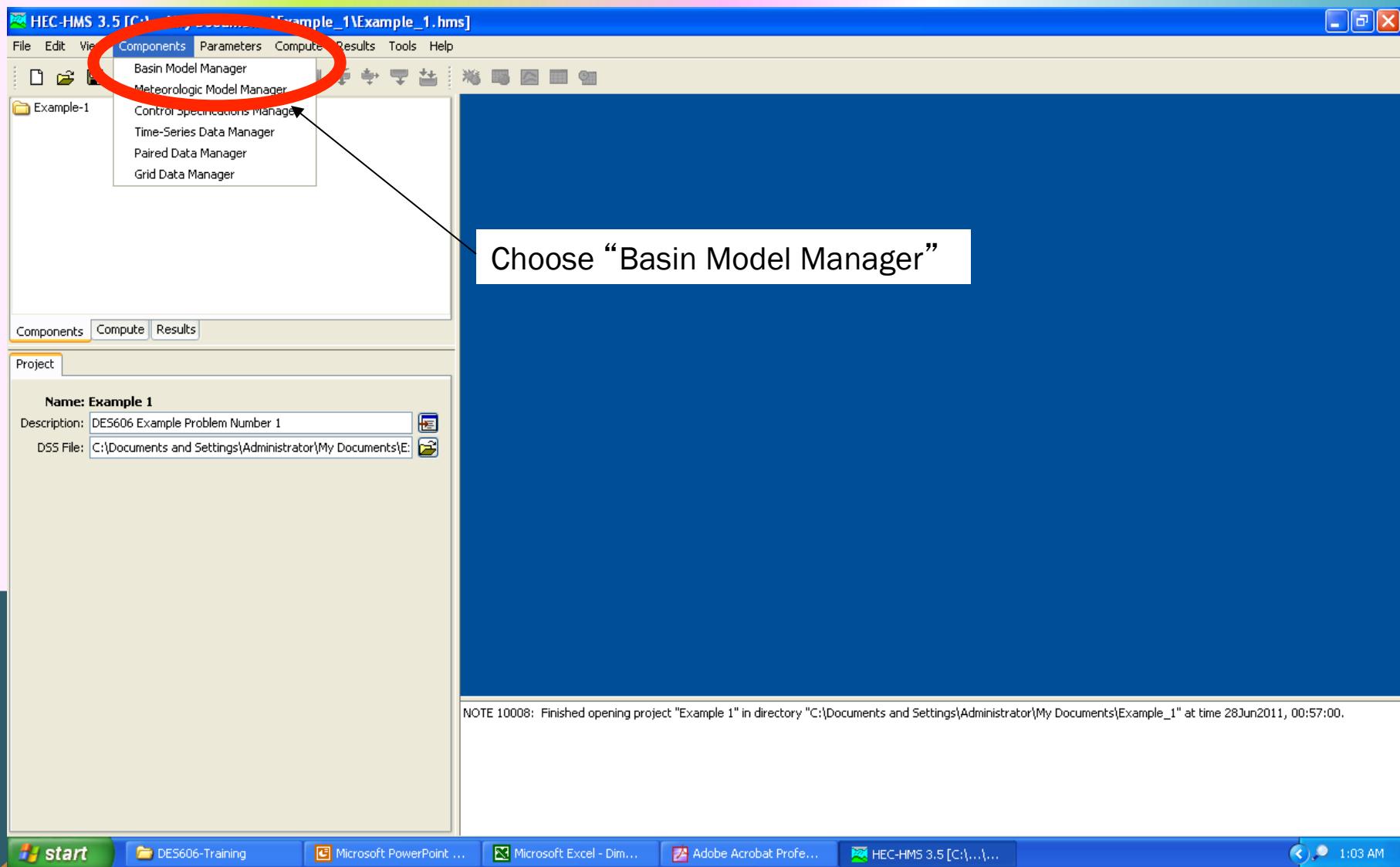
CREATE PROJECT



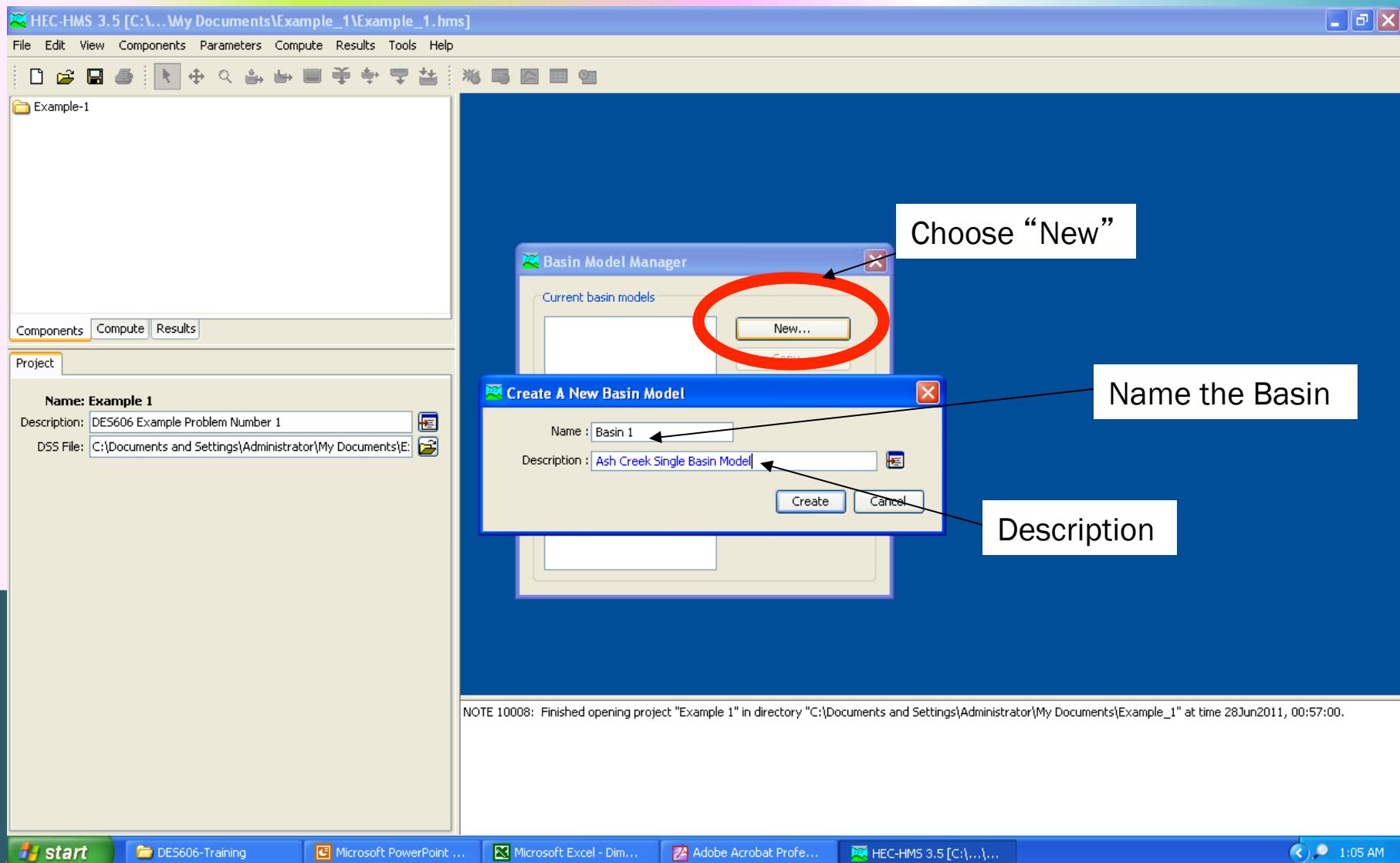
CREATE BASIN MODEL



CREATE BASIN MODEL



CREATE BASIN MODEL



CREATE BASIN MODEL

The screenshot shows the HEC-HMS 3.5 software interface. The title bar reads "HEC-HMS 3.5 [C:\...\My Documents\Example_1\Example_1.hms]". The menu bar includes File, Edit, View, Components, Parameters, Compute, Results, Tools, and Help. The toolbar has various icons, with the second icon from the left circled in red and an arrow pointing to it from the text "2) Sub Basin Creation Tool". The left pane shows a file tree with "Example-1" expanded, showing "Basin Models" and "Ash Creek Basin". The main workspace contains a sub-basin creation tool window titled "Basin Model [Ash Creek Basin]" which is currently empty. A large callout bubble points to this window with the text "Select, then put a sub-basin into the hydrologic elements area". The bottom status bar displays "NOTE 10008: Finished opening project "E"" and "time 28Jun2011, 00:57:00.". The taskbar at the bottom shows other open applications: DES606-Training, Microsoft PowerPoint ..., Microsoft Excel - Dim..., Adobe Acrobat Profe..., and HEC-HMS 3.5 [C:\...\...]. The system tray shows the date and time as "1:09 AM".

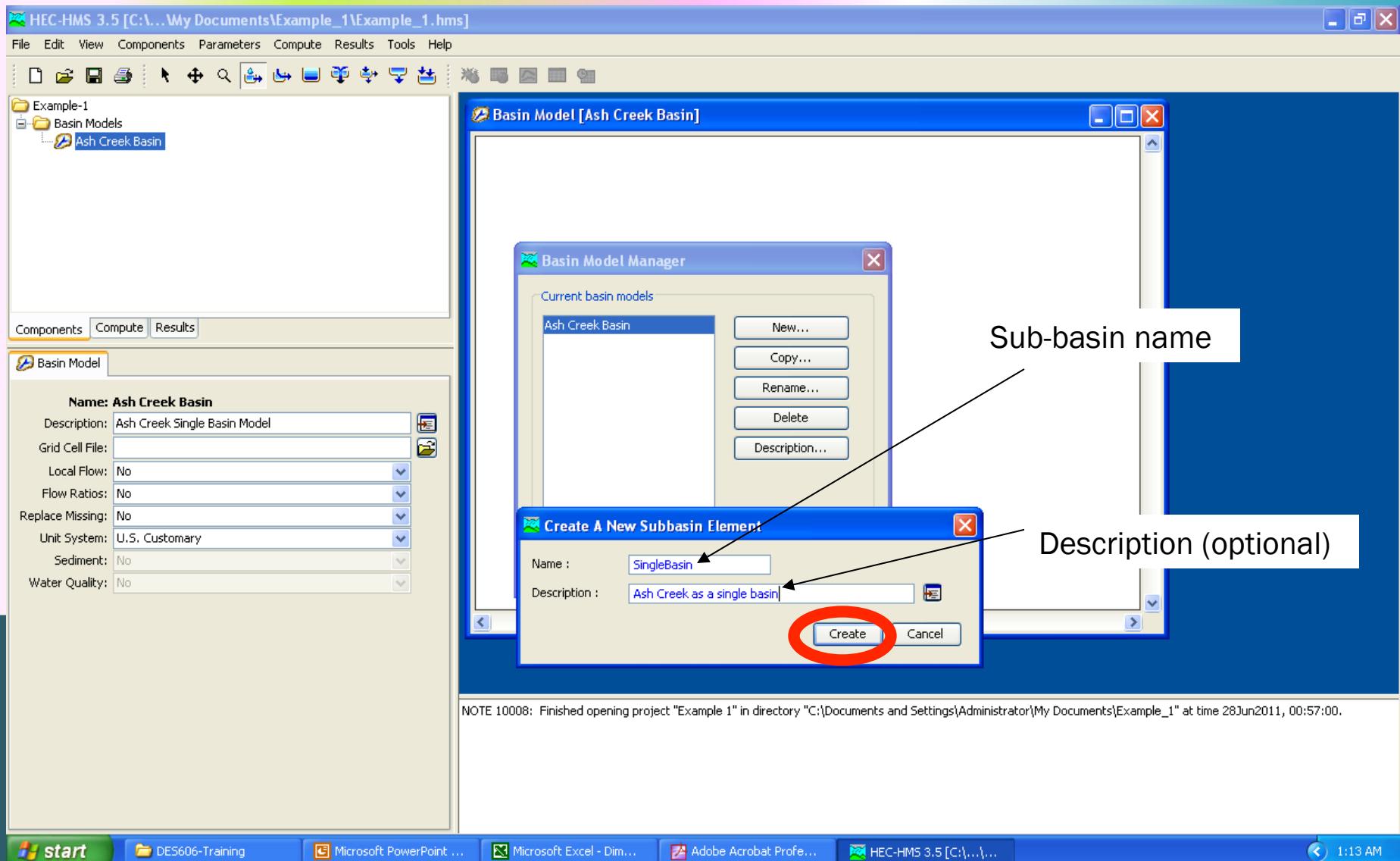
2) “Sub Basin Creation Tool”

Select, then put a sub-basin into the hydrologic elements area

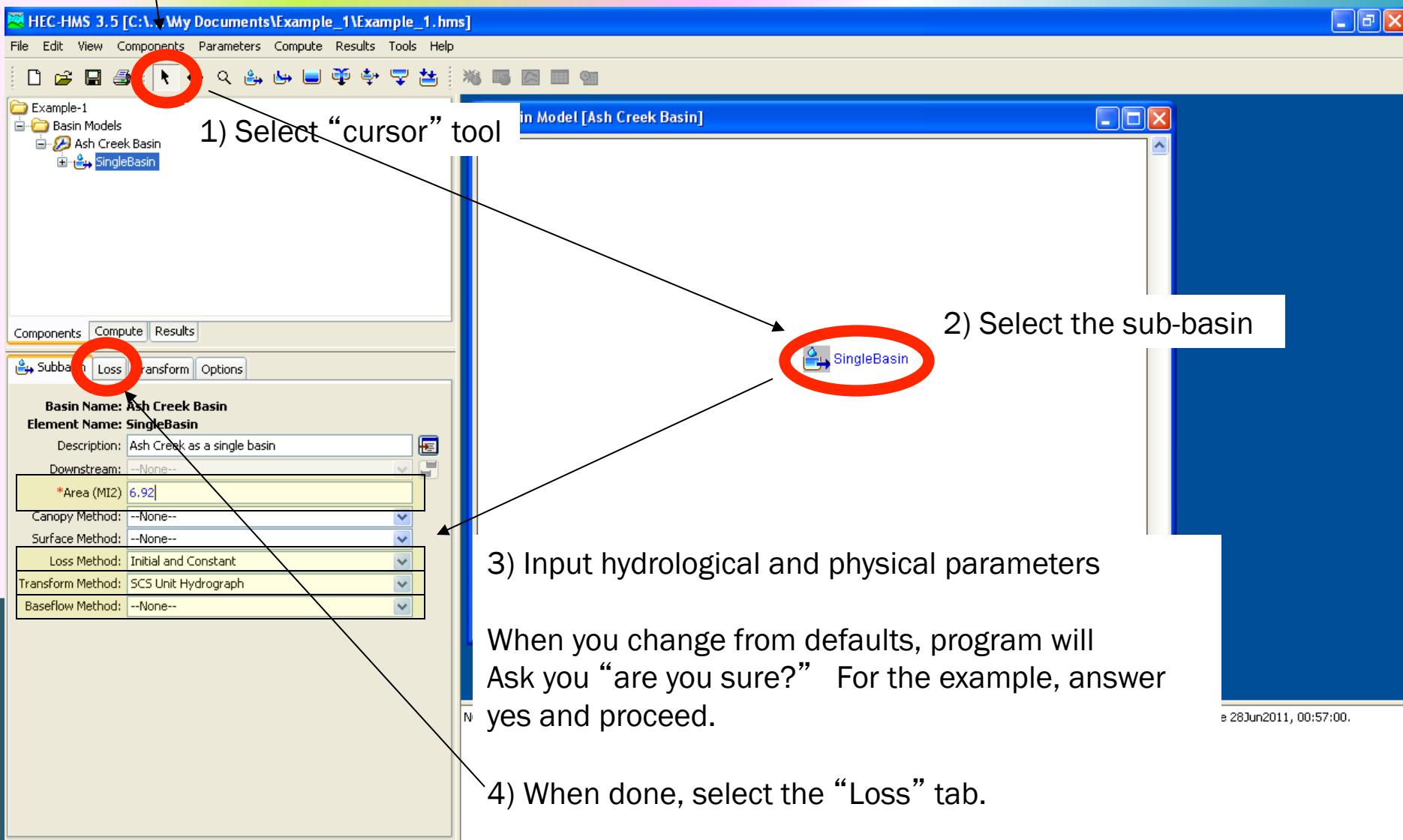
1) Select the Basin Name in the Component Manager Window

Basin Hydrologic Elements
(Starts Empty – we will populate)

CREATE BASIN MODEL



BASIN MODEL DATA INPUT



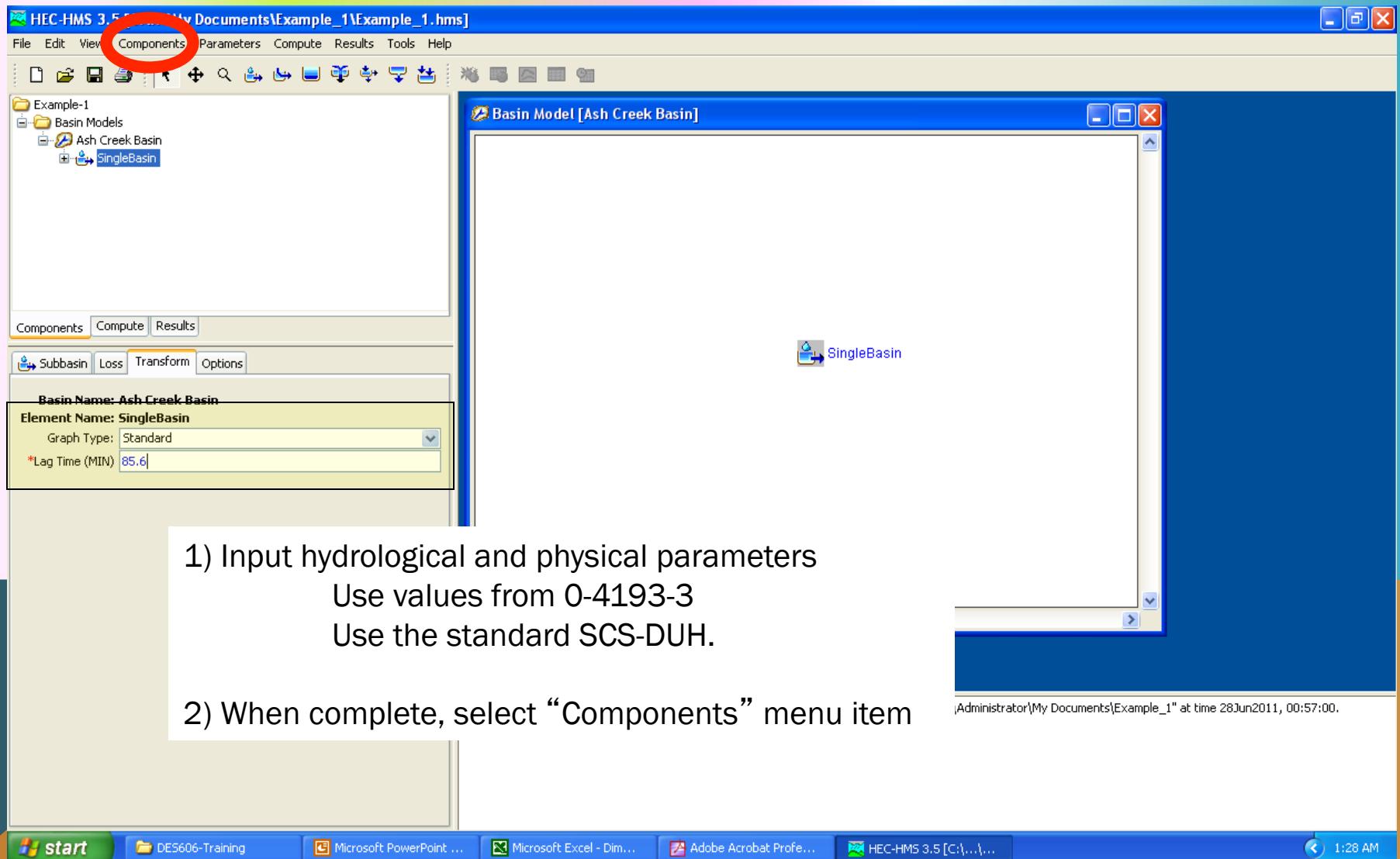
BASIN MODEL DATA INPUT

The screenshot shows the HEC-HMS 3.5 software interface. The title bar reads "HEC-HMS 3.5 [C:\...\My Documents\Example_1\Example_1.hms]". The menu bar includes File, Edit, View, Components, Parameters, Compute, Results, Tools, and Help. The toolbar contains various icons for file operations. The left panel is a file browser showing a folder structure: Example-1 > Basin Models > Ash Creek Basin > SingleBasin. The main workspace is titled "Basin Model [Ash Creek Basin]" and displays a graph with a single blue line labeled "SingleBasin". Below the graph, there is a legend with a blue arrow icon. The bottom left of the workspace has a small preview window showing a different view of the data. The bottom right of the workspace has some text: "C:\Administrator\My Documents\Example_1" at time 28Jun2011, 00:57:00. The bottom of the screen shows the Windows taskbar with icons for Start, DE5606-Training, Microsoft PowerPoint ..., Microsoft Excel - Dim..., Adobe Acrobat Profe..., and HEC-HMS 3.5 [C:\...\...]. The system tray shows the date and time as 1:23 AM.

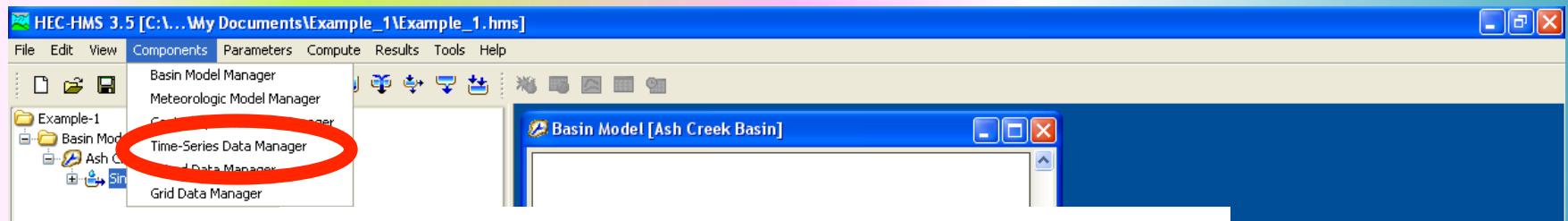
1) Input hydrological and physical parameters
Use values from 0-4193-7
Use 0% IC; 0-4193-7 accounted for IC

2) When complete, select “Transform” tab.

BASIN MODEL DATA INPUT

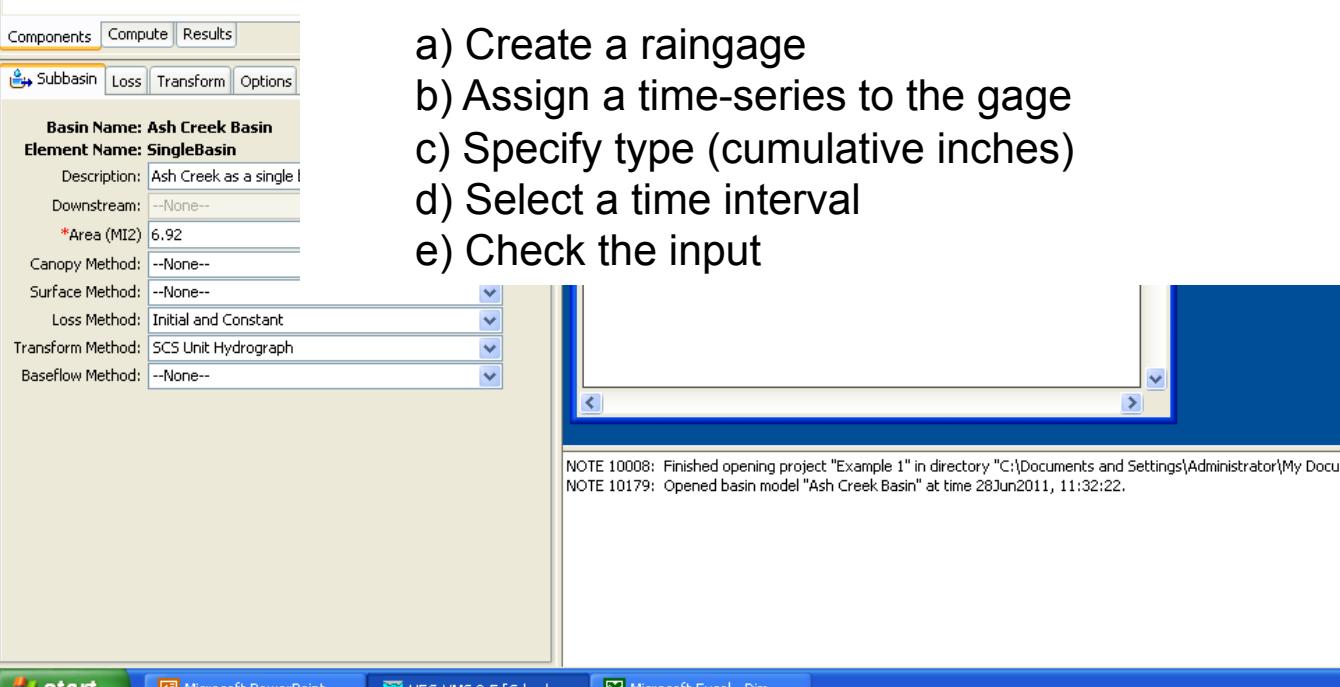


CREATE RAINFALL INPUT

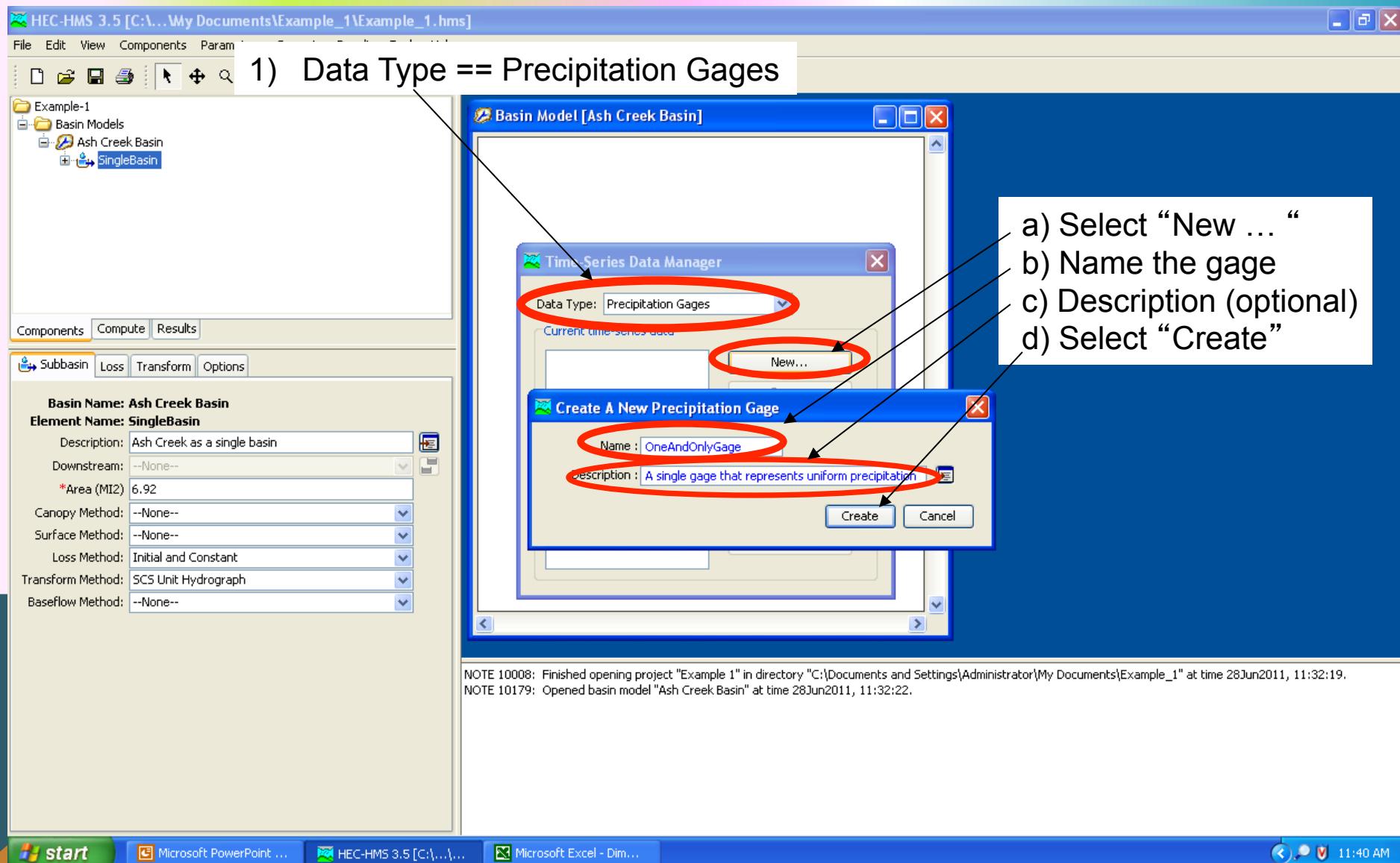


- 1) Choose “Time-series” Data Manager
Will supply the hyetograph input as a time-series.

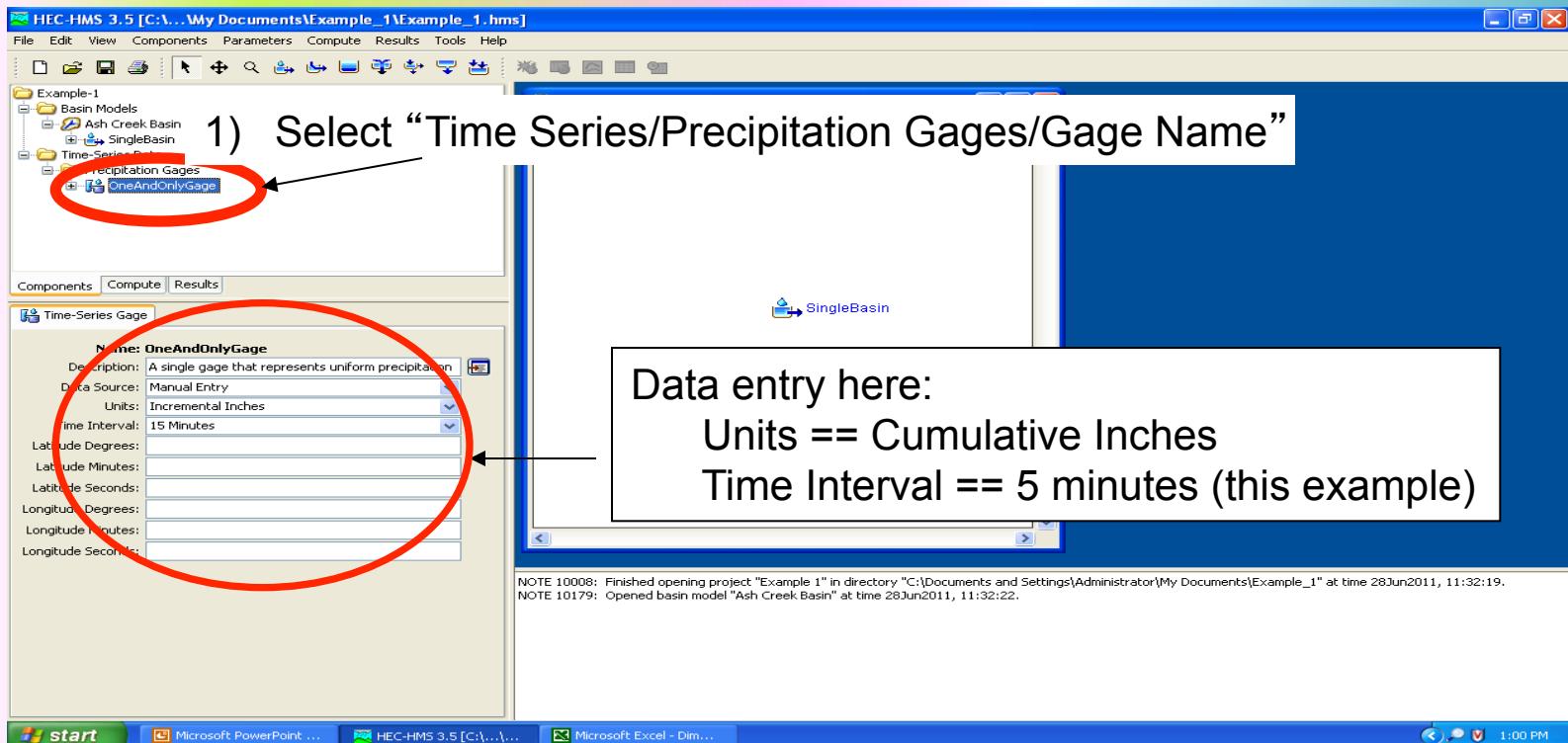
- a) Create a raingage
- b) Assign a time-series to the gage
- c) Specify type (cumulative inches)
- d) Select a time interval
- e) Check the input



CREATE RAINFALL INPUT



CREATE RAINFALL INPUT



CREATE RAINFALL INPUT

HEC-HMS 3.5 [C:\...\My Documents\Example_1\Example_1.hms]

File Edit View Components Parameters Compute Results Tools Help

Select “Time Window”
We will make a 3:15 -hour long input sequence.

Example-1

- Basin Models
 - Ash Creek Basin
 - SingleBasin
- Time-Series Data
 - Precipitation Gages
 - OneAndOnlyGage
 - 01Jan2000, 00:00 - 01Jan2000, 03:15

Components Compute Results

Time-Series Gage Time Window Table Graph

Name: OneAndOnlyGage
Description: A single gage that represents uniform precipitation
Data Source: Manual Entry
Units: Cumulative Inches
Time Interval: 5 Minutes
Latitude Degrees:
Latitude Minutes:
Latitude Seconds:
Longitude Degrees:
Longitude Minutes:
Longitude Seconds:

SingleBasin

NOTE 10008: Finished opening project "Example 1" in directory "C:\Documents and Settings\Administrator\My Documents\Example_1" at time 28Jun2011, 11:32:19.
NOTE 10179: Opened basin model "Ash Creek Basin" at time 28Jun2011, 11:32:22.
NOTE 10604: 1441 missing or invalid values for gage "OneAndOnlyGage".
NOTE 10604: 1621 missing or invalid values for gage "OneAndOnlyGage".
NOTE 10604: 181 missing or invalid values for gage "OneAndOnlyGage".
NOTE 10604: 141 missing or invalid values for gage "OneAndOnlyGage".
NOTE 10604: 142 missing or invalid values for gage "OneAndOnlyGage".

start Microsoft PowerPoint ... HEC-HMS 3.5 [C:\...\...].exe Microsoft Excel - Dim... 1:09 PM

CREATE RAINFALL INPUT

HEC-HMS 3.5 [C:\...\My Documents\Example_1\Example_1.hms]

File Edit View Components Parameters Compute Results Tools Help

Example-1
Basin Models
Ash Creek Basin
SingleBasin
Time-Series Data
Precipitation Gages
OneAndOnlyGage
01Jan2000, 00:00 - 01Jan2000, 03:15

Select “Table” – we will cut-and-paste the time series from Excel

Components Compute Results

Time-Series Gage Time Window Table Graph

Name: OneAndOnlyGage
*Start Date (ddMMYYYY) 01Jan2000
*Start Time (HH:mm) 00:00
*End Date (ddMMYYYY) 01Jan2000
*End Time (HH:mm) 03:15

Basin Model [Ash Creek Basin]

SingleBasin

NOTE 10008: Finished opening project "Example 1" in directory "C:\Documents and Settings\Administrator\My Documents\Example_1" at time 28Jun2011, 11:32:19.
NOTE 10179: Opened basin model "Ash Creek Basin" at time 28Jun2011, 11:32:22.
NOTE 10604: 1441 missing or invalid values for gage "OneAndOnlyGage".
NOTE 10604: 1621 missing or invalid values for gage "OneAndOnlyGage".
NOTE 10604: 181 missing or invalid values for gage "OneAndOnlyGage".
NOTE 10604: 141 missing or invalid values for gage "OneAndOnlyGage".
NOTE 10604: 142 missing or invalid values for gage "OneAndOnlyGage".

start Microsoft PowerPoint ... HEC-HMS 3.5 [C:\...\My Documents\Example_1\Example_1.hms] Microsoft Excel - Dim... 1:14 PM

CREATE RAINFALL INPUT

Select “Table” – we will cut-and-paste the time series from Excel

- Cut and paste 00:05 to 03:10 from the spreadsheet.
- The first value at 00:00 is hand-entered as 0.00
- The last value at 03:15 is hand entered as 3.00

The screenshot shows the HEC-HMS 3.5 software interface. On the left, the project tree shows 'Example-1' with 'Basin Models' and 'Time-Series Data'. Under 'Time-Series Data', there is a 'OneAndOnlyGage' entry with a file path '01Jan2000, 00:00 - 01Jan2000, 03:15'. The main window has tabs for 'Components', 'Compute', and 'Results'. The 'Table' tab is selected, displaying a grid of data:

Time (ddMMYYYY, HH:mm)	Precipitation (IN)
01Jan2000, 00:00	0.00
01Jan2000, 00:05	0.17
01Jan2000, 00:10	0.44
01Jan2000, 00:15	0.66
01Jan2000, 00:20	0.85
01Jan2000, 00:25	0.99
01Jan2000, 00:30	1.11
01Jan2000, 00:35	1.20
01Jan2000, 00:40	1.28
01Jan2000, 00:45	1.35
01Jan2000, 00:50	1.40
01Jan2000, 00:55	1.45
01Jan2000, 01:00	1.49
01Jan2000, 01:05	1.53
01Jan2000, 01:10	1.57
01Jan2000, 01:15	1.62
01Jan2000, 01:20	1.66
01Jan2000, 01:25	1.71

A red circle highlights the row for 01Jan2000, 00:05. A red arrow points from this row to the corresponding row in an adjacent Excel spreadsheet window. The Excel window shows a table with columns 'time(min)', 'time(hr)', and 'depth(in)'. The cell for 'depth(in)' at row 70 (0.17002) is also circled in red. A graph in the Excel window shows a curve fitting the data, with the equation $y = 0.0823x^5 - 0.7932x^{1/2}$.

time(min)	time(hr)	depth(in)
5	0.083333	0.17002
10	0.166667	0.44199
15	0.25	0.664421
20	0.333333	0.845187
25	0.416667	0.991361
30	0.5	1.109259
35	0.583333	1.204476
40	0.666667	1.281927
45	0.75	1.345886
50	0.833333	1.40003
55	0.916667	1.44747
60	1	1.4908
65	1.083333	1.532131
70	1.166667	1.573131
75	1.25	1.615069
80	1.333333	1.658849
85	1.416667	1.705052
90	1.5	1.753978
95	1.583333	1.805683
100	1.666667	1.860018

At the bottom of the Excel window, there are buttons for 'Draw', 'AutoShapes', and other tools, along with status bars showing 'Ready', 'Sum=72.46650611', and 'NUM'.

CREATE RAINFALL INPUT

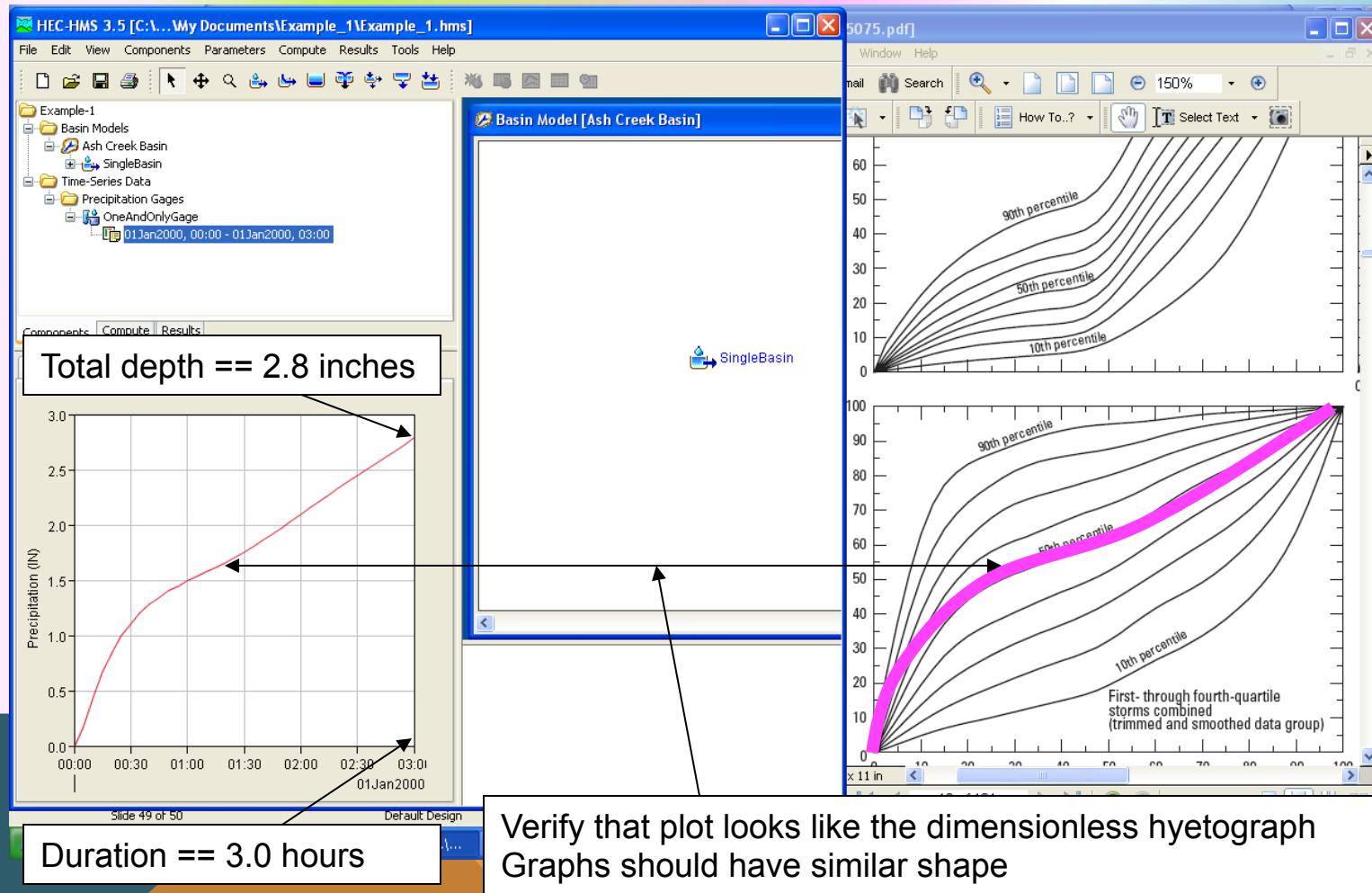
Select “Table” – we will cut-and-paste the time series from Excel

- Cut and paste 00:05 to 03:00 from the spreadsheet.
- The first value at 00:00 is hand-entered as 0.00

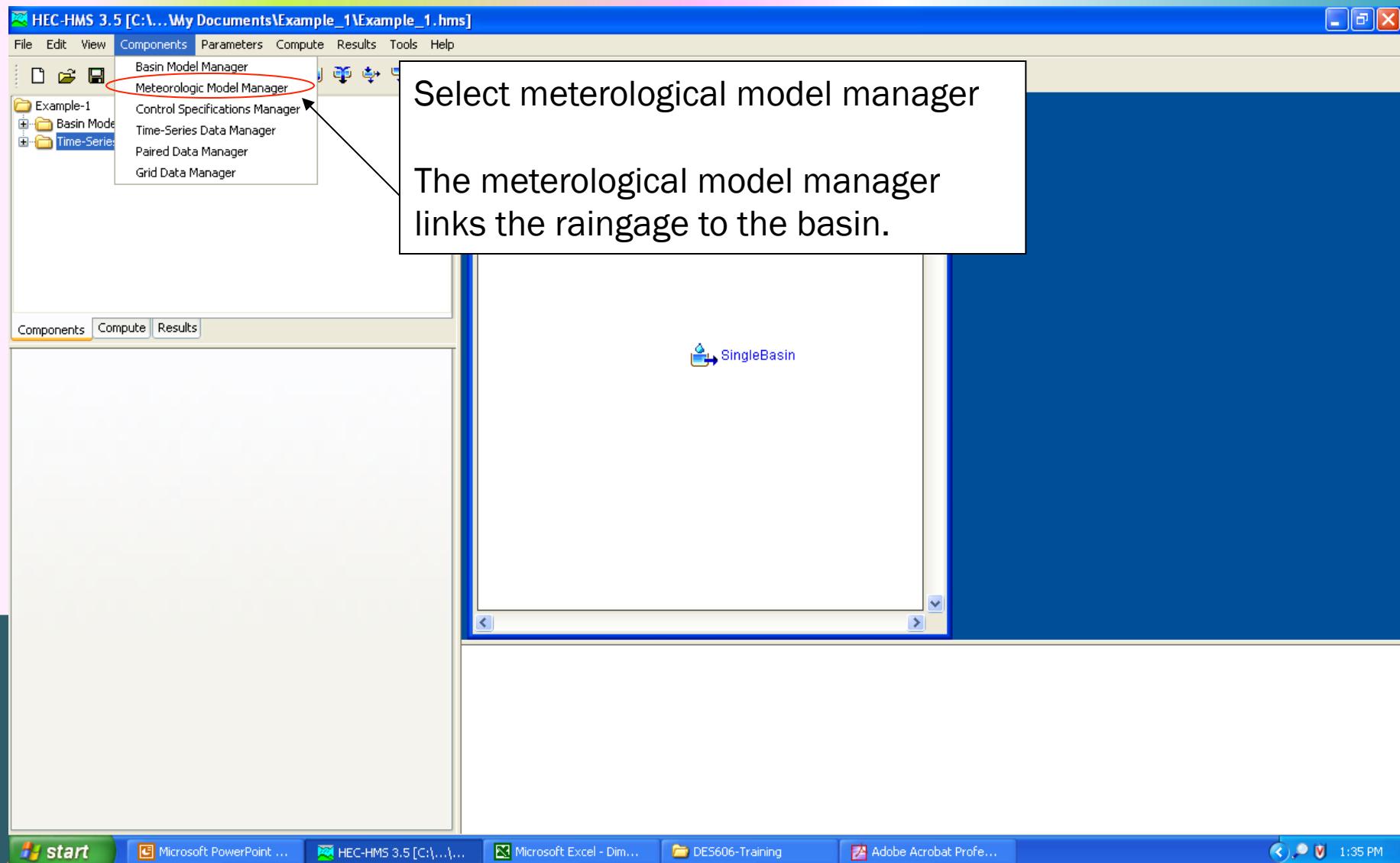
The screenshot shows the HEC-HMS 3.5 software interface. On the left, there's a tree view of project components: Example-1 > Basin Models > Ash Creek Basin > SingleBasin, and Time-Series Data > Precipitation Gages > OneAndOnlyGage. The 'OneAndOnlyGage' node is selected, showing a timestamp range of 01Jan2000, 00:00 - 01Jan2000, 03:15. In the center, there are four tabs: Components, Compute, Results, and Table. The Table tab is active, displaying a grid of data. The first column is 'Time (ddMMYYYY, HH:mm)' and the second is 'Precipitation (IN)'. The data starts with 0.00 at 00:00 and 0.17 at 00:05. A red circle highlights the cell for 00:05. A callout box from the 'Table' tab points to a specific cell in an Excel spreadsheet window on the right. This cell is highlighted with a red oval and contains the value 0.17002. The Excel window also shows other columns: 'time(min)', 'time(hr)', 'depth(in.)', and 'b0', 'b1', 'b2', 'b3'. To the right of the Excel window is a graph titled 'Hyetograph' showing Depth (inches) over time. The graph has a curve starting at (0,0) and ending at approximately (100, 1.7).

Time (ddMMYYYY, HH:mm)	Precipitation (IN)
01Jan2000, 00:00	0.00
01Jan2000, 00:05	0.17
01Jan2000, 00:10	0.44
01Jan2000, 00:15	0.66
01Jan2000, 00:20	0.85
01Jan2000, 00:25	0.99
01Jan2000, 00:30	1.11
01Jan2000, 00:35	1.20
01Jan2000, 00:40	1.28
01Jan2000, 00:45	1.35
01Jan2000, 00:50	1.40
01Jan2000, 00:55	1.45
01Jan2000, 01:00	1.49
01Jan2000, 01:05	1.53
01Jan2000, 01:10	1.57
01Jan2000, 01:15	1.62
01Jan2000, 01:20	1.66
01Jan2000, 01:25	1.71

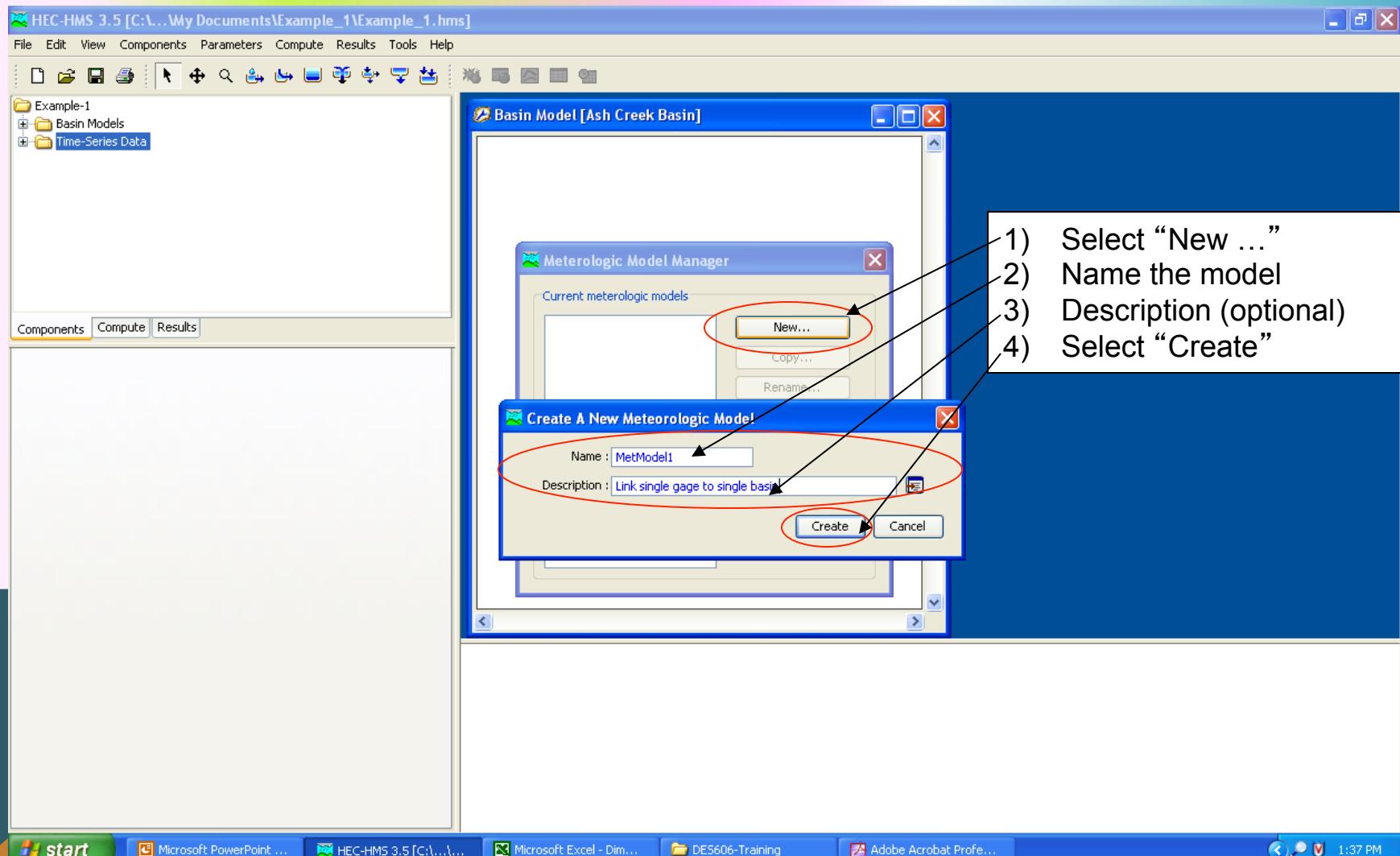
CREATE RAINFALL INPUT



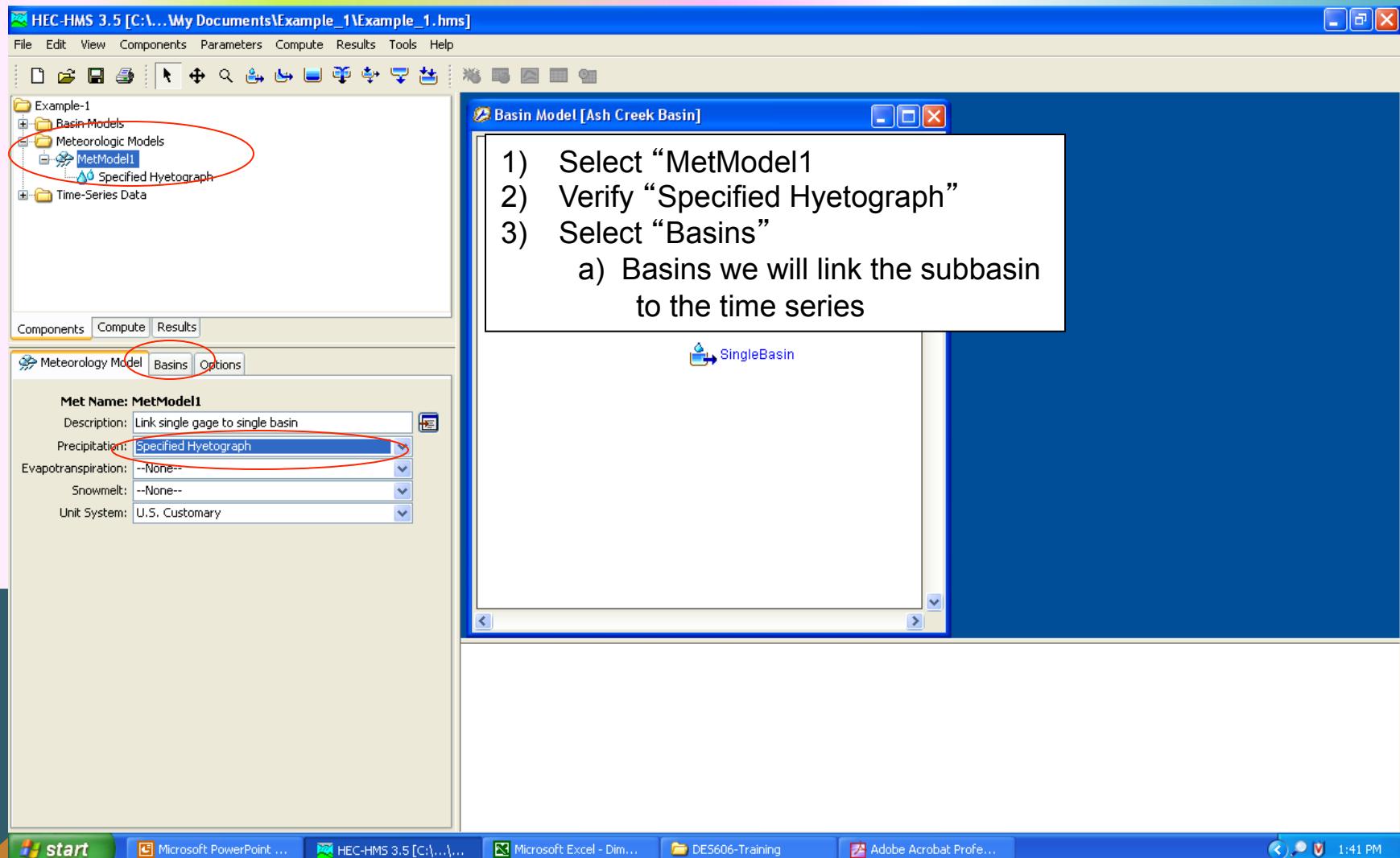
CREATE METEROLOGICAL MODEL



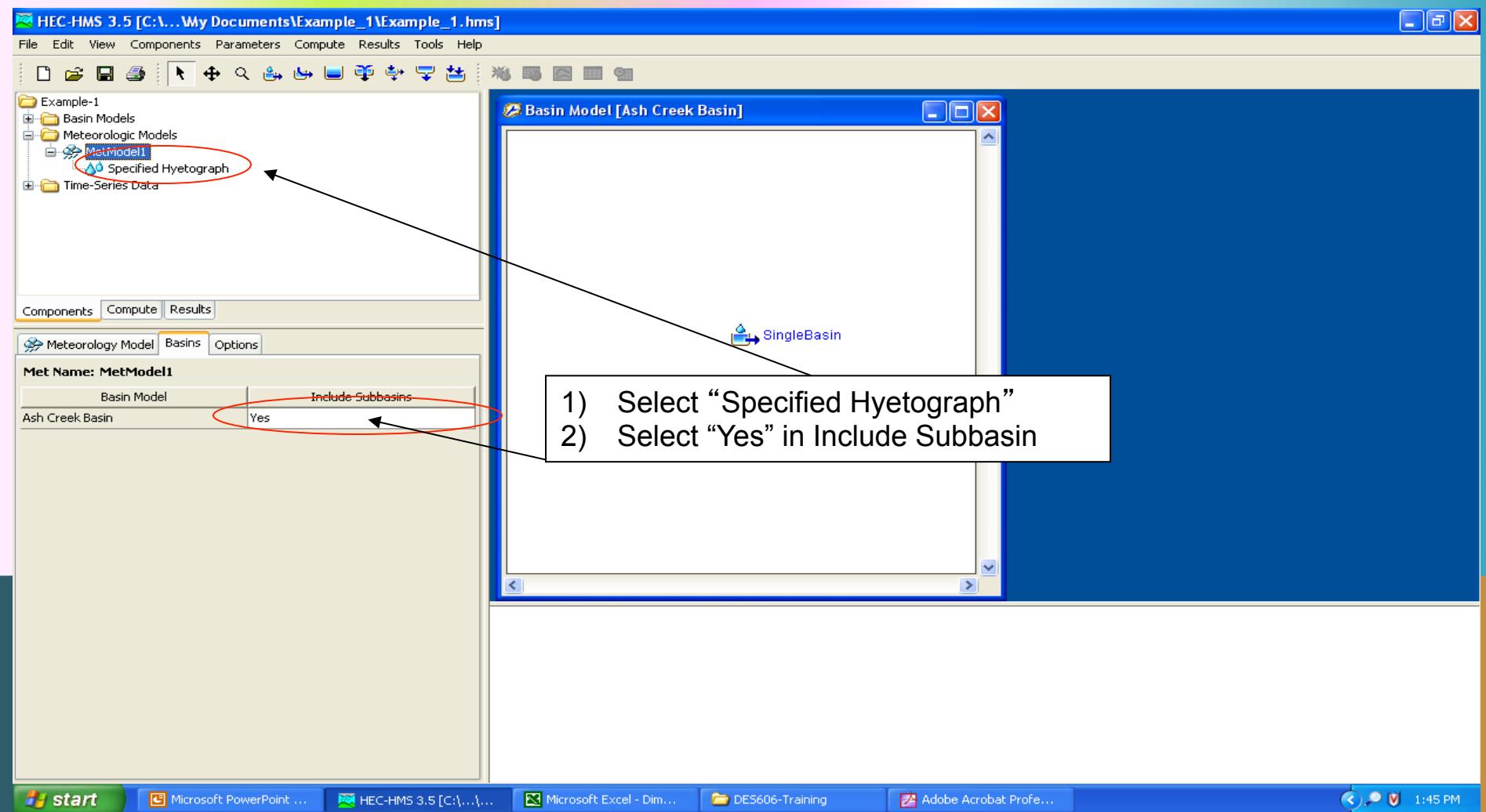
CREATE METEROLOGICAL MODEL



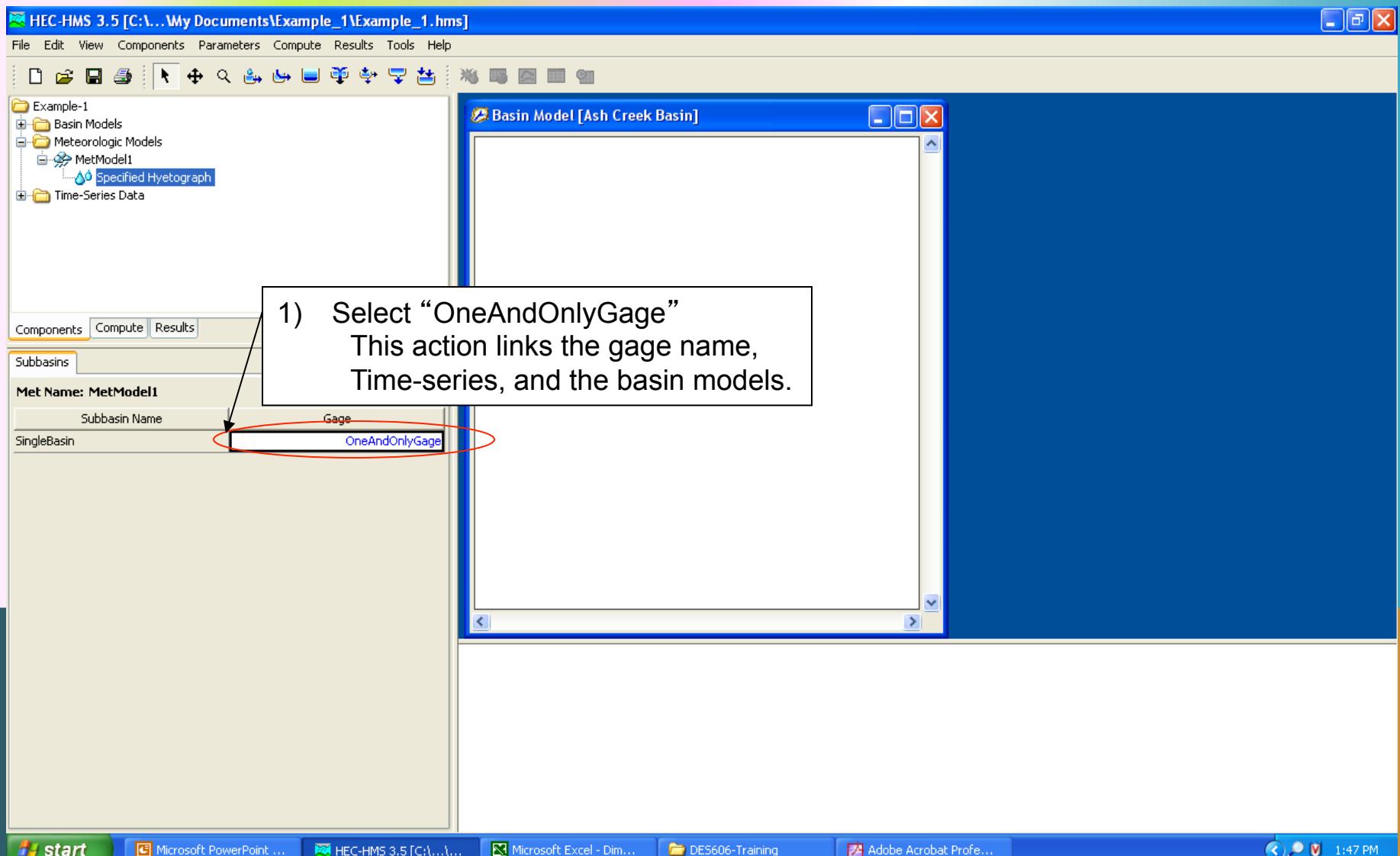
CREATE METEROLOGICAL MODEL



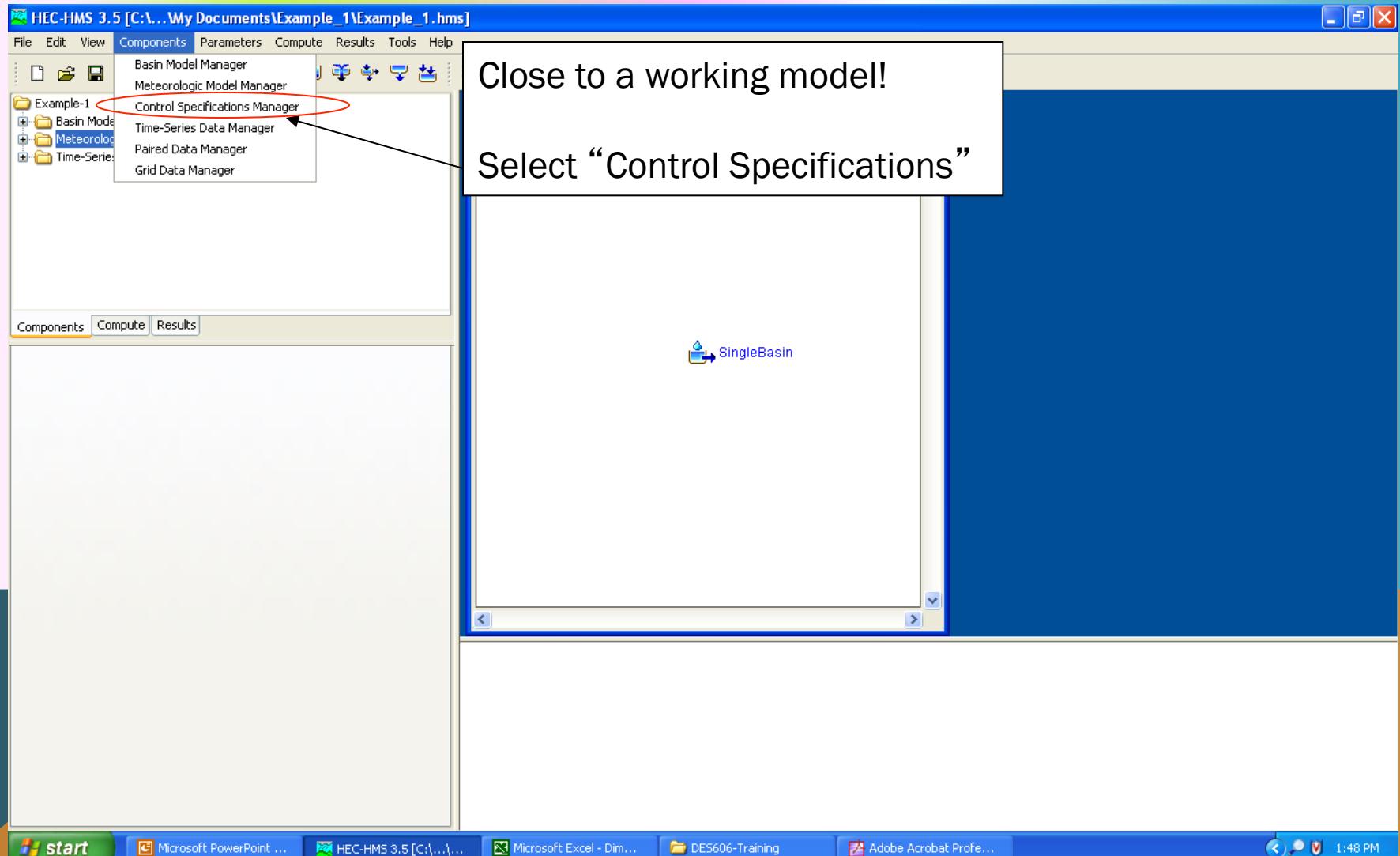
CREATE METEROLOGICAL MODEL



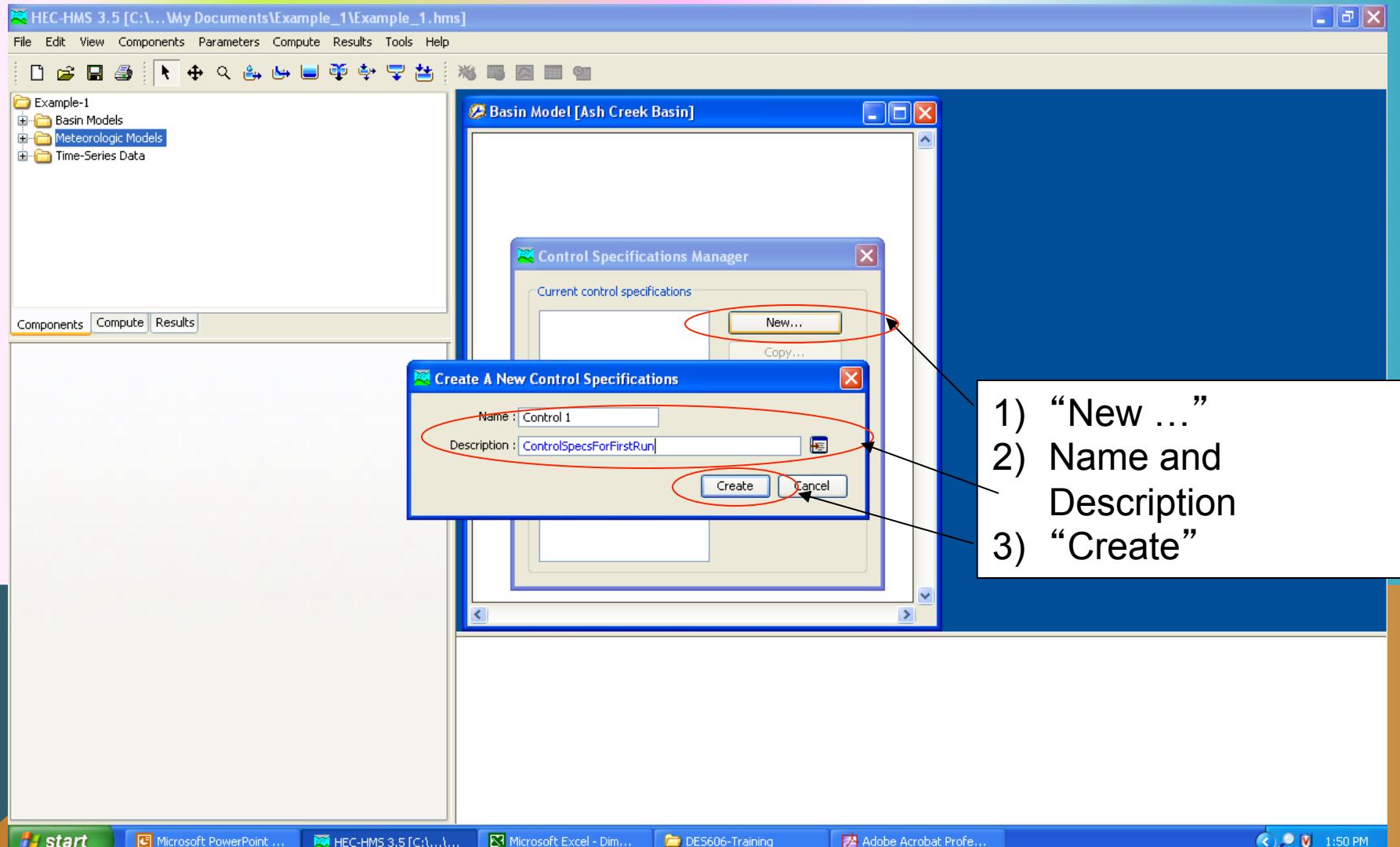
CREATE METEROLOGICAL MODEL



CREATE CONTROL SPECIFICATIONS



CREATE CONTROL SPECIFICATIONS



CREATE CONTROL SPECIFICATIONS

HEC-HMS 3.5 [C:\...\My Documents\Example_1\Example_1.hms]

File Edit View Components Parameters Compute Results Tools Help

Example-1

- Basin Models
 - Ash Creek Basin
 - SingleBasin
- Meteorologic Models
- Control Specifications
 - Control 1
- Time-Series Data
 - Precipitation Gages
 - OneAndOnlyGage
 - 01Jan2000, 00:00 - 01Jan2000, 03:00

Components Compute Results

Control Specifications

Name: Control 1
Description: ControlSpecsForFirstRun
Start Date (ddMMYYYY): 01Jan2000
*Start Time (HH:mm): 00:00
*End Date (ddMMYYYY): 01Jan2000
*End Time (HH:mm): 23:00
Time Interval: 15 Minutes

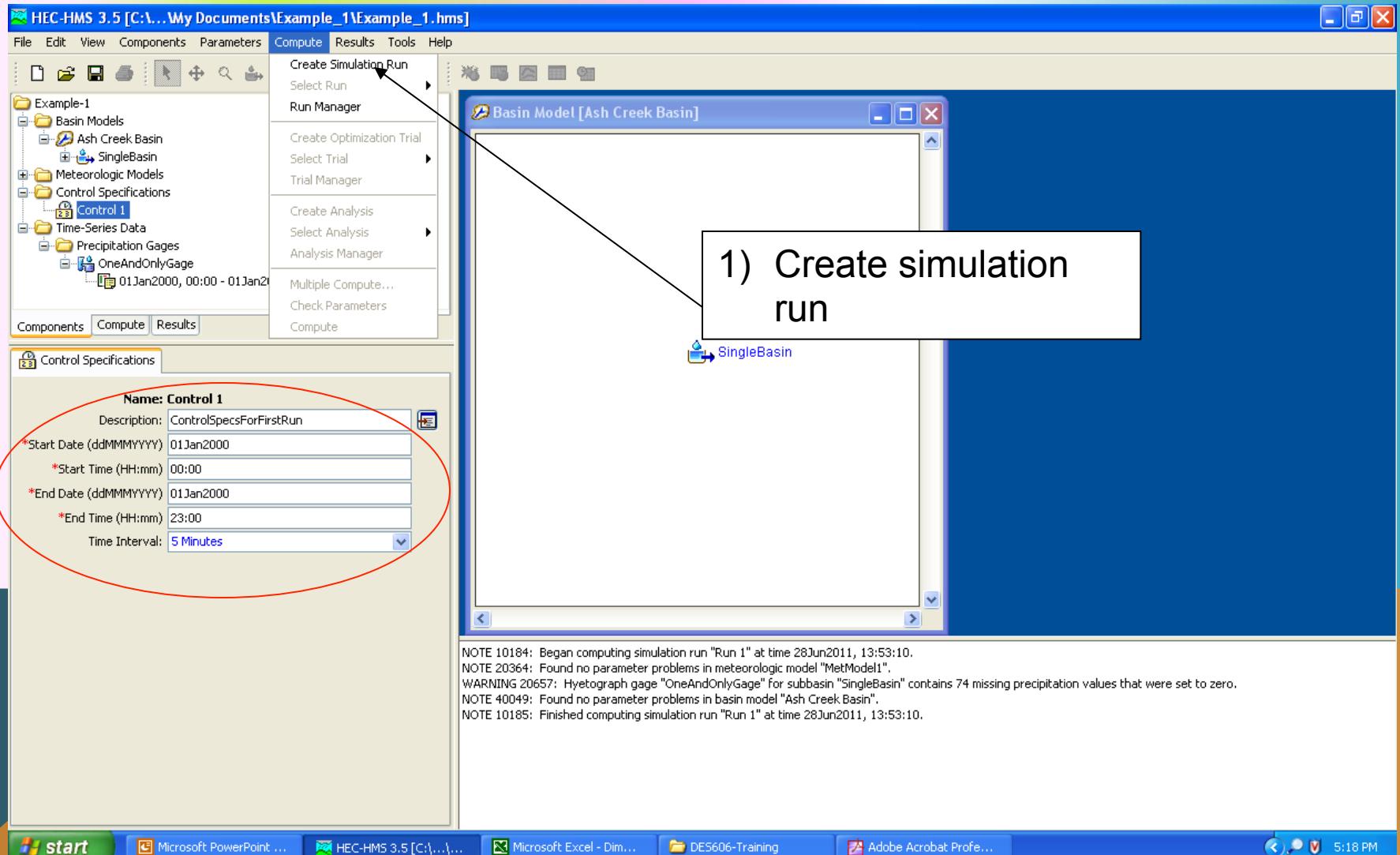
Basin Model [Ash Creek Basin]

1) Provide simulation start and end dates/time
2) Should cover the rainfall input time, but can be longer
3) Time step should be appropriate.

NOTE 10184: Began computing simulation run "Run 1" at time 28Jun2011, 13:53:10.
NOTE 20364: Found no parameter problems in meteorologic model "MetModel".
WARNING 20657: Hyetograph gage "OneAndOnlyGage" for subbasin "SingleBasin" contains 74 missing precipitation values that were set to zero.
NOTE 40049: Found no parameter problems in basin model "Ash Creek Basin".
NOTE 10185: Finished computing simulation run "Run 1" at time 28Jun2011, 13:53:10.

start Microsoft PowerPoint ... HEC-HMS 3.5 [C:\...\... Microsoft Excel - Dim... DES606-Training Adobe Acrobat Profe... 5:16 PM

CREATE SIMULATION



CREATE SIMULATION

HEC-HMS 3.5 [C:\...\My Documents\Example_1\Example_1.hms]

File Edit View Components Parameters Compute Results Tools Help

Example-1

- Basin Models
 - Ash Creek Basin
 - SingleBasin
- Meteorologic Models
- Control Specifications
 - Control 1
- Time-Series Data
 - Precipitation Gages
 - OneAndOnlyGage
 - 01Jan2000, 00:00 - 01Jan2000, 03:00

Components Compute Results

Control Specifications

Name: Control 1

Description: ControlSpecsForFirstRun

*Start Date (ddMMYYYY) 01Jan2000

*Start Time (HH:mm) 00:00

*End Date (ddMMYYYY) 01Jan2000

*End Time (HH:mm) 23:00

Time Interval: 5 Minutes

Basin Model [Ash Creek Basin]

Create a Simulation Run [Step 1 of 4]

A simulation run must have a name. You can give it a description after it has been created.

Name

To continue, enter a name and click Next.

< Back Next > Cancel

NOTE 10184: Began computing simulation run "Run 1" at time 28Jun2011, 13:53:10.
NOTE 20364: Found no parameter problems in meteorologic model "MetModel".
WARNING 20657: Hyetograph gage "OneAndOnlyGage" for subbasin "SingleBasin" contains 74 missing precipitation values that were set to zero.
NOTE 40049: Found no parameter problems in basin model "Ash Creek Basin".
NOTE 10185: Finished computing simulation run "Run 1" at time 28Jun2011, 13:53:10.

start Microsoft PowerPoint ... HEC-HMS 3.5 [C:\...\...] Microsoft Excel - Dim... DES606-Training Adobe Acrobat Profe... 5:19 PM

CREATE SIMULATION

HEC-HMS 3.5 [C:\...\My Documents\Example_1\Example_1.hms]

File Edit View Components Parameters Compute Results Tools Help

Example-1

- Basin Models
 - Ash Creek Basin
 - SingleBasin
- Meteorologic Models
- Control Specifications
 - Control 1
- Time-Series Data
 - Precipitation Gages
 - OneAndOnlyGage
 - 01Jan2000, 00:00 - 01Jan2000, 03:00

Components Compute Results

Control Specifications

Name: Control 1

Description: ControlSpecsForFirstRun

*Start Date (ddMMYYYY) 01Jan2000

*Start Time (HH:mm) 00:00

*End Date (ddMMYYYY) 01Jan2000

*End Time (HH:mm) 23:00

Time Interval: 5 Minutes

Basin Model [Ash Creek Basin]

1) Verify model selections
2) Choose next

Create a Simulation Run [Step 2 of 4]

A simulation run includes a basin model. Select one from the list below.

Name	Description
Ash Creek Basin	Ash Creek Single Basin Model

To continue, select a basin model and click Next.

< Back Next > Cancel

NOTE 10184: Began computing simulation run "Run 1" at time 28Jun2011, 13:53:10.
NOTE 20364: Found no parameter problems in meteorologic model "MetModel".
WARNING 20657: Hyetograph gage "OneAndOnlyGage" for subbasin "SingleBasin" contains 74 missing precipitation values that were set to zero.
NOTE 40049: Found no parameter problems in basin model "Ash Creek Basin".
NOTE 10185: Finished computing simulation run "Run 1" at time 28Jun2011, 13:53:10.

start Microsoft PowerPoint ... HEC-HMS 3.5 [C:\...\]... Microsoft Excel - Dim... DES606-Training Adobe Acrobat Profe... 5:20 PM

CREATE SIMULATION

HEC-HMS 3.5 [C:\...\My Documents\Example_1\Example_1.hms]

File Edit View Components Parameters Compute Results Tools Help

Example-1

- Basin Models
 - Ash Creek Basin
 - SingleBasin
- Meteorologic Models
- Control Specifications
 - Control 1
- Time-Series Data
 - Precipitation Gages
 - OneAndOnlyGage
 - 01Jan2000, 00:00 - 01Jan2000, 03:00

Components Compute Results

Control Specifications

Name: Control 1

Description: ControlSpecsForFirstRun

*Start Date (ddMMYYYY) 01Jan2000

*Start Time (HH:mm) 00:00

*End Date (ddMMYYYY) 01Jan2000

*End Time (HH:mm) 23:00

Time Interval: 5 Minutes

Basin Model [Ash Creek Basin]

Create a Simulation Run [Step 3 of 4]

Selected basin model "Ash Creek Basin". A simulation run includes a meteorologic model. Select one from the list below.

Name	Description
MetModel1	Link single gage to single basin

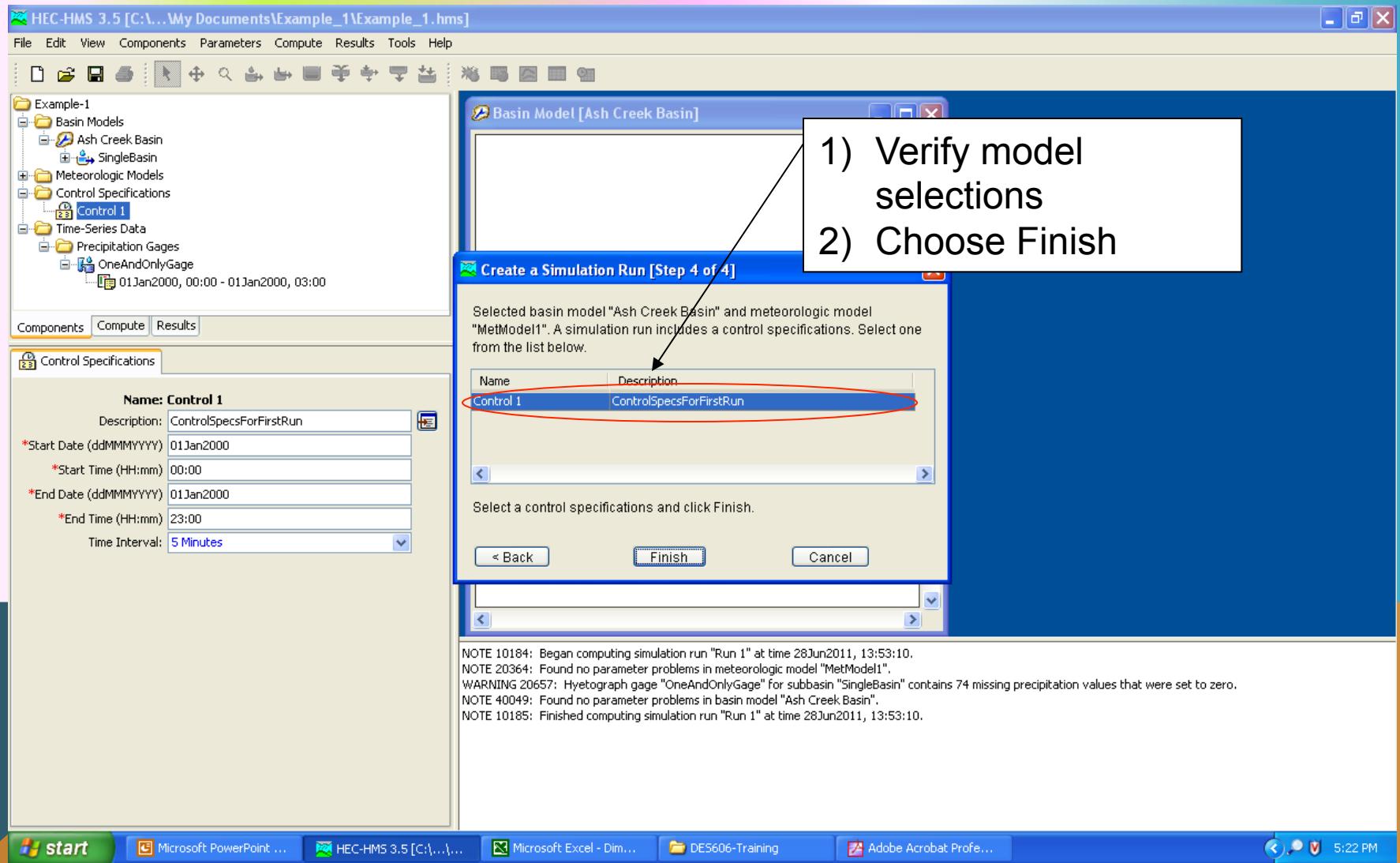
To continue, select a meteorologic model and click Next.

< Back Next > Cancel

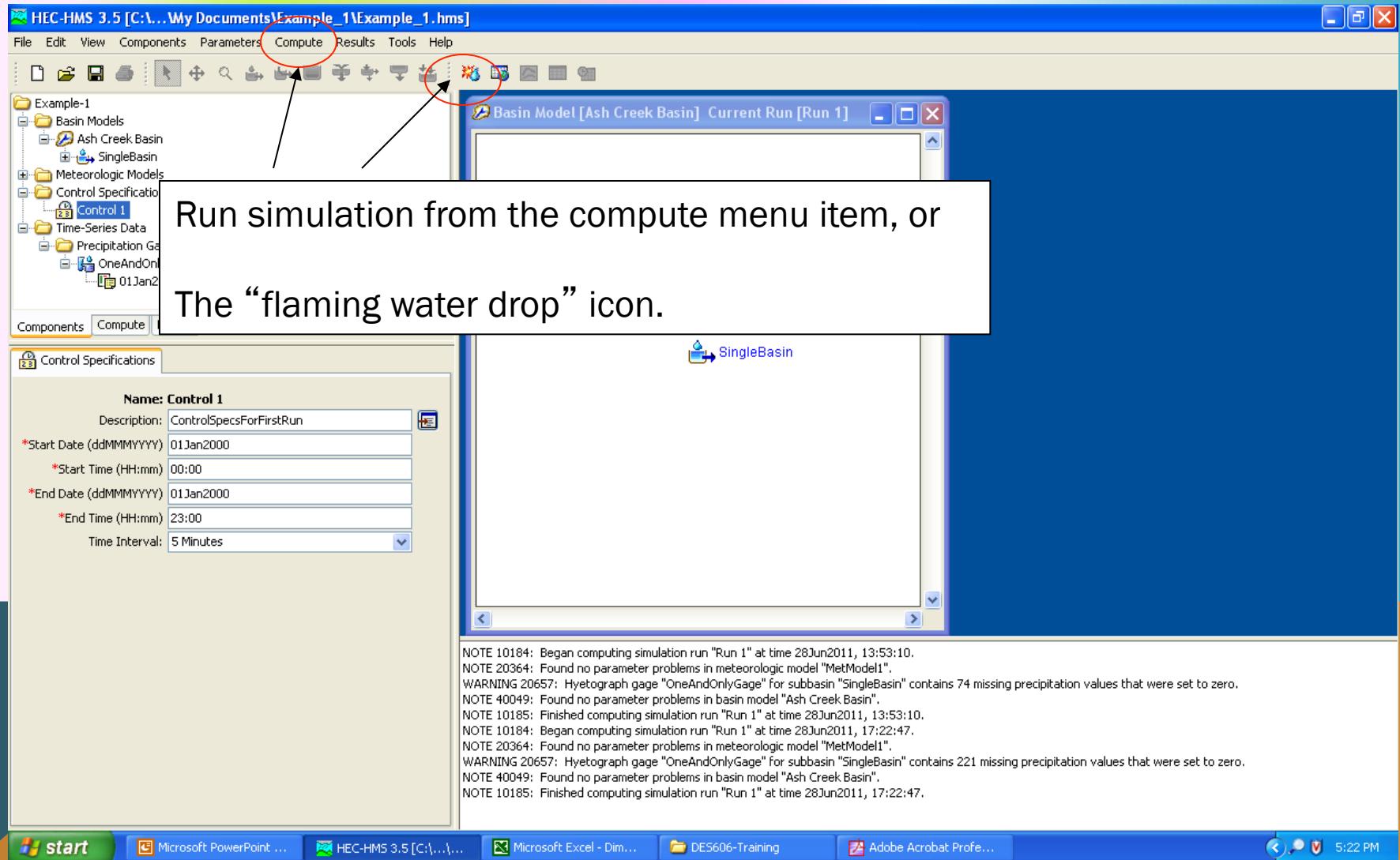
NOTE 10184: Began computing simulation run "Run 1" at time 28Jun2011, 13:53:10.
NOTE 20364: Found no parameter problems in meteorologic model "MetModel1".
WARNING 20657: Hyetograph gage "OneAndOnlyGage" for subbasin "SingleBasin" contains 74 missing precipitation values that were set to zero.
NOTE 40049: Found no parameter problems in basin model "Ash Creek Basin".
NOTE 10185: Finished computing simulation run "Run 1" at time 28Jun2011, 13:53:10.

1) Verify model selections
2) Choose next

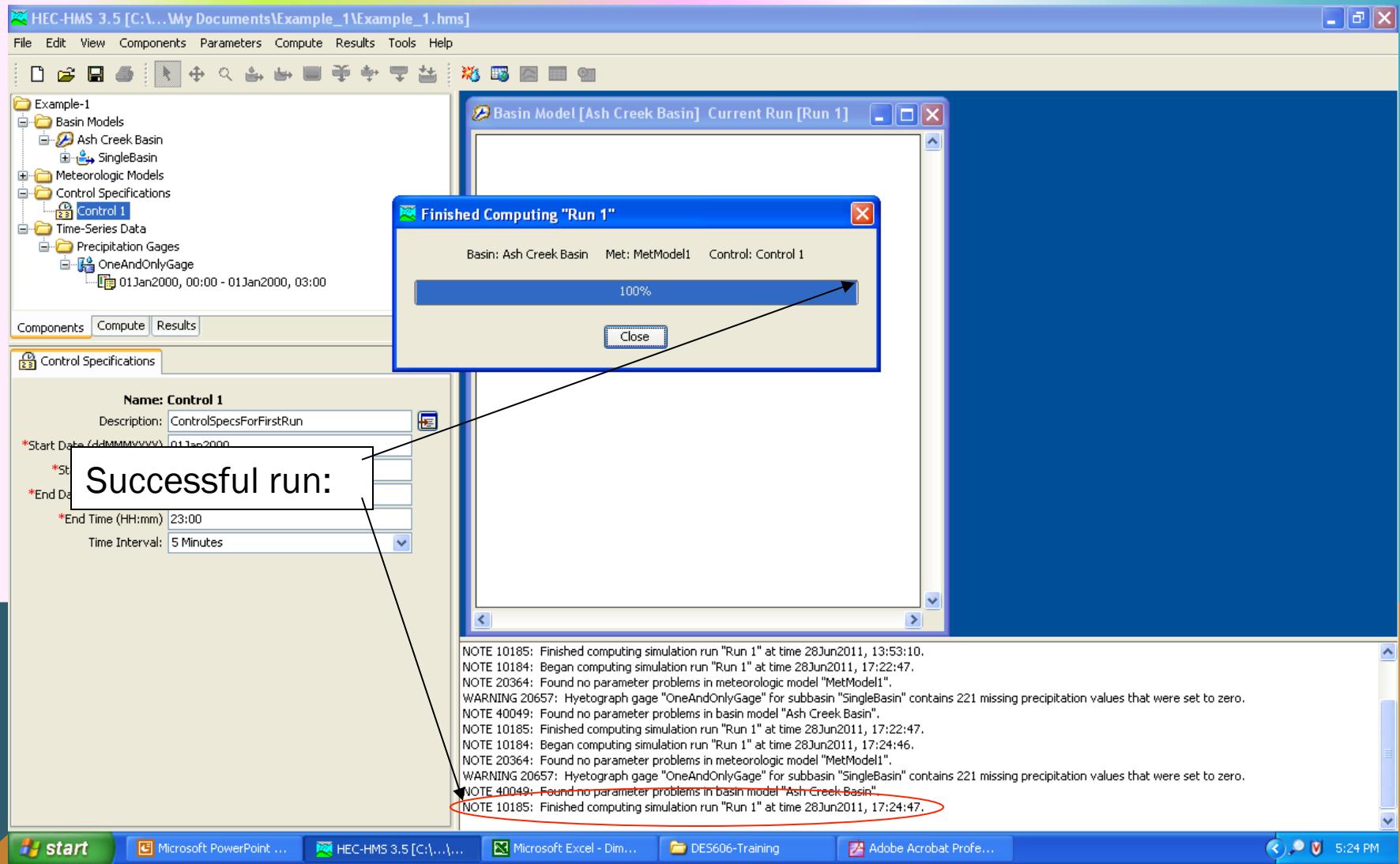
CREATE SIMULATION



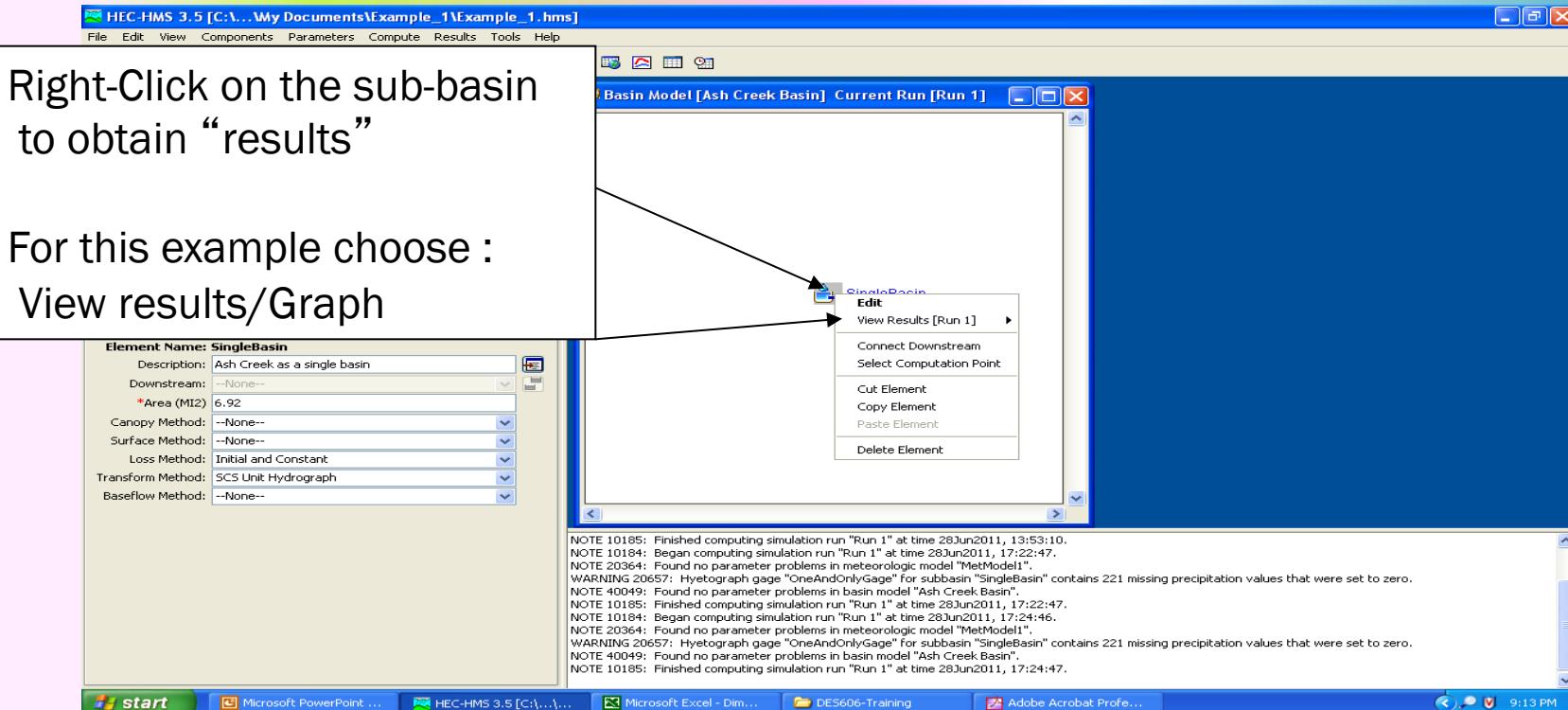
RUN SIMULATION



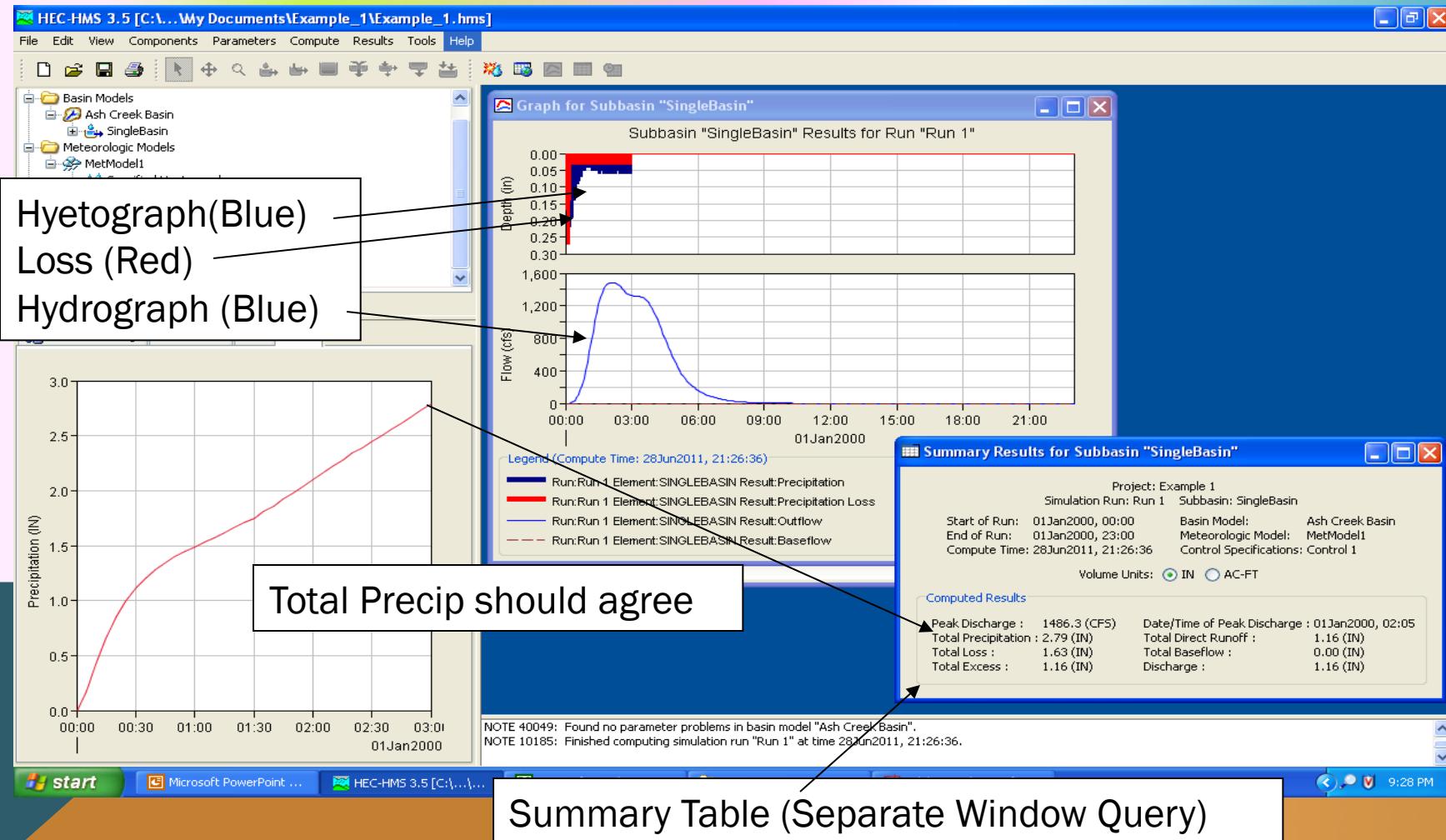
RUN SIMULATION



RUN SIMULATION



VIEW RESULTS



ADD OBSERVATIONS

Intentional input basin lag as 80 minutes

Use a historical storm and see how well (or poorly) we did

Use Time-Series-Manager to add these new gages

Use Control-Specifications to build control conditions for this different run.

NEXT TIME

- ES7 Solution Sketch
- Unit Hydrographs – HMS Workshop
 - Multiple sub-basins