Activity 1

At this time, complete- Activity 1. Be sure to write out your answers. After you have completed the Activity, check your answers against the solutions in the back of the module. If you missed any, refer back in the Study Guide. When you are satisfied that you know the material, turn to Unit Hydrographs.

Uses of Hydrographs

1. What kind of hydrograph indicates hazards of existing and planned dams should they collapse?

2. What kind of hydrograph is a one-day, ten-day hydrograph for a principal spillway?

3. What kind of hydrograph would you need to determine the hydrologic effects of proposed structure or channel changes?

Activity 2

At this time, complete Activity 2. After you have completed the activity, check your answers against the solution located near the back of the module. If you missed any, refer back in the Study Guide.

Procedure used in developing a unit hydrograph.

Given

Four activity hydrographs shown in figure 6 and the data recorded in table 1.

Assume that the four hydrographs shown were recorded at the same stream gage during four different floods of varying magnitudes, and that the floods occurred from rainfalls having the same duration of rainfall excess (runoff).

Find

Construct an average unit hydrograph from this information. The method of determining the unit hydrograph is shown for Flood Hydrograph A.
Complete the calculations and fill in tables 1 and 2. Draw unit hydrographs for -Floods Hydrographs B, C, and D on figure 6.

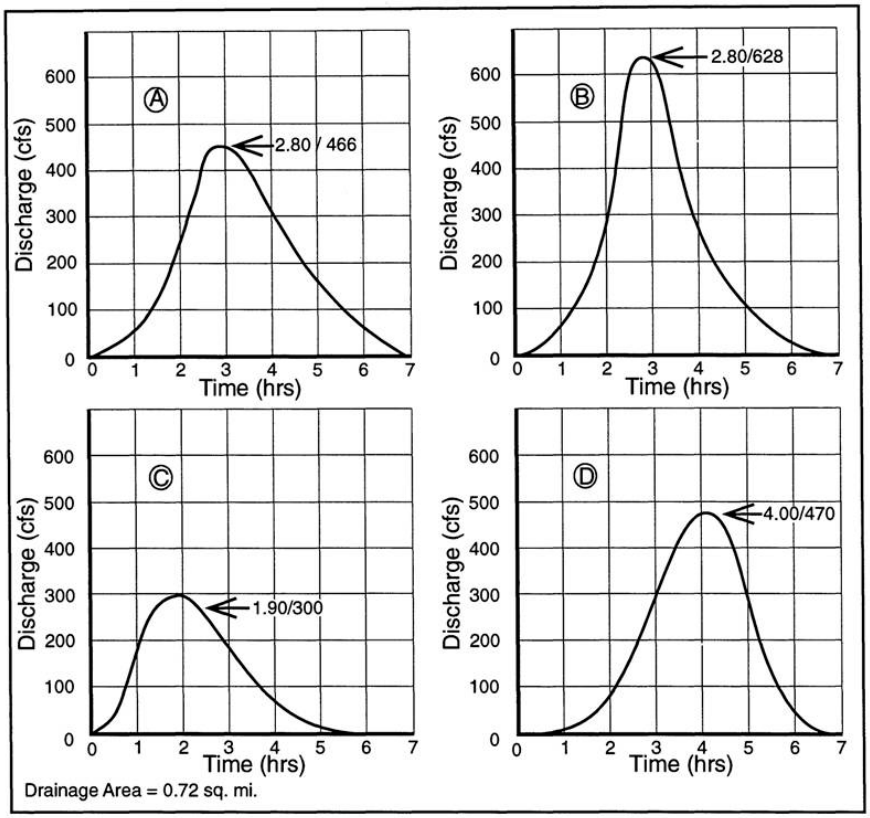

Figure 6. Natural hydrographs.

Unit Hydrograph Development Hydrograph

	A	B	C	D	**average**
Area under hyd. (sq units)	12.71	13.95	7.44	12.03	
Volume (cfs-hr)	1,271				
Measured Runoff Depth on Watershed (in)	2.74				
Time to Peak (hr)	2.80				
Peak Discharge (cfs)	466				
Unit Peak Discharge (cfs)	170				

Table 1. Unit Hydrograph development hydrograph.

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Computation of Average Unit Hydrograph

1	2	3	4	5	6	7	8	9	10	11
Time (hr)	Hydrograph A		Hydrograph B		Hydrograph C		Hydrograph D		Sum of Unit Hyds. (cfs)	Average Unit Hyds. (cfs)
	Measured (cfs)	Unit (cfs)	Measured (cfs)	Unit (cfs)	Measured (cfs)	Unit (cfs)	Measured (cfs)	Unit (cfs)		
0	0	0	0		0		0			
0.5	19	7	36		21		10			
1.0	56	20	89		140		28			
1.5	120	44	170		281		55			
2.0	240	88	300	100	300	188	105	41	417	104
2.5	450		614		261		219			
3.0	461		610		191		339			
3.5	379		393		118		432			
4.0	280		257		66		470			
4.5	203		163		40		415			
5.0	140		100		22		207			
5.5	87		55		11		82			
6.0	46		22		4		30			
6.5	15		3		0		7			
7.0	0		0		0		0			
Proportionality Constant		2.74		3.00		1.60		2.59		

Table 2. Computation of average unit hydrograph.

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Activity 3

You have completed all of the work for Activity 2. Continue with Activity 3. Please follow the instructions closely to be sure you fully understand the procedures given. Use the given data and the solution page to measure your progress. If you miss any portion, refer back to the Study Guide.

Rood Hydrograph Development

Given

The average unit hydrograph shown in figure 7. Assume a storm producing 2.8 inches of runoff had the same rainfall excess duration as was used in Activity 1.

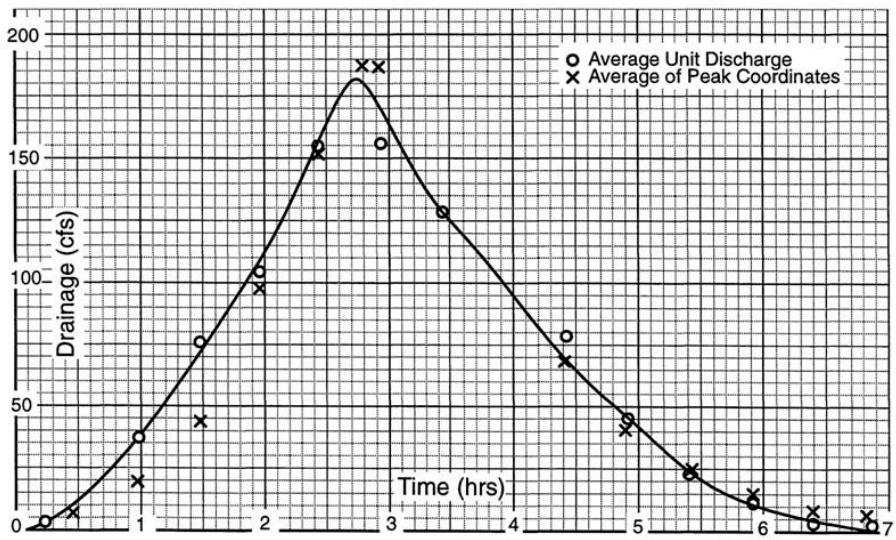

Figure 7. Average unit hydrograph.

Calculate a hydrograph for 2.8 inches of runoff for the same watershed used in Activity 2.

Procedure

1. Coordinates from average hydrograph, figure 7.

For this activity, use time increments of 0.5 hours. You should start with 0.0 hour and end with 7.0 hours.

Discharges from the best-fit curve for the average unit hydrograph have been tabulated for you and are shown on table 3. Times of 0.0 hours and 7.0 hours have 0 cfs discharges.

To calculate discharges for Q = 2.8 inches, multiply the average unit discharge (table 3) by 2.8. For example, at 0.5 hours, the Q = 2.8 inches discharge is: (10) (2.8) = 28 cfs, rounded to the nearest cfs. Continue to multiply all unit discharges by 2.8 to get the discharges of a hydrograph for Q = 2.8 inches of runoff.

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2. Volume check of average unit hydrograph and 2.8-inch volume hydrograph.

Total both the average unit discharge and Q = 2.8 inches discharge columns on table 3. Do not include discharges for peak time at 2.87 hours. Record the sums on table 3.

If all time increments are equal (0.5 hours), you can compute runoff volume (cfs-hrs) by adding all ordinates (cfs) and multiplying the summation '- cfs) by the time increment (0.5 hours) to get a volume '- cfs-hrs).

The test for volume accuracy is to find runoff depth as follows:

$$\frac{cfs-hrs}{sq-mi} * .00155/(\frac{cfs-hrs}{sq-mi}) = _____ \text{in}$$

3. Plot the 2.8-inch hydrograph on figure 8.

Unit Hydrograph Adjustment for Q = 2.8 Inches of Runoff

Time (hr)	Average Discharge (cfs)	Unit Q = 2.8" Discharge (cfs)	Time (hr)	Average Discharge (cfs)	Unit Q = 2.8" Discharge (cfs)
0.0	0	0	3.5	137	
0.5	10		4.0	102	
1.0	37		4.5	62	
1.5	70		5.0	44	
2.0	110		5.5	22	
2.5	157		6.0	10	
*2.87	*187	*	6.5	3	
3.0	182		7.0	0	0

Table 3. Unit hydrograph adjustment for a = 2.8 inches of runoff. • Peak values not included in summation.

Volume Check of Unit Hydrograph: Use the formula from Item 5.

Volume Check of Q = 2.8" Hydrograph:

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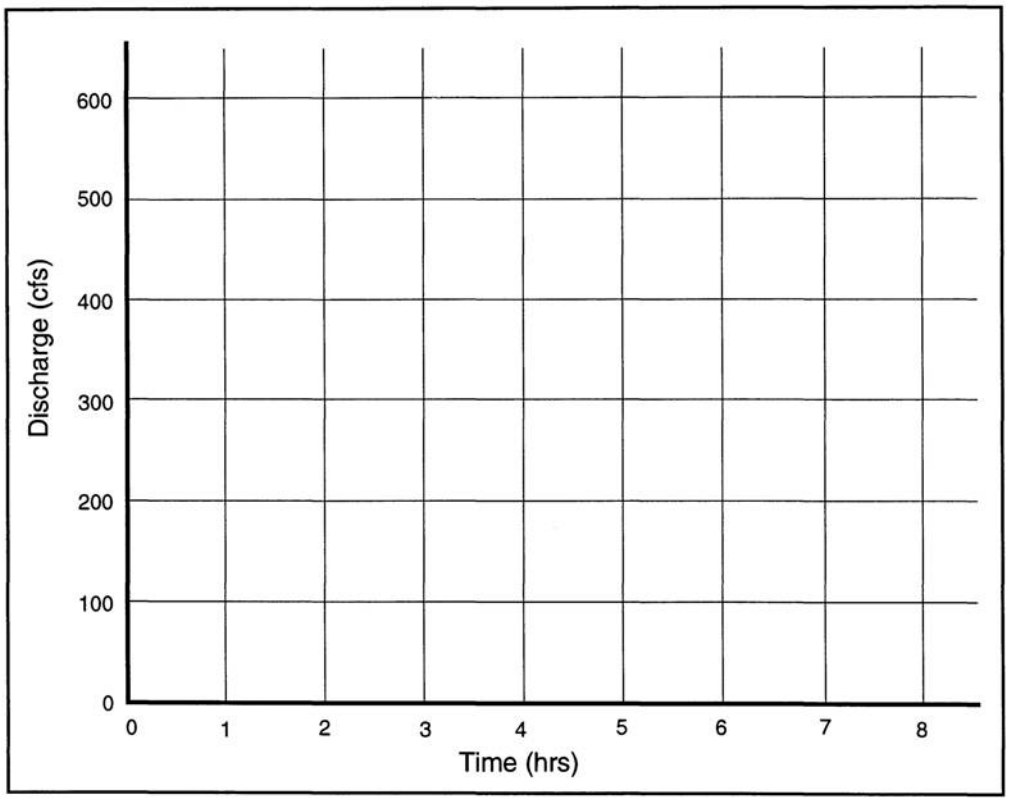

Figure 8. Hydrograph construction (from composite unitgraph) for Q = 2.8 inches.

Activity 4

Now, test your skill at developing a composite flood hydrograph using the graphical method. Please follow the activity closely to be sure you fully understand the procedure used. Check occasionally with the solutions to be sure you are on the right track. If you miss any portion, refer back to the Study Guide.

Complete this activity on composite hydrograph development by graphical methods. Be sure to go step-by-step and to be sure you understand a step before moving to the next. Check your accuracy by occasionally referring to the solution.

Given

Drainage area = 2.14 sq miles, or 1370 acres

Time of Concentration T_p = 4.0 hours

CN = 77

Storm Rainfall = 4.67 inches

Storm Duration = 8 hours

Storm Distribution (table 6)

Storm Runoff = 2.35 inches

To Do

Estimate a composite flood hydrograph for the given storm. Use the graphical method and a triangular NRCS Unit Hydrograph.

Solution (Show all steps)

Worksheet for Incremental Hydrographs

1	2	3	4	5	6	7	8
Time (hr)	Mass Rainfall (in)	Mass Runoff (in)	Incremental Runoff (in)	Peak (cfs)	T Start (hr)	T Peak (hr)	TEnd (hr)
.0	.00	0.00	.00				
0.5	0.10	0.00	.00				
1.0	0.20	0.00	.00				
1.5	0.50	0.00	.00				
2.0	0.80	0.01	.01				
2.5	1.40	0.18	.17				
3.0	2.00	0.45	.27				
3.5	2.50	0.74	.29				
4.0	3.00	1.07	.33				
4.5	3.10	1.14	.07				
5.0	3.21	1.22	.08				
5.5	3.88	1.72	.50				
6.0	4.55	2.25	.53				
6.5	4.60	2.29	.04				
7.0	4.65	2.33	.04				
7.5	4.66	2.34	.01				
8.0	4.67	2.35	.01				

Table 6. Activity 4.

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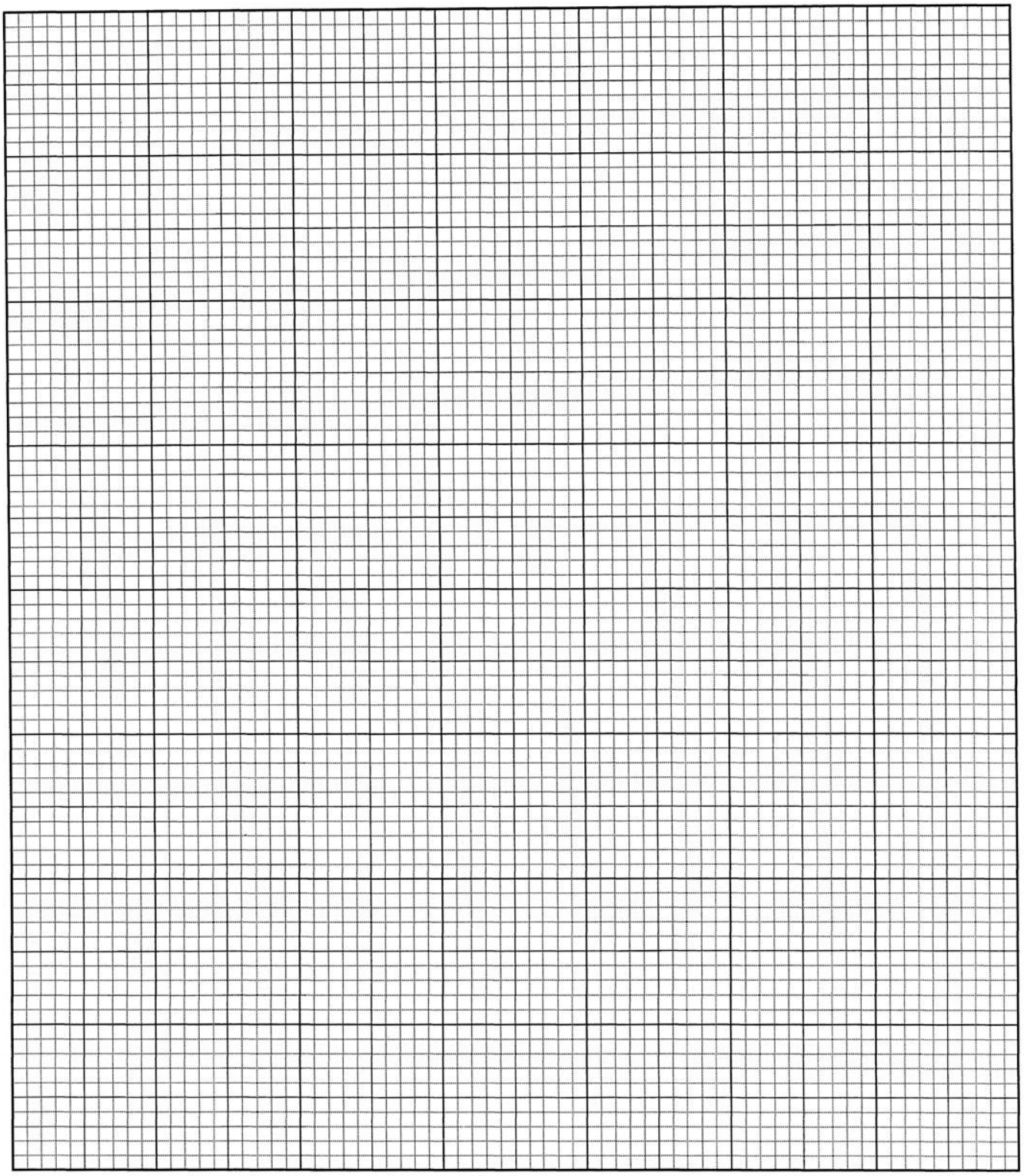

Figure 17. Activity 4. Composite flood hydrograph.

Activity 5

Please complete Activity 5 on developing a composite flood hydrograph using the computations method. Follow the activity closely to be sure you fully understand the procedure used. Check occasionally with the solutions to be sure you are on the right track. If you miss any portion, refer back to the Study Guide.

Composite Rood Hydrographs by the Computation Method

A flood hydrograph can also be developed using a calculator as follows:

1. The procedure for this calculator method is the same as the graphical one used to determine the unit hydrograph coordinates and the incremental runoff depths. These are the first six steps of the graphical method.

   Thus, using the information in Example 1, obtain the incremental runoff.

2. The unit hydrograph coordinates for curvilinear shape are shown on table 7. * These discharges were obtained by use of the dimensionless unit hydrograph shown in figure 9. A plot of the unit hydrograph is displayed in figure 18.

   * Two examples of the procedure for determining curvilinear unit hydrograph coordinates follow:

At time = 0.9 hr, t/T_p= .9/1.5= 0.6. From figure 9 at t/T_p = 0.6, read q_p= 0.666.

$q = 0.660\ q_p = 0.660(1480) = 975.$

At time = 3.6 hr, t/T_p =3.6/1.5= 2.4.

From figure 9 at t/T_p = 2.4,

read $q_p = 0.147$. $q = 0.147\ q_p = 0.147(1480) = 220.$

Hydrograph Development Worksheet

Time (hrs)		Unit Hydrograph Discharge (cfs)						
		.33	.26	.18	.12	.06	0	
0.0	0	.27	.33	.26	.18	.12	.06	
0.3	150	.12	.27	.33	.26	.18	.12	0
0.6	460	0	.12	.27	.33	.26	.18	18
0.9	975		0	.12	.27	.33	.26	96
1.2	1375			0	.12	.27	.33	291
1.5	1480				0	.12	.27	619
1.8	1375					0	.12	1017
2.1	1155						0	1373
2.4	830							
2.7	575							
3.0	415							
3.3	305							
3.6	220							
3.9	160							
4.2	115							
4.5	80							
4.8	60							
5.1	45							
5.4	30							
5.7	20							
6.0	15							
6.3	12							
6.6	8							
6.9	5							
7.2	2							
7.5	0							

Table 7. Activity 5.

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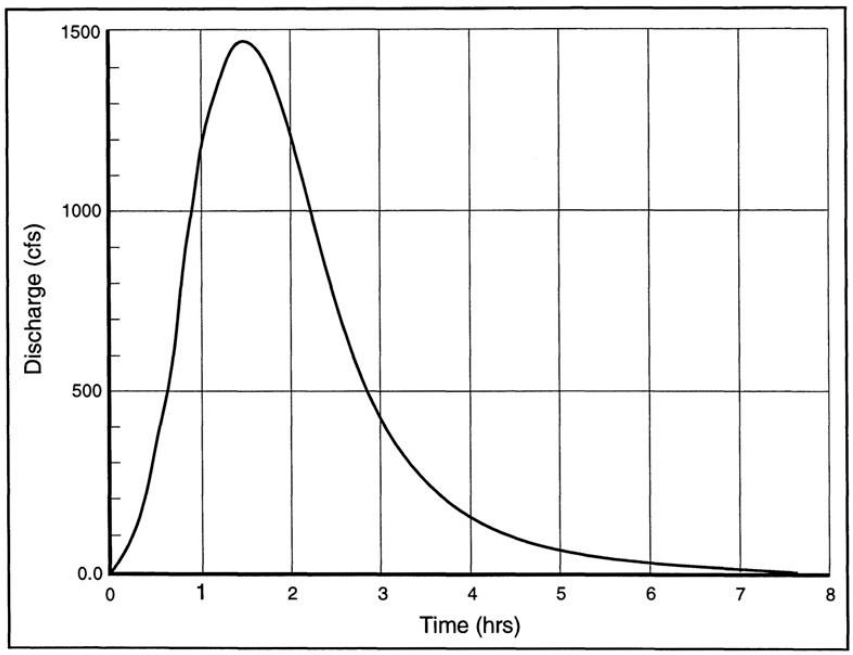

Figure 18. Activity 5. Curvilinear unit hydrograph solution.

3. Now take the incremental runoff values in table 4, and tabulate in reverse order on a separate piece of paper. This tabulation shall have the same line spacing as used in table 7.

0.09
0.19
0.24
0.32
0.41
0.36
0.25
0.11
0.05
0.01
0.00
0.00
0.06
0.12
0.18
0.26
0.33
0.27
0.12
0.00

4. Place the strip of paper along side of column 2 of table 7 and slide down until the first increment of runoff (0.12) on the strip of paper is opposite the first discharge (150) on the unit hydrograph (Column 2). Multiplying 0.12 x 150 = 18. Tabulate in column 3 opposite the zero on the strip of paper. A few discharges for the composite hydrograph have been calculated as a demonstration for your use in the table 7 Worksheet.

5. Move the strip of paper down one line and compute. (0.12 x 460) + (0.27 x 150) = 96. Tabulate in Column 3 opposite the zero on the strip of paper.

6. Continue moving the strip of paper containing the runoff down one line at a time and accumulatively multiply each runoff increment by the unit hydrograph discharge opposite the increment.

   If only the peak discharge of the flood hydrograph is desired, it can be found by making only a few computations, placing the larger increments of runoff near the peak discharge of the unit hydrograph.

7. Complete the hydrograph calculations through time = 7.5 hrs, and plot the composite hydrograph on figure 19.

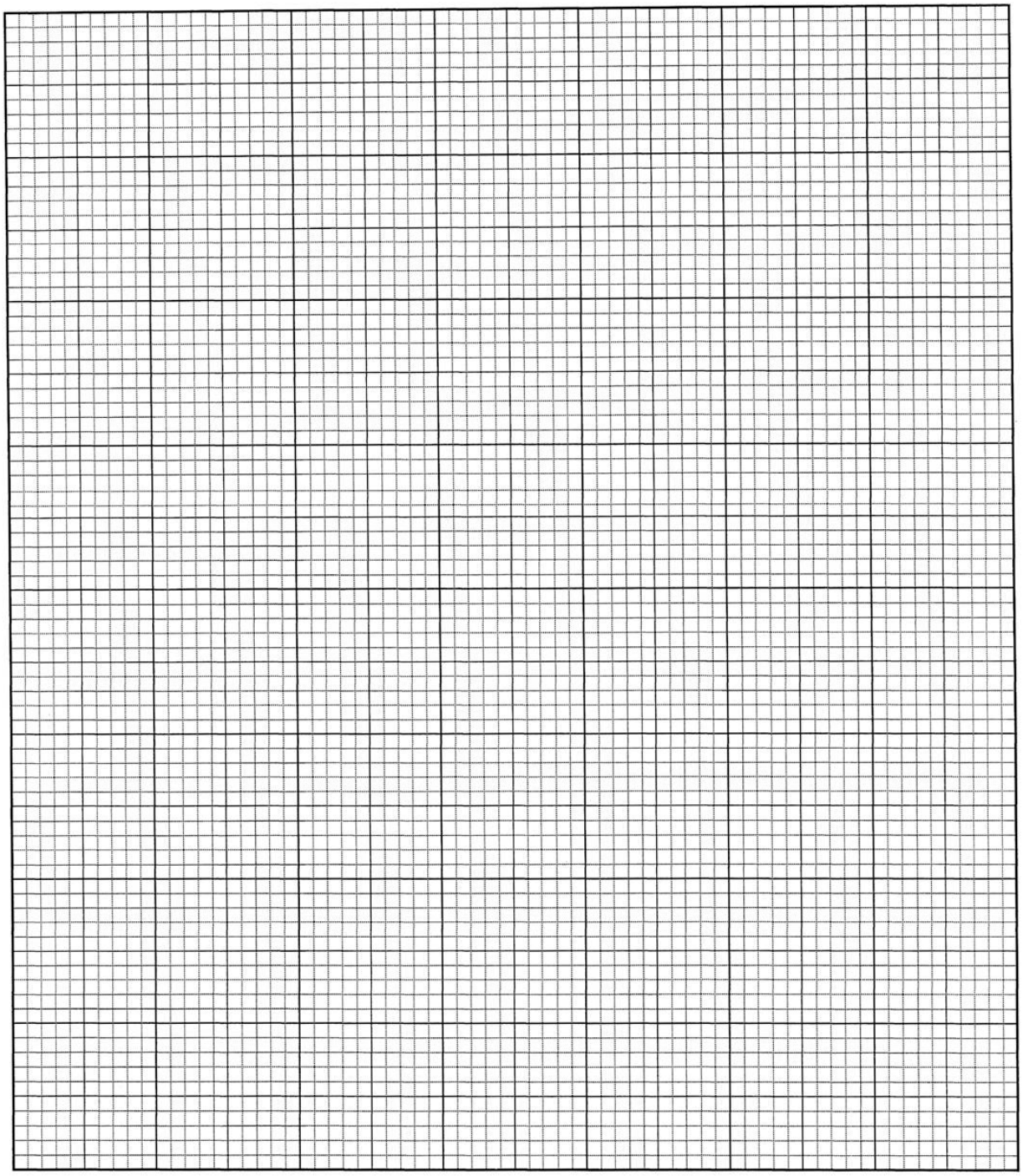

Figure 19. Activity 5. Composite flood hydrograph.