Student Name: ____ FALL 2024

CE 3354 Engineering Hydrology
Exam 2, Fall 2024

Students should write their name on **all sheets of paper**.
Students are permitted to use the internet, their own notes and the textbook.
Students are **forbidden** to **communicate with other people** during the examination.

1. Figure 1 below shows a model of the water cycle. The arrows show the movement of water molecules through the water cycle. The circled numbers processes that dominate as the water molecules reach the different stages of the water cycle.

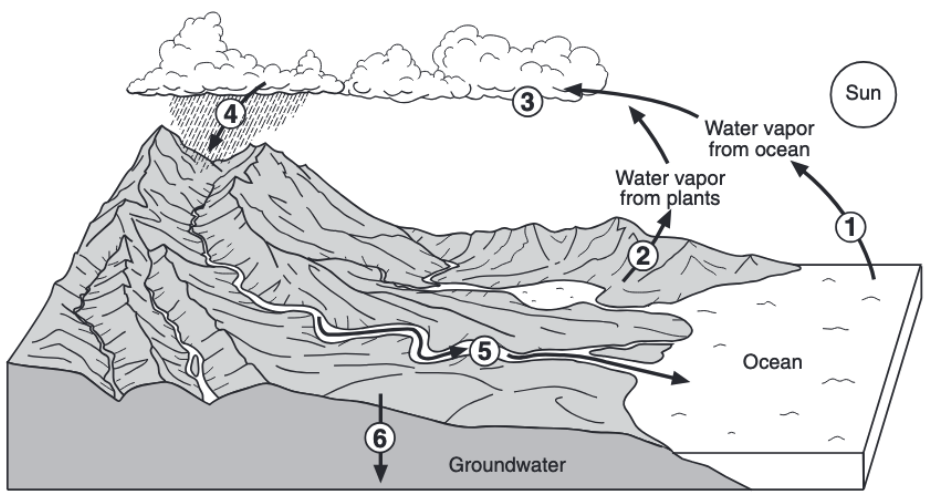

Figure 1: Water Cycle Diagram

Complete Table 1 by the water cycle process occurring at each number.

Table 1: Dominant Water Cycle Process

Item	: Water Cycle Process
1	:
2	:
3	: Condensation (into clouds)
4	:
5	:
6	:

2. Consider the two graphs in Figure 2, which show the relationship between the amount of rainfall during a storm and the amount of discharge in a nearby stream. Letter A represents the time when approximately 50% of the precipitation from the storm has fallen. Letter B represents the time when peak runoff from the storm is flowing in the stream. The delay is the difference in time between letters A and B on the graph. Graph I shows data before urbanization in an area. Graph II shows data after urbanization in the same area

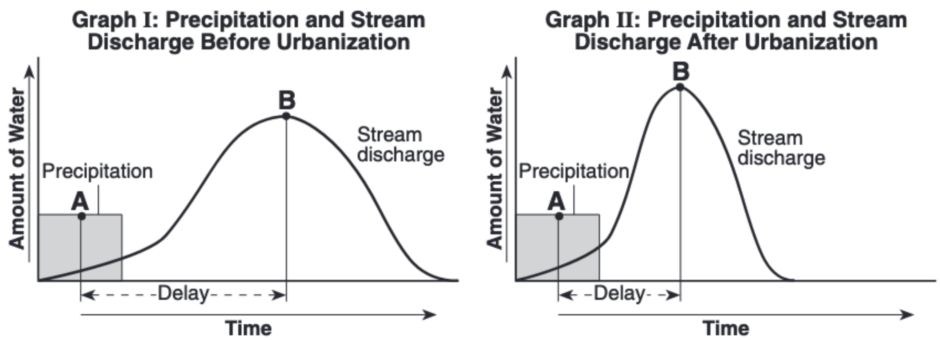

Figure 2: Hydrographs

a) What is a likely explaination for the delay time between points A and B?

b) How did urbanization affect delay time between points A and B?

c) How did urbanization affect the maximum stream discharge?

3. Figure 3 shows the average monthly discharge, in cubic feet per second, for a stream in New England.

Data Table

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec
Discharge (ft^3/sec)	48	52	59	66	62	70	72	59	55	42	47	53

Figure 3: Tabular Data for New England Stream

a) On the grid on Figure 4, plot with an X the average stream discharge for each month shown in the data table.

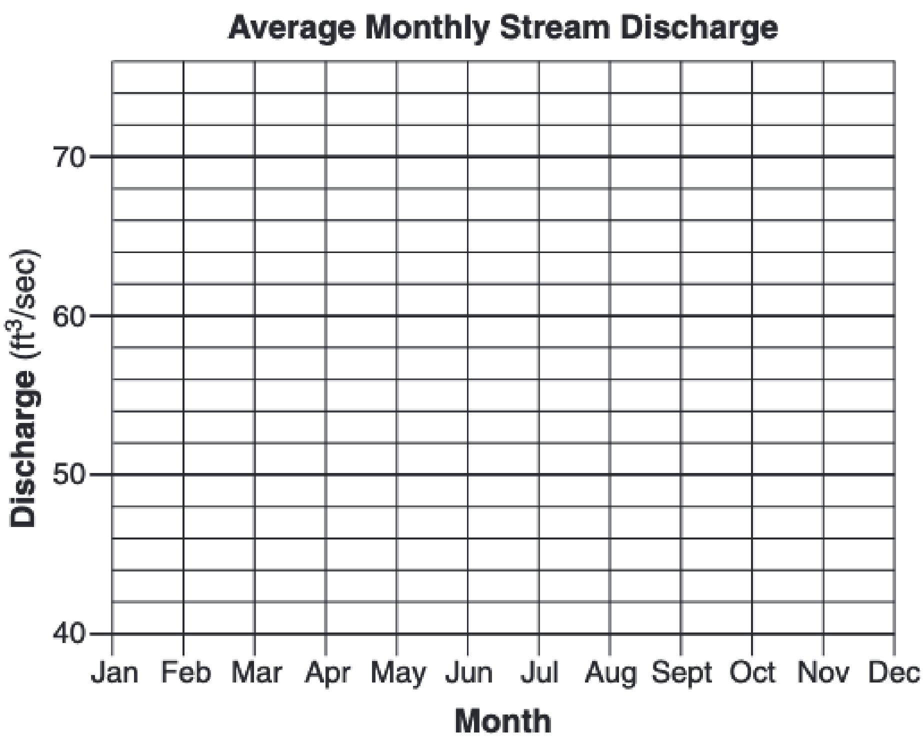

Figure 4: Monthly Average Discharge for New England Stream

b) Explain one possible reason why this stream's discharge in April is greater than this stream's discharge in January.

c) What is the average streamflow for this stream?

d) How many standard deviations from this average is the maximum monthly streamflow?

e) How many standard deviations from this average is the minimum monthly streamflow?

4. Figure 5 is a small watershed comprised of two distinct land cover types.

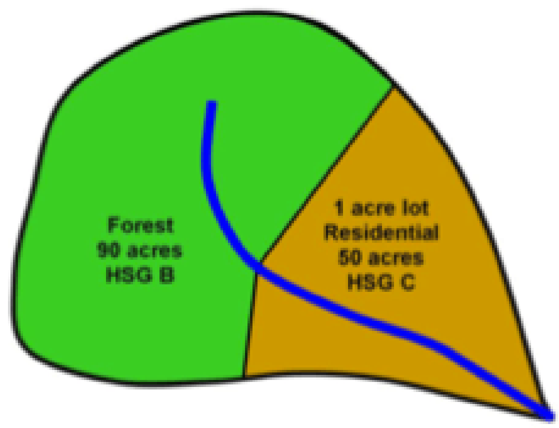

Figure 5: A watershed

The forest portion has a flow path length of 360 feet, at an average slope of 0.01 (1%) until it reaches the residential portion whose path length is 430 feet, at an average slope of 0.005 (0.5%).

a) Determine the composite CN value for the watershed.

b) Estimate the time of concentration for the entire watershed using the NRCS-Upland method (Gupta pp. 718-720).

5. A tabulation of an observed storm and associated runoff for the drainage area are listed below in Table 2. The runoff was measured at the culvert system and indicated by the blue circle on the map in Figure 6.

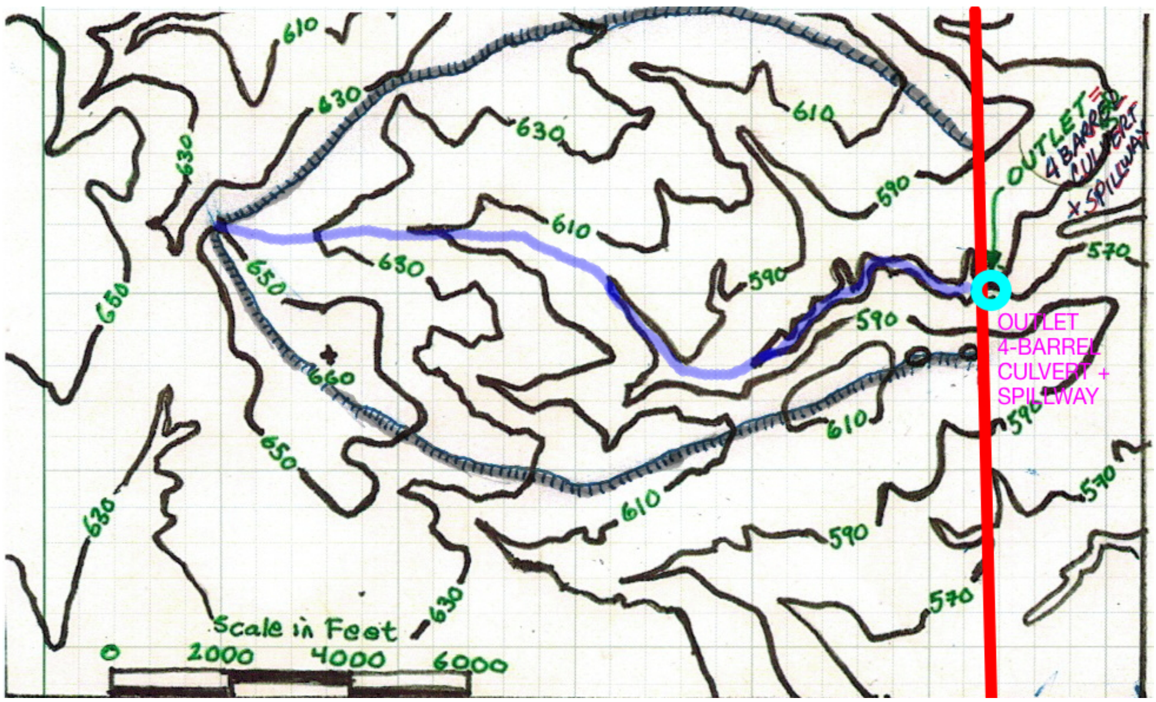

Figure 6: Plan view of a small watershed draining to a culvert under a roadway

Determine

a) The approximate drainage area in ft^2

b) Complete Table 2

Table 2: Tabulated Rainfall and Runoff for Watershed

Time (hrs)	Accumulated Rain (inches)	Observed Discharge (cfs)	Incremental Volume (ft^3)	Cumulative Volume (ft^3)
0	0.000	0.00		
1	0.000	0.00		
2	0.000	0.00		
3	0.000	0.00		
4	0.000	0.00		
5	0.000	0.00		
6	0.000	0.00		
7	0.000	0.00		
8	0.101	0.20		
9	0.106	0.31		
10	0.111	0.31		
11	0.115	0.31		
12	0.120	0.31		
13	0.120	0.40		
14	0.150	0.40		
15	0.750	24.66		
16	2.750	588.23		
17	2.940	808.70		
18	3.030	154.28		
19	3.030	94.68		
20	3.030	27.56		
21	3.090	36.13		
22	3.210	19.65		
23	3.300	7.00		
24	3.300	0.00		

c) The loss from the raw precipitation input to the watershed.

d) An appropriate CN for the watershed supported by the tabular data.

e) The maximum retention S for the watershed supported by the tabular data.

6. Figure 7 is the unit hydrograph response for a watershed to a 1-hour long **excess rainfall** event of intensity equal to 1-inch/hour.

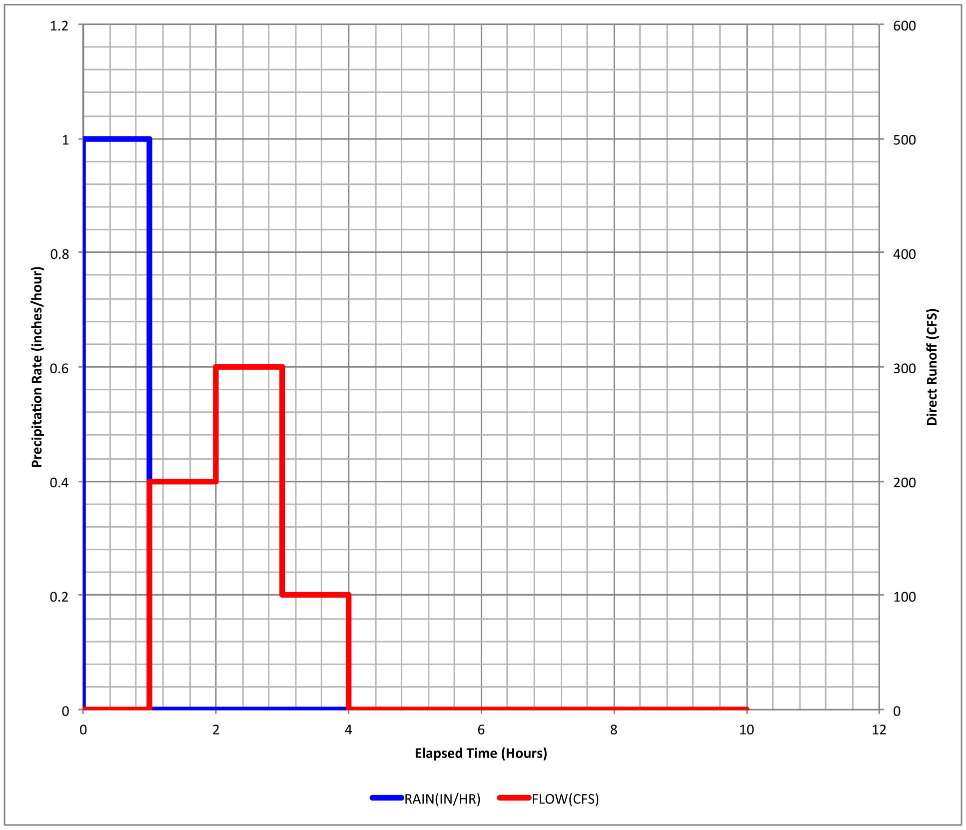

Figure 7: Unit hydrograph response (red) to a 1-inch per hour constant intensity precipitation (blue) input.

a) What is the meaning of **excess rainfall**?

b) How many non-zero intervals of (including the hour zero to hour one interval) direct runoff are indicated by the unit hydrograph?

c) What is the maximum discharge in CFS indicated by the unit hydrograph?

d) What is the total volume (in ft^3) of runoff depicted by the unit hydrograph?

e) Compute the watershed area (in mi^2) of the watershed?

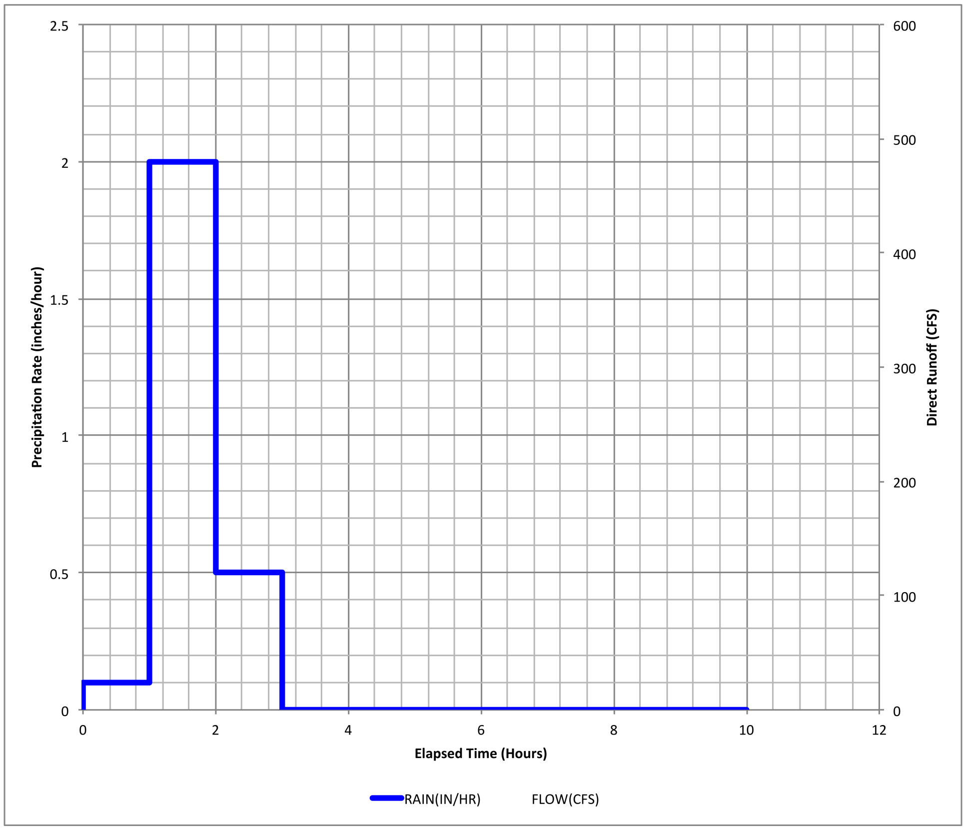

Figure 8: 3-hour event comprised of 3 consecutive 1-hour events.

f) What is the total volume (in ft^3) of runoff anticipated for the storm depicted in Figure 8?

g) Plot the response to the 3 consecutive 1-hour events with the intensities indicated in Figure 8.