

**Solutions Chapter 5**

**5.1** Calculate the *TC* and *R* coefficients for each subbasin in the given watershed. Assume that the equations listed in Table 5.10 are applicable and that  $S=S_0$ .

Subbasin Number	Area		L		Lca	
	(ac)	(mi <sup>2</sup> )	(ft)	(mi)	(ft)	(mi)
1	1280	<b>1.999</b>	7000	<b>1.323</b>	4000	<b>0.756</b>
2	1485	<b>2.320</b>	9000	<b>1.701</b>	5050	<b>0.954</b>
3	1517	<b>2.370</b>	8750	<b>1.654</b>	4975	<b>0.940</b>
4	2752	<b>4.300</b>	10000	<b>1.89</b>	6340	<b>1.198</b>

Using the equation in Table 5.10, we calculate the *TC* and *R* coefficients for each subbasin.

Subbasin Number	TC	R
1	0.3	2.31
2	0.57	3.61
3	0.36	1.33
4	0.44	1.34

- 5.2** Create the Basin Model of the watershed in HEC-HMS using the data provided. Set up input data for the watershed using Clark's unit hydrograph method ( $TC$  &  $R$ ). Use Muskingum routing methods and assume that  $K = 0.60$  hr and  $x = 0.4$  in reaches AB and BC. Assume two subreaches and assume baseflow is zero.
- 5.3** Using the data shown in Fig.5.9b (or Table 5.9), create two Meteorologic Models in HEC-HMS using the 24-hr hypothetical design storms for the 100-yr frequency and the 10-yr frequency events. Place the peak center at 50% for both storms and use 15-min maximum intensity duration.

- 5.4 Create a new Basin Model for HEC-HMS Problem 5.2 to reflect a detention pond near point B. Assume that the pond can be modeled in such a way that only the runoff from subbasin 3 should be routed through it. The storage-discharge relation is given as follows.

$S$ (ac-ft)	0	55	294	416	550	600
$Q$ (cfs)	0	120	277	329	377	5000

The Basin and Meteorological Models can be created following the steps described in Example 5.2. No further calculations are needed at this point.

- 5.5 The watershed is predicted to grow in the next 20 years and approach 100% development over most of the watershed. If this occurs, certain parameters will change, as shown in the following table. Compute the new  $TC$  and  $R$  coefficients and change the Basin Model of Problem 5.3 to reflect these fully development conditions. Assume that the Muskingum values used in Problem 5.2 will still be correct.

The new  $TC$  and  $R$  values for the developed watershed are the following:

Subbasin Number	$TC$	$R$
1	0.26	1.23
2	0.37	1.36
3	0.26	1.13
4	0.34	1.2

5.6 Run the HEC-HMS model with  $\Delta t = 15$  min to reflect the existing conditions, the effect of the pond with existing conditions, fully developed conditions, and the effect of the pond with fully developed conditions for both the 100-yr and the 10-yr design storms. Compare the peak flows at point C for the various run combinations.

	10-year storm event				100-year storm event			
	Existing	Det.Pond	Dev.	Dev. + Det.Pond	Existing	Det.Pond	Dev.	Dev. + Det.Pond
Peak Flow (cfs)	8,007.6	5,887.3	9,305.2	6,933.1	12,249	10,731	13,866	13,057
Total Outflow (ac-ft)	4014.3	3,796.4	3,984.8	3,772.5	6,500.3	6,250.3	6,279.5	6,035.1
Time	1.30 (2 Jan)	1.45 (2 Jan)	1.30 (2 Jan)	1.45 (2 Jan)	1.30 (2 Jan)	2.15 (2 Jan)	1.30 (2 Jan)	1.45 (2 Jan)

- For both 10 yr and 100 yr storm events and all the different scenarios, the addition of a detention pond detains the water and delays the time to peak.
- The highest peak outflow is observed, as expected, in the developed watershed scenario. The addition of a detention pond decreases the peak outflow significantly in the 10 yr storm but presents less effective results in the 100 yr storm case.

5.7 Set up a diversion at junction B of the existing condition basin using the inflow-diversion relationship from Table 5.16, and compare the peak outflows at point B and at point C of the new basin model for the 10-yr and 100-yr storm events.

Junction B

	10-yr storm event		100-yr storm event	
	Existing	Exist.+Diversion	Existing	Exist.+Diversion
Peak Flow (cfs)	4532.9	1133.2	7097.2	1774.3
Total Outflow (ac-ft)	2286	571.5	3784	946
Time	1.15 (Jan 02)	1.15 (Jan 02)	1.15 (Jan 02)	1.15 (Jan02)

Junction C

	10-yr storm event		100-yr storm event	
	Existing	Exist.+Diversion	Existing	Exist.+Diversion
Peak Flow (cfs)	8007.6	5543.1	12249	8189.2
Total Outflow (ac-ft)	4014.3	2300.1	6500.3	3662.7
Time	1.30 (Jan 02)	00.45 (Jan 02)	1.30 (Jan 02)	00.45 (Jan02)

The diversion at point B produces significant impact to the peak outflows at junctions B and C.

Approximately, at Junction B, the peak outflow is reduced to 1/4 of its former value and at Junction C, the peak outflow is reduced to 2/3 of its former value for both storm events.

5.8 Repeat Problem 5.4, placing the pond at B so that all the flow above point B, including runoff from subbasin 3, is accepted into the pond. Increase the storage by a factor of and use the 10-year design storm. Compare the resulting hydrographs and peak flows at point B and C and discuss the differences.

	10-yr storm event			
	Junction B	Reservoir		Junction C
Peak Flow (cfs)	4532.9	Peak Inflow (time)	4447.8 (2.00 Jan 02)	5074
		Peak Outflow (time)	312.21 (14.30 Jan 02)	
Total Outflow (ac-ft)	2286	Total Inflow	2285.6	2288.7
		Total Outflow	574.76	
Time	1.15 (Jan 02)			00.45 (Jan 02)

The addition of a reservoir that accepts all the flow above point B is an effective flood control measure for a 10 yr storm for this watershed. Due to the reservoir, the peak outflow at the outlet is only 542 cfs more than the peak outflow at junction B (1/9 of its former value).

5.9 For the Muskingum coefficients given in Problem 5.2, determine the dimensions of a wide rectangular channel needed to carry the 100-yr flow under existing development conditions. Use a Manning's  $n$  value of 0.04, and assume a channel  $L = 10,000$  ft and  $S = 0.01$ .

Muskingum  $K$  is travel time through the reach for reach BC of 10,000 ft and  $K = 0.6$  hr

$$K = L/V = 10,000/V$$

$V = 4.63$  ft/sec and use Manning's Equation

$$V = \frac{1.49}{n} R^{2/3} \sqrt{S_0} \quad \text{where } S_0 = 0.01, R \approx y \text{ wide rectangle}$$

$$V = \frac{1.49}{.04} y^{2/3} \sqrt{.01} = 4.63 \text{ ft/sec}$$

$$\text{Solving for } y \rightarrow y^{2/3} = 1.24$$

$$Y = 1.39 \text{ ft}$$

For  $Q_{100} = 12,643$  cfs

$$\text{Width} = Q/vy = 12643 \text{ cfs} / (4.63)(1.39) \text{ ft}^2$$

$$\underline{\text{Width} = 1965 \text{ ft}} \text{ (too wide for channel)}$$

Rework with slope of 0.001,  $n = .04$ ,  $v = 4.63$  ft/s

$$4.63 = \frac{1.49}{.04} y^{2/3} \sqrt{.001}$$

$$\text{or } y^{2/3} = 3.93$$

$$y = 7.8 \text{ ft depth}$$

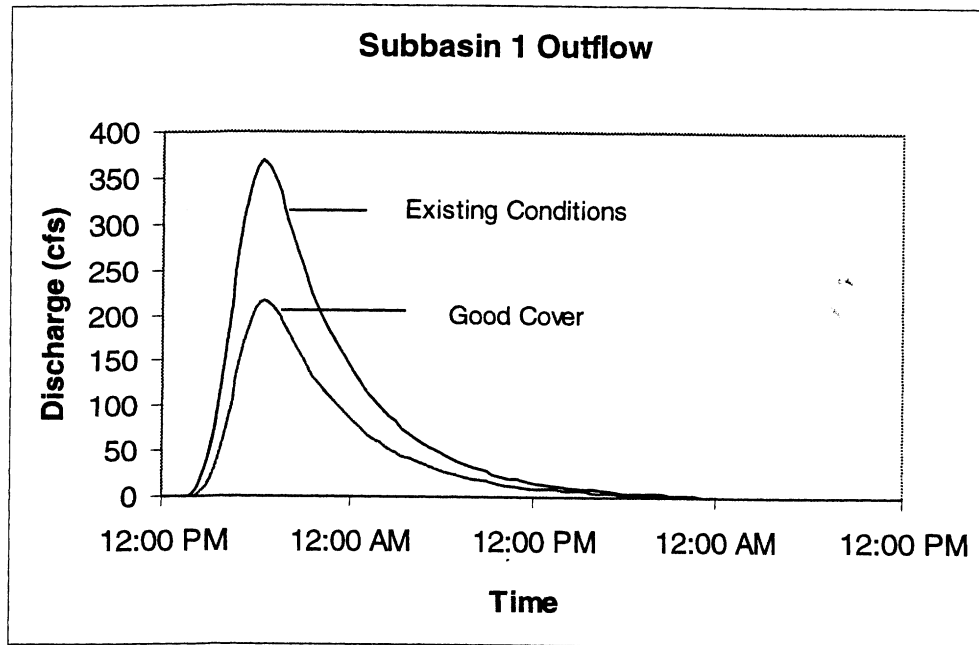
$$\text{width} = 12643 / (4.63)(7.8)$$

$$\underline{\text{width} = 350 \text{ ft}} \text{ (more reasonable)}$$

**5.10** Rework Example 5.1 assuming the same type of soil and that the woods in subbasin 1 have grown much dense and provide good cover. Run the revised HEC-HMS and then graph the original and the updated discharge hydrographs from subbasin 1. How does the curve number affect the amount of runoff?

Peak Discharge: 367.10 (19 Jun 1983, 18:00)

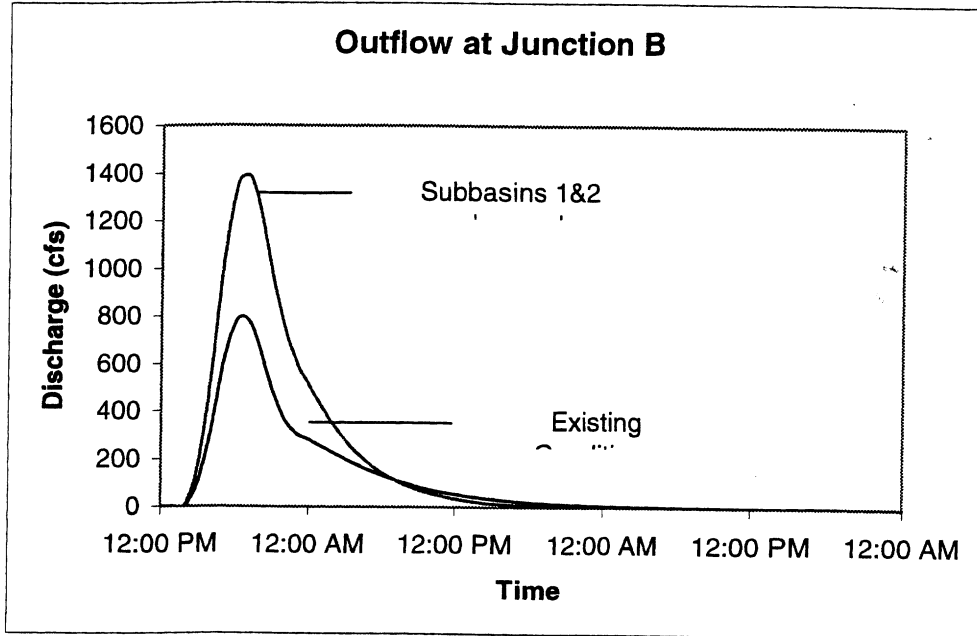
Good Cover: 213.4 (19 Jun 1983, 18:00)



The peak discharge and the amount of runoff have been significantly reduced in the good cover scenario.

5.11 Rework Example 5.1 as described in Problem 5.10 and also assume that subbasin 2 has been developed into ¼-ac residences. Let the value for  $TC = 1.14$  and  $R = 3.5$ . Plot the final hydrograph for the whole basin versus the original one in Example 5.1. Discuss the difference.

Peak Discharge: 1383.7 (19 Jun 1983, 19.00) 888.77 ac-ft (total outflow)



In the existing conditions scenario, the peak outflow is almost the half of the peak outflow in the developed watershed scenario. Furthermore, the total outflow in the existing conditions is much less than the total outflow in the developed watershed. Of course the duration of the flow in the existing conditions is longer than the one in the developed conditions but the level of the flow at that additional period is very low.

5.12 Alter the rainfall in Example 5.1 by using the following hourly cumulative measurements:

TIME (hr)	0	1	2	3	4	5	6	7	8	9	10
RAINFALL (in.)	0	0.47	0.74	1.34	2.64	2.87	3.08	3.95	5.16	5.44	5.44

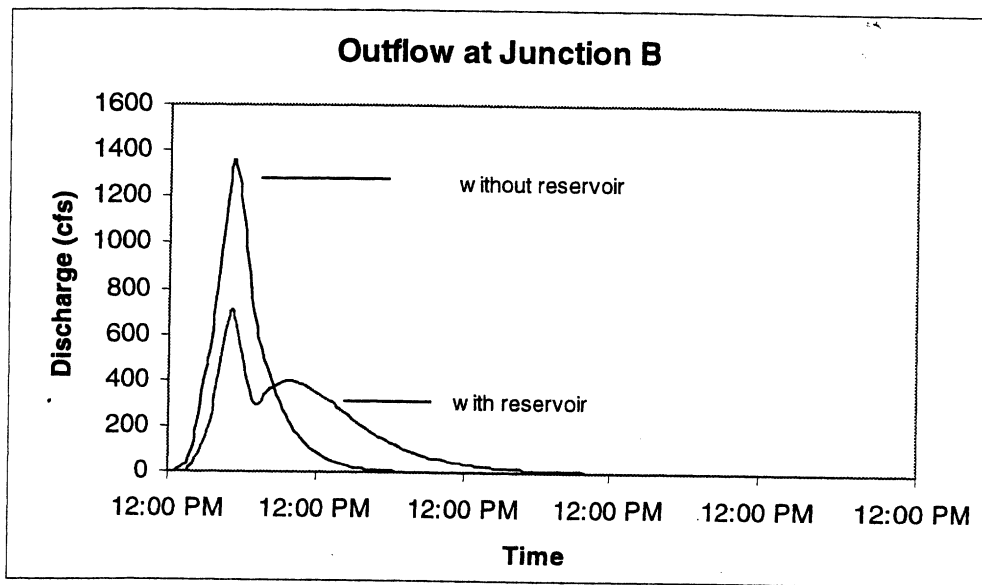
Assume that there is a detention pond at point B of the basin that is used for flood control.

Assume a storage-discharge relationship  $S = k \cdot Q$ , where  $k$  is equivalent to 0.75 acre-ft/cfs.

Prepare a graph of the outflow from the basin, with and without detention, and compare results.

Without Detention Pond: Peak Discharge: 1358.4 (19 Jan 83, 22:00)

With Detention Pond: Peak Discharge: 708.77 (19 Jan 83, 22:00)



The addition of the reservoir reduces approximately to the half the peak outflow. As we can see from the graph, the duration of the flow in the reservoir scenario is significantly increased but the level of the flow for the most part of that additional time period is very low.