3. Estimate the peak flow of a square shaped 50 acre, single family residential area in Harris County. The site is graded from an elevation of 150ft at the corner to 139ft at the outlet as depicted on Figure 7.

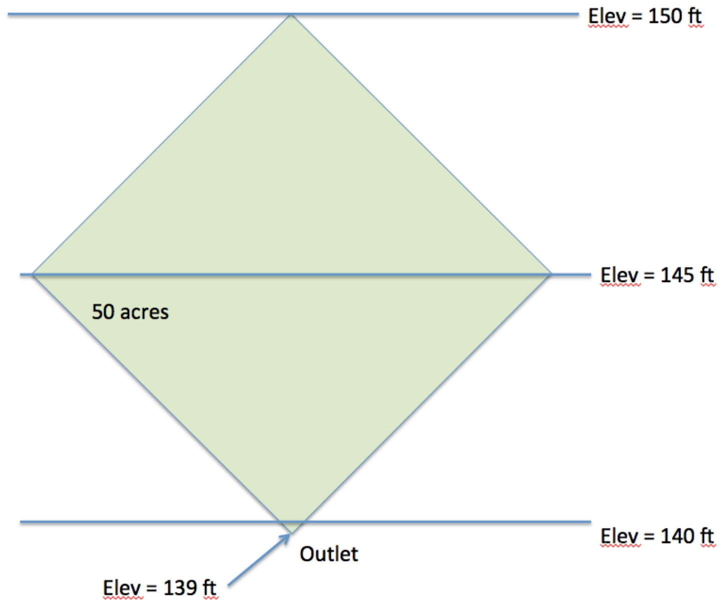

Figure 7: 50 acre square watershed with elevation contour overlay

i) Draw on the diagram the longest flow path from the highest elevation to the outlet, and determine the length of the flow path in feet.

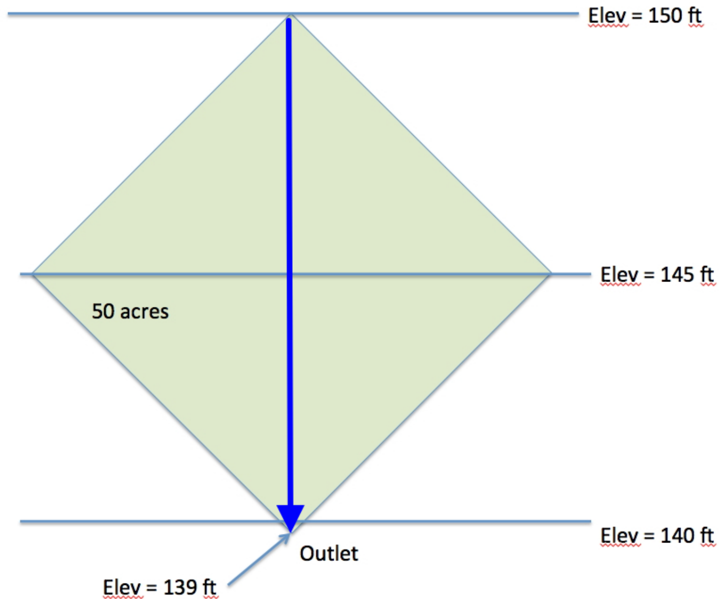

Figure 8: 50 acre square watershed with elevation contour overlay and a reasonable average (long) flow path shown. Observe grading is such that any point on the watershed drains down.

Length of the path on the diagram is $L = \sqrt{2 \times 50 \times 43560} ft. = 2087$ ft.

ii) Estimate the time of concentration.

Any method would be fine, I choose the NRCS Upland method because its super easy. Figure 9 is a screen capture of a spreadsheet that implements the upland method described in NEH 630 (citation is on the spreadsheet).

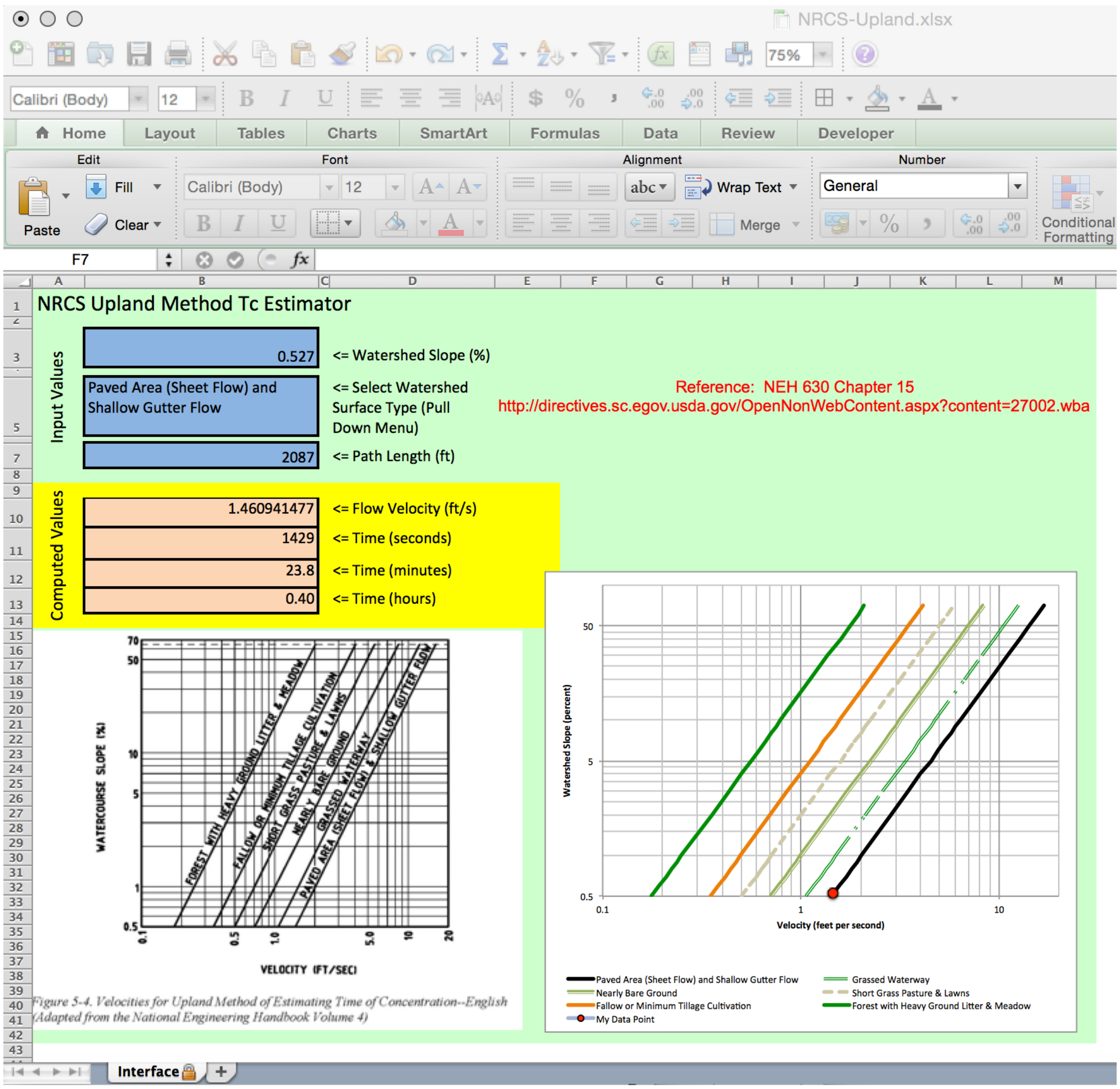

Figure 9: NRCS Upland Method applied to flow path in Figure 8

iii) Estimate the peak discharge for a 10-year storm, 6-hour using the Rational Method.

The rational method would use 24 minutes as the time of concentration. Using either Texas DDF atlas or `EBDLKUP-2015` we would obtain a rainfall intensity.

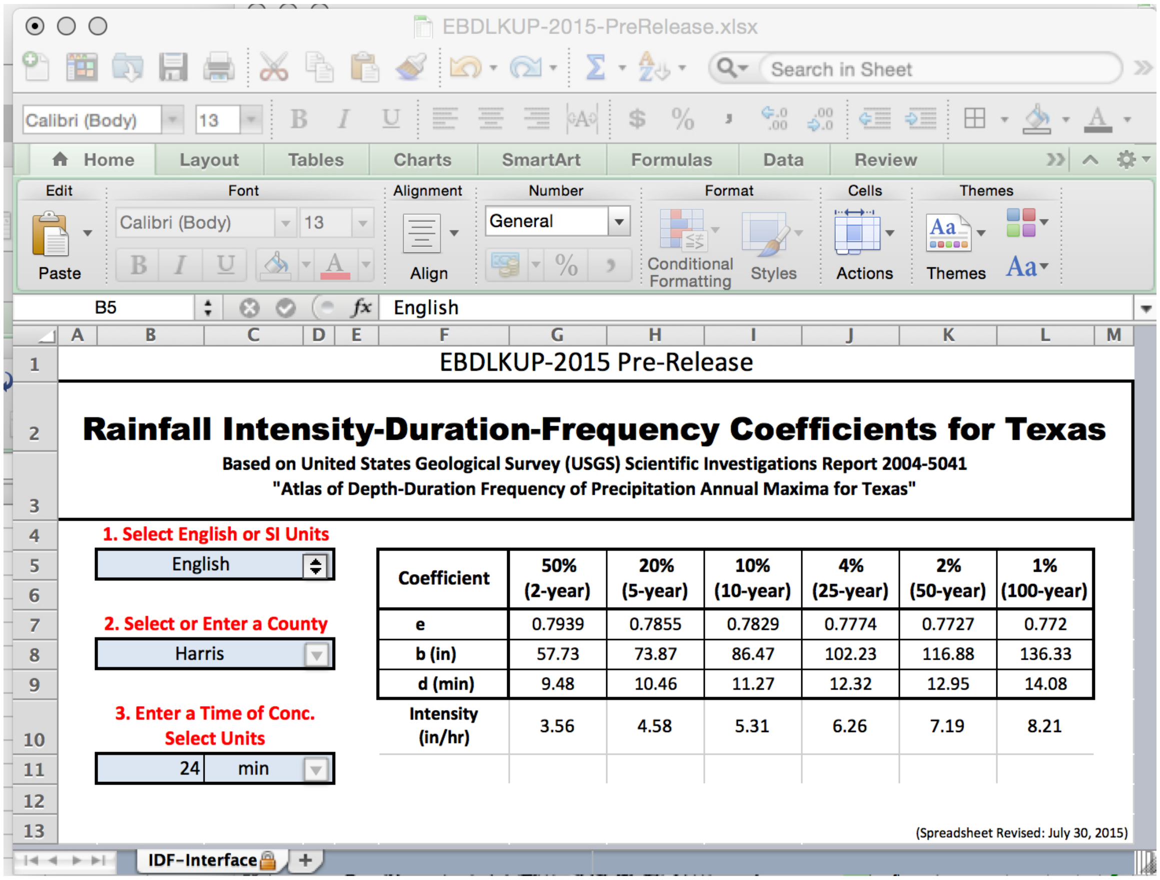

Figure 10: EBDLKUP-2015 applied to Harris County for the T_c estimated from the flow path in Figure 8

Next need a runoff coefficient. Many sources, for example the Texas Hydraulic Design Manual

Table 4-10: Runoff Coefficients for Urban Watersheds

Type of drainage area	Runoff coefficient
Business:	
Downtown areas	0.70-0.95
Neighborhood areas	0.30-0.70
Residential:	
Single-family areas	0.30-0.50
Multi-units, detached	0.40-0.60
Multi-units, attached	0.60-0.75
Suburban	0.35-0.40
Apartment dwelling areas	0.30-0.70
Industrial:	
Light areas	0.30-0.80
Heavy areas	0.60-0.90
Parks, cemeteries	0.10-0.25
Playgrounds	0.30-0.40
Railroad yards	0.30-0.40

Figure 11: Table of Rational Equation Runoff Coefficients

Use the value for single-family residential; I decided to use the higher value (0.5).

The typical rational method estimated discharge would be:

$$Q_p = (0.5)(5.31\ in/hr)(50acres) \approx\ 133\ cfs \tag{1}$$

The 6-hour "part" is irrelevant in conventional Rational method.

iv) Use SWMM to simulate the runoff hydrograph from the watershed for a 10-year, 6-hour storm using the NRCS 6-hr Rainfall Distribution Curves (in Lecture Notes). Include a screen capture of the SWMM model.

First build the 6 hour storm. The depth of the storm is 5.04 inches (0.84 in/hr * 6 hrs).

	A	B	C	D	E	F	G	H	I	J	K	L
1	SCS 6-hour Rainfall Distribution (from Chow, Maidment, Mays, 1988 pg. 461)											
2					Depth =>	5.04	INTERPOLATE TABLE				INTERPOLATED VALUES	
3	Hour t	t/6	Pt/P6		TIME	DEPTH	Time_Lo	Time_Hi	Depth_Lo	Depth_Hi	Time (hrs)	Depth (in)
4	0	0	0		0	0	0	0.6	0	0.2016	0	0
5	0.6	0.1	0.04		0.6	0.2016	0	0.6	0	0.2016	0.25	0.084
6	1.2	0.2	0.1		1.2	0.504	0	0.6	0	0.2016	0.5	0.168
7	1.5	0.25	0.14		1.5	0.7056	0.6	1.2	0.2016	0.504	0.75	0.252
8	1.8	0.3	0.19		1.8	0.9576	0.6	1.2	0.2016	0.504	1	0.4032
9	2.1	0.35	0.31		2.1	1.5624	1.2	1.5	0.504	0.7056	1.25	0.5292
10	2.28	0.38	0.44		2.28	2.2176	1.5	1.8	0.7056	0.9576	1.5	0.7056
11	2.4	0.4	0.53		2.4	2.6712	1.5	1.8	0.7056	0.9576	1.75	0.9156
12	2.52	0.42	0.6		2.52	3.024	1.8	2.1	0.9576	1.5624	2	1.1256
13	2.64	0.44	0.63		2.64	3.1752	2.1	2.28	1.5624	2.2176	2.25	1.8648
14	2.76	0.46	0.66		2.76	3.3264	2.4	2.52	2.6712	3.024	2.5	3.0184
15	3	0.5	0.7		3	3.528	2.64	2.76	3.1752	3.3264	2.75	3.7002
16	3.3	0.55	0.75		3.3	3.78	3	3.3	3.528	3.78	3	3.6288
17	3.6	0.6	0.79		3.6	3.9816	3	3.3	3.528	3.78	3.25	3.738
18	3.9	0.65	0.83		3.9	4.1832	3.3	3.6	3.78	3.9816	3.5	3.948
19	4.2	0.7	0.86		4.2	4.3344	3.6	3.9	3.9816	4.1832	3.75	4.0824
20	4.5	0.75	0.89		4.5	4.4856	3.9	4.2	4.1832	4.3344	4	4.2504
21	4.8	0.8	0.91		4.8	4.5864	4.2	4.5	4.3344	4.4856	4.25	4.3596
22	5.4	0.9	0.96		5.4	4.8384	4.5	4.8	4.4856	4.5864	4.5	4.4856
23	6	1	1		6	5.04	4.5	4.8	4.4856	4.5864	4.75	4.5696
24							4.8	5.4	4.5864	4.8384	5	4.6536
25							4.8	5.4	4.5864	4.8384	5.25	4.7754
26							5.4	6	4.8384	5.04	5.5	4.8804
27							5.4	6	4.8384	5.04	5.75	4.956
28											6	5.04

Figure 12: 6-hour SCS storm for Harris County, interpolated to 15-minute intervals.

Next build the simple SWMM model and insert the rainfall into the model

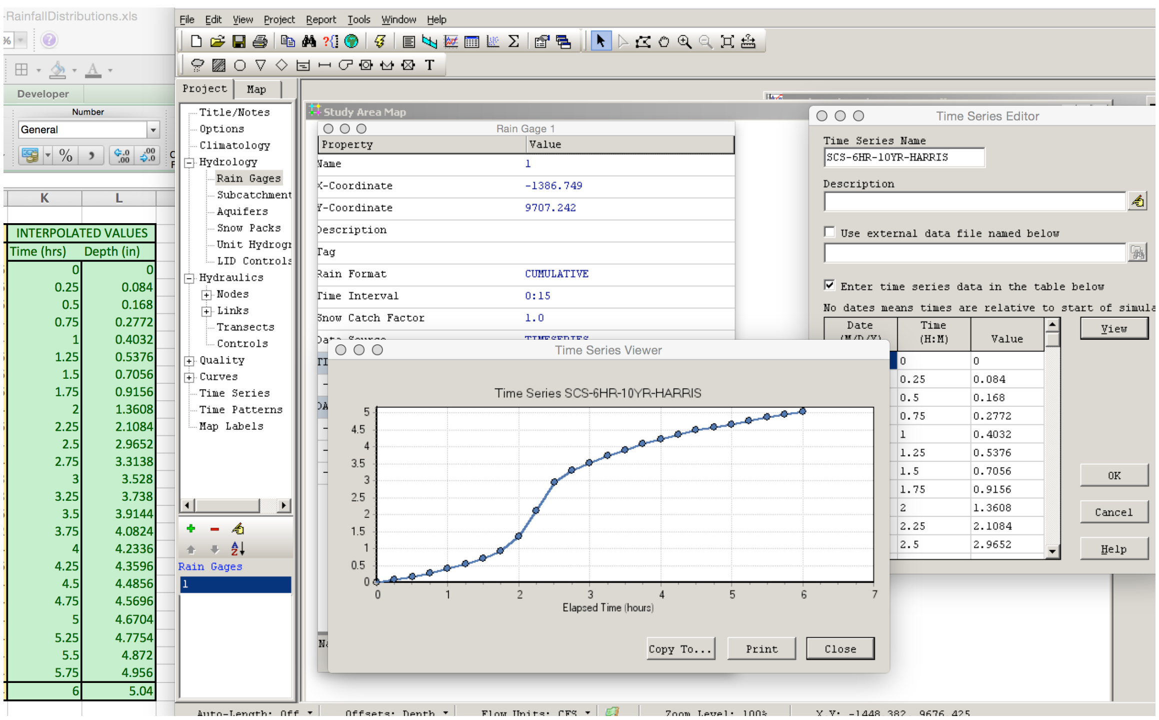

Figure 13: SWMM Subcatchment model – adding the rainfall to a gage

v) Include a screen capture of the sub-catchment dialog box where you supply sub-catchment area, and width. Describe how you selected your width for your model.

Next we will need to estimate a reasonable curve number. Use tables from design manuals to estimate the CN, for example,

Table 4-19: Runoff Curve Numbers For Urban Areas

Cover type and hydrologic condition	Average percent impervious area	A	B	C	D
Dirt (including right-of-way)		72	82	87	89
Western desert urban areas:					
Natural desert landscaping (pervious areas only)		63	77	85	88
Artificial desert landscaping (impervious weed barrier, desert shrub with 1- to 2-in. sand or gravel mulch and basin borders)		96	96	96	96
Urban districts:					
Commercial and business	85	89	92	94	95
Industrial	72	81	88	91	93
Residential districts by average lot size:					
1/8 acre or less (townhouses)	65	77	85	90	92
1/4 acre	38	61	75	83	87
1/3 acre	30	57	72	81	86
1/2 acre	25	54	70	80	85
1 acre	20	51	68	79	84
2 acres	12	46	65	77	82
Developing urban areas: Newly graded areas (pervious area only, no vegetation)		77	86	91	94

Table 4-19 notes: Values are for average runoff condition, and $I_a = 0.2S$.
The average percent impervious area shown was used to develop the composite CNs.
Other assumptions are: impervious areas are directly connected to the drainage system, impervious areas have a CN of 98, and pervious areas are considered equivalent to open space in good hydrologic condition.

Figure 14: Urban area curve number table from Texas Hydraulic Design Manual

Using 1/4 acre lots as our situation, and Harris County would have HSG C or D (use D) we obtain a curve number of 87.

Put that into SWMM as in the next screen capture

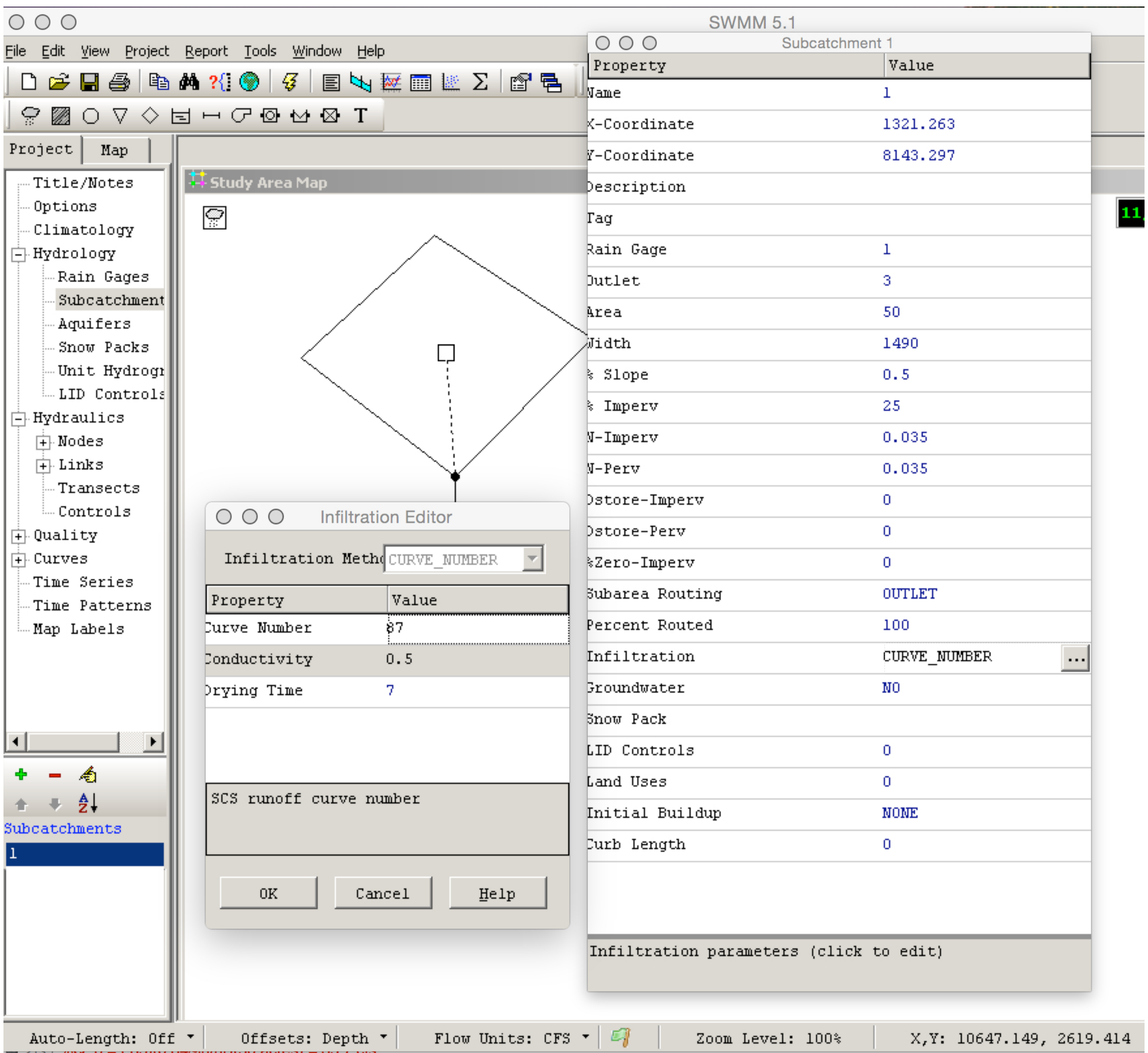

Figure 15: Curve number entry in SWMM – also shows other values used on the watershed. Used the length of a side of the rectangle as an average width for the drainage area.

vi) Determine the calculated peak discharge from the SWMM model and compare its value to the value from the Rational Method.

Now we will run SWMM and capture its estimated peak discharge from the watershed.

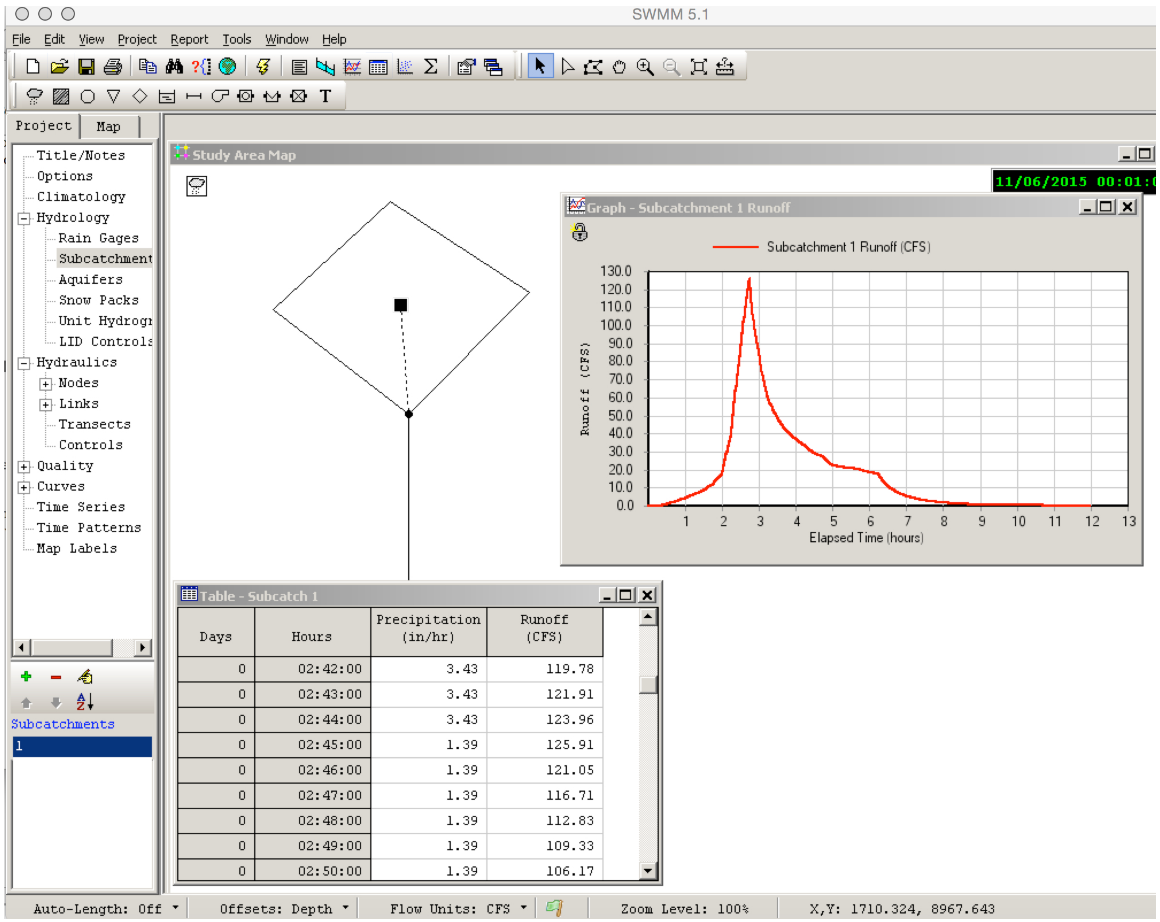

Figure 16: SWMM output for the watershed. $Q_p \approx 126\ CFS$

So as a comparison for this particular case, using Rational Method the estimated peak discharge is 133 CFS, while the same situation modeled in SWMM using appropriate CN values is 126 CFS. Thus for this particular situation, the results are essentially the same. The exercise illustrates the external effort (finding tables for various parameters) that is required for either method.