CE 3354 Engineering Hydrology
Exam 1, Fall 2024

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

1. Hydrology is
   a) Study of the atmosphere, ocean, and surface waters
   b) The study of the occurrence, distribution, and movement of water above, on, and below the surface of the earth
   c) A study of the processes of evaporation, infiltration, and storage
   d) The study of the relationship between rainfall and runoff
2. The fundamental unit of hydrology is ?
   a) The rainfall depth
   b) The main channel length
   c) The main channel slope
   d) The watershed
3. What is the relationship between the Annual Exceedance Probability (AEP) and the Annual Recurrence Interval (ARI)?
   a) The ARI is the average number of years between years containing one or more events exceeding a prescribed magnitude
   b) The AEP and ARI are the multiplicative inverse of one another
   c) The AEP is a plot of probability and magnitude
   d) The ARI is a plot of probability and magnitude
4. An annual recurrence interval of 100-years is equivalent to an AEP of what percent?
   a) 1-percent.
   b) 10-percent.
   c) 50-percent.
   d) 100-percent.

5. What is a flood frequency curve?
   a) A plot of the discharge magnitude and the Weibull plotting position
   b) A plot of the frequency and discharge
   c) A plot of estimated exceedance probability and discharge
   d) A plot of discharge and time
6. What is a plotting position?
   a) Location in a chart of a data pair
   b) The multiplicative inverse of relative frequency
   c) An estimate of probability associated with an observation based on its position within a ranked sample set
   d) An estimate of probability associated with an observation based on its magnitude relative to the arithmetic mean
7. To what type of data series would we apply the Bulletin 17C procedure ?
   a) Annual maximum rainfall
   b) Hourly rainfall
   c) Annual maximum discharge
   d) Instantaneous discharge
8. Rainfall behavior is expressed as a combination of
   a) depth and duration
   b) intensity and probability or frequency
   c) duration and probability or frequency
   d) depth or intensity, duration, and probability or frequency
9. Rainfall intensity is
   a) the ratio of accumulated depth to duration
   b) instantaneous rainfall rate
   c) slope of the depth duration curve at a duration of one hour
   d) integral of the depth duration curve from 0 to 24 hours

10. Figure 1 is a depth-duration-frequency plot for precipitation.

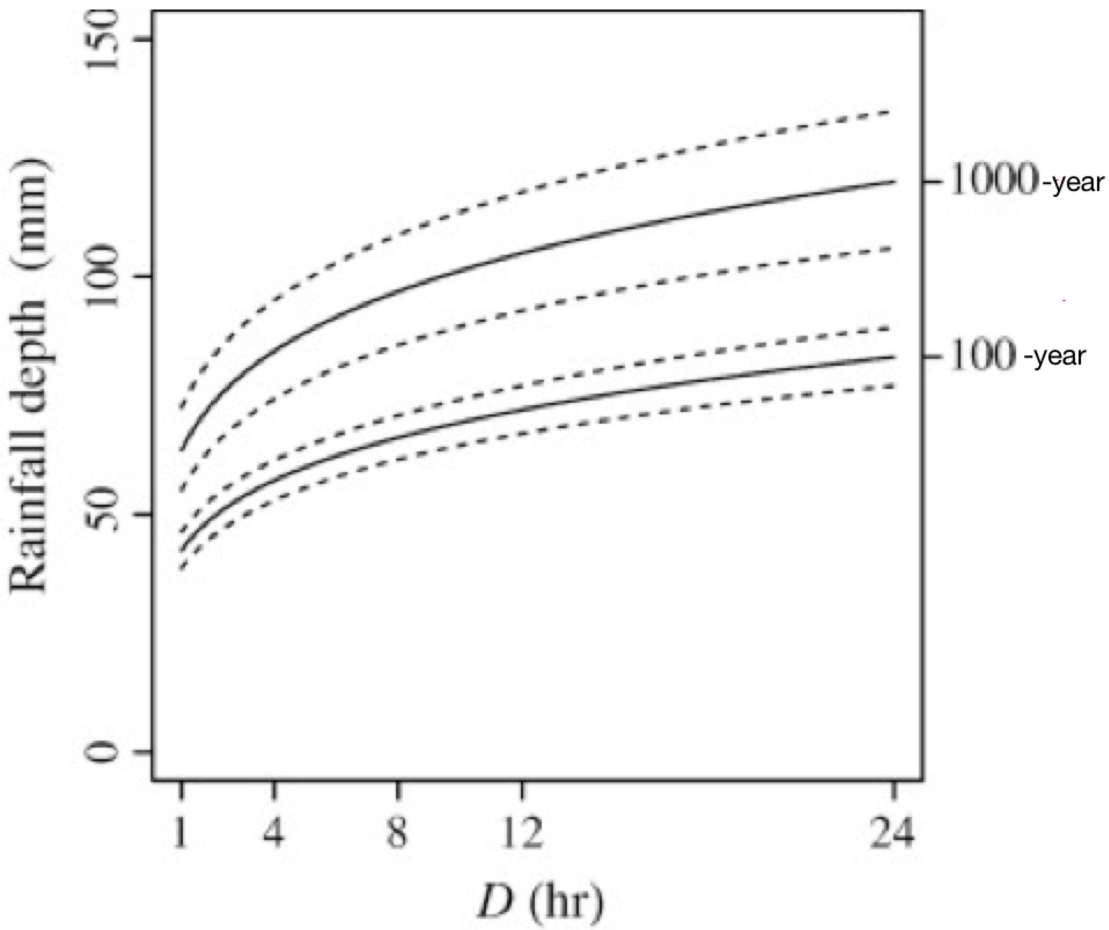

Figure 1: Depth-duration-frequency curve

The approximate depth, in millimeters, for a 4 hour, 100-yr (1% chance) storm is

a) 125 millimeters

b) 75 millimeters

c) 55 millimeters

d) 45 millimeters

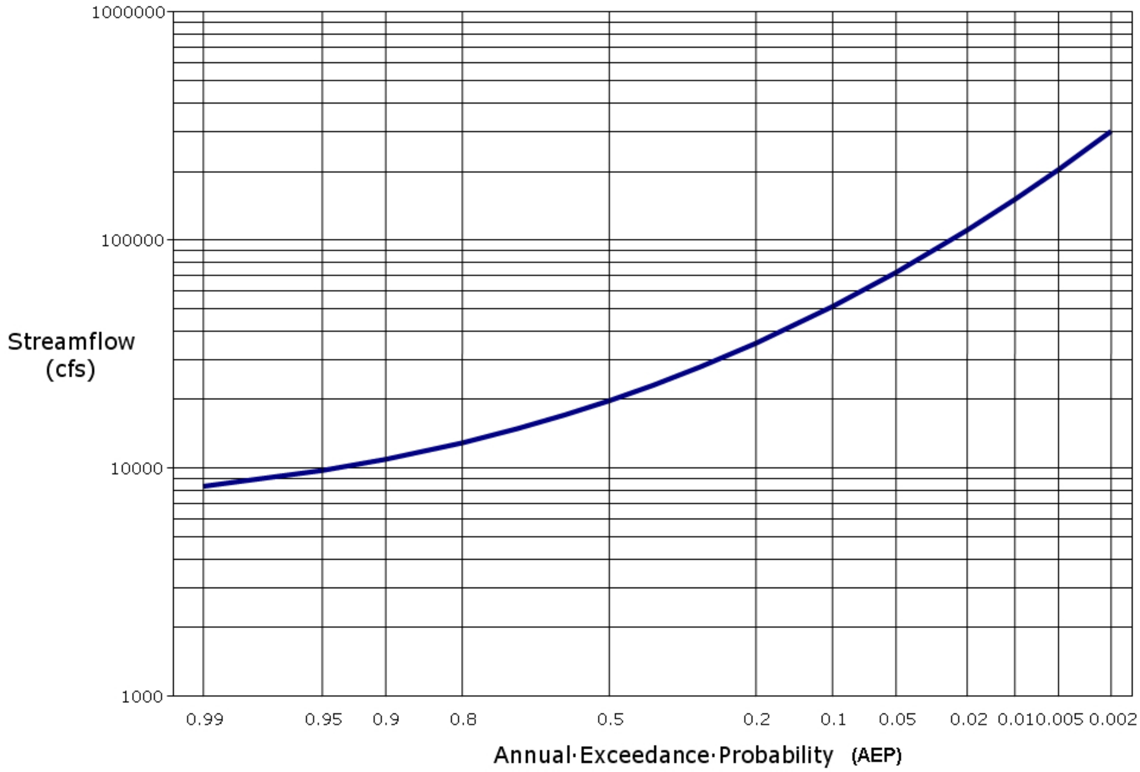

Figure 2: Flood frequency curve for a gaging station

11. Figure 2 is a flood frequency curve. The probability of observing a discharge of magnitude of $50,000\ CFS$ or more is

    (a) 0.01

    (b) 0.05

    (c) 0.10

    (d) 0.50

12. The median discharge from Figure 2 is

    (a) $10,000\ CFS$

    (b) $20,000\ CFS$

    (c) $50,000\ CFS$

    (d) $90,000\ CFS$

13. The equation $k\frac{dQ}{dt} + Q(t) = I(t)$ is used to describe the response of streamflow to a constant rate of precipitation applied indefinitely on some watershed. Suppose that $Q(t) = 0$ for $t = 0$, the watershed characteristic time constant is $k = 2\ hrs$, and $I(t) = 2$ for $t = [0, 12)\ hrs$ and then $I(t) = 0$ for $t = [12, 24]\ hrs$.

    Determine:

    (a) The necessary equation(s) to predict the response $Q(t)$ over the 24-hour period.

    (b) Plot the values of $Q(t)$ over the 24-hour period (i.e. complete Figure 3 below, showing the discharge $Q(t)$).

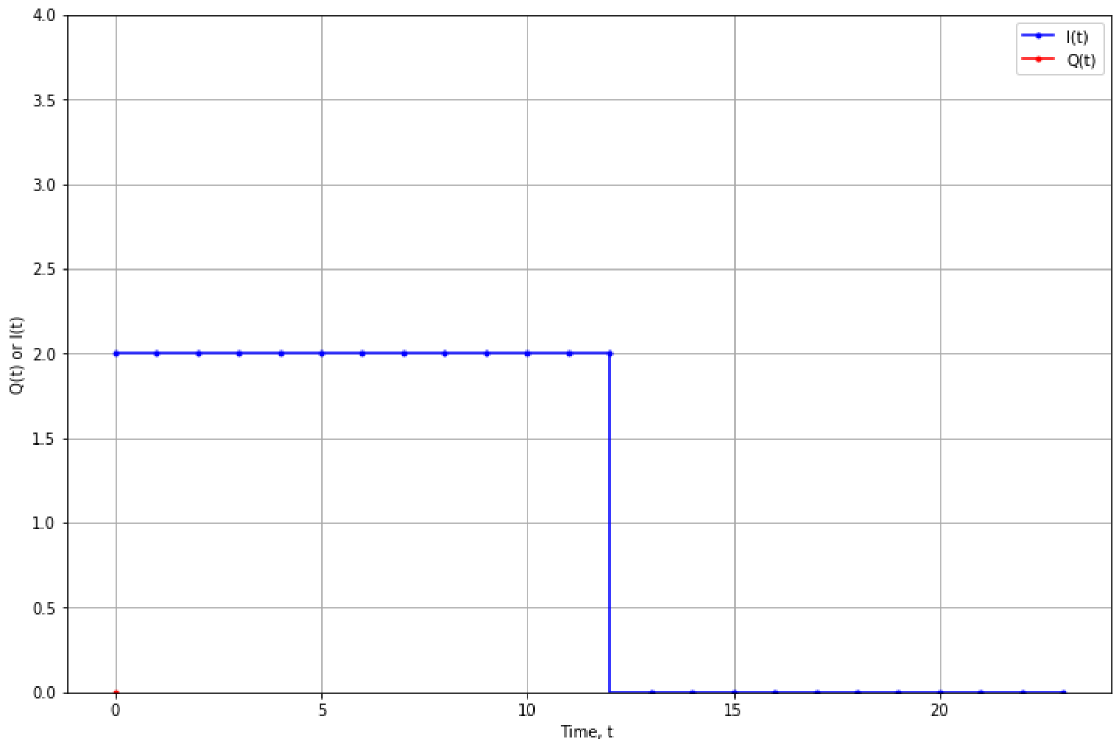

Figure 3: Plot of Runoff for Watershed described by $k\frac{dQ}{dt} + Q(t) = I(t)$, where $I(t)$ is as shown (in blue)

Show your work below (and on next page)

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14. Figure 4 is a topographic map of a small drainage basin. The contours show elevation in meters. Many of the contours are labeled. A culvert structure is located on the Eastern portion of the basin, near the outlet shown on Figure 4. The red line is a proposed impoundment alignment, beneath which the culvert structure is placed.

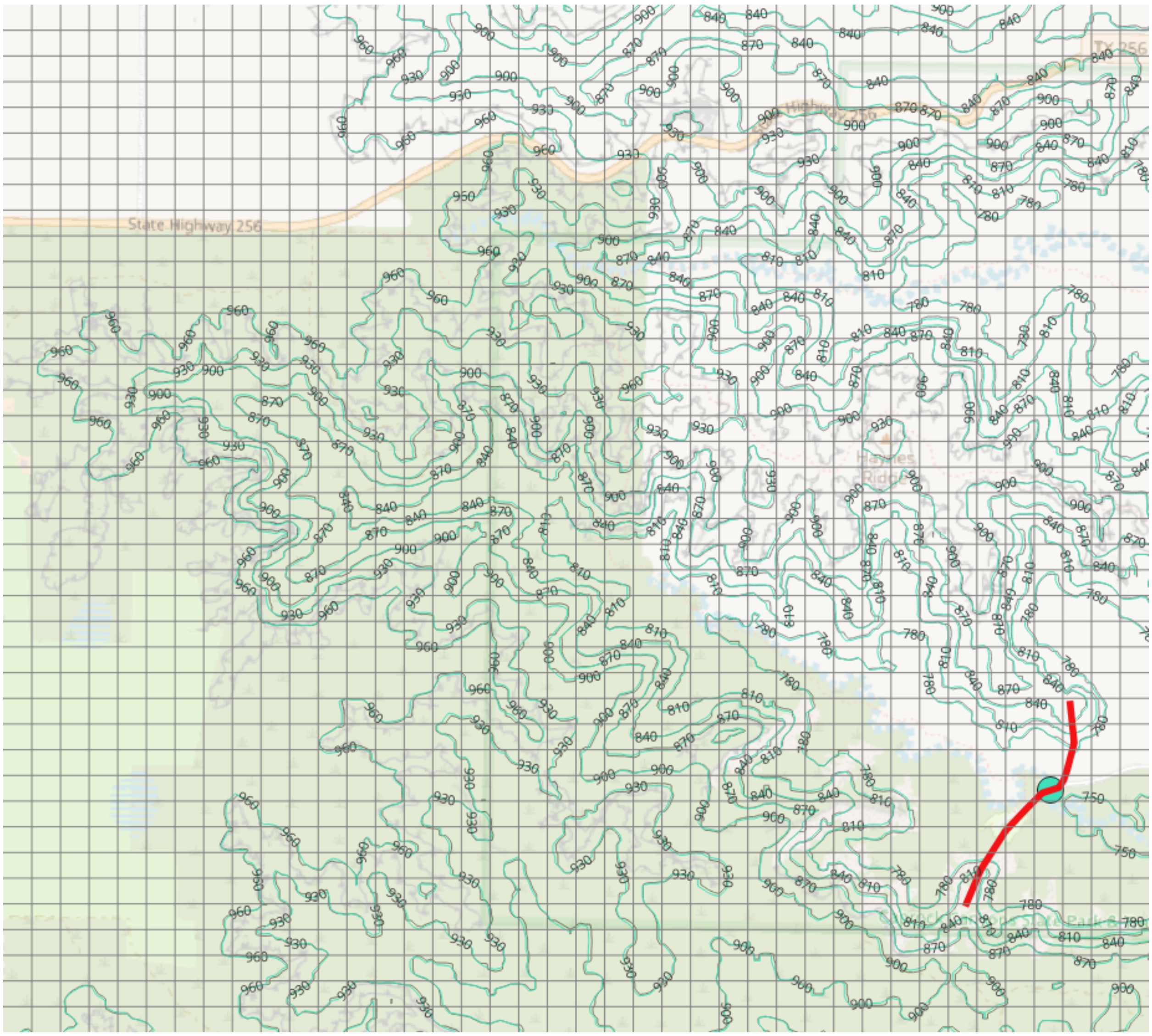

Figure 4: Topographic Map of a portion of the Earth. Elevations are in *meters*. Each square is 150 *meters* on a side. North (by convention) is up.

Figure 5 is a photograph of a representative culvert system comprised of 4-parallel , 4-foot diameter, 100-foot long culverts. The lowest portion of the proposed impoundment structure directly above the culverts is at elevation 810 meters. The culverts are to be laid on a dimensionless slope of 0.02.

Figure 5: Multiple-barrel outlet structure

a) Delineate the drainage area to the culverts using the 810 meter elevation as the pour point elevation (located at the blue marker in the drawing).

b) Determine the area of each small square.

c) Estimate the drainage area in square meters of the drainage basin.

d) Convert the drainage area from square meters into acres.

e) Convert the drainage area from acres into square miles.

f) The water surface area when the culvert system (like a dam, with 4 holes in the wall) impounds water to a water surface elevation of 760 *meters* is essentially zero. Complete the elevation (side) view sketch of the embankment and culvert system in Figure 6 by indicating the elevations on the sketch of the roadway crest, the culvert inlet elevation (also the upstream base of the embankment), and culvert outlet elevation.

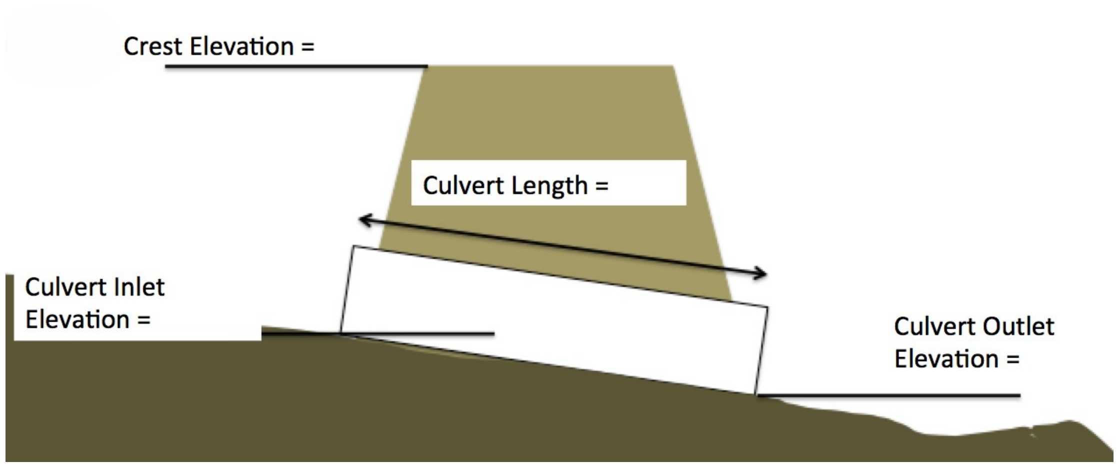

Figure 6: Culvert system elevation view sketch

g) Estimate the water surface area (area of the pool on the upstream side of the embankment) when the embankment impounds water to a water surface elevation of 780 *meters*. Describe how you made the estimate.

h) Estimate the water surface area when the embankment impounds water to a water surface elevation of 790 *meters*. Describe how you made the estimate.

i) Estimate the water surface area when the embankment impounds water to a water surface elevation of 810 *meters*. Describe how you made the estimate.

15. Figure 7 is a tabulation of an observed storm and runoff for the drainage area depicted by the map in Figure 4. The runoff was measured before the installation of the roadway, at the location indicated by the blue circle on the map.

TIME-HOURS	ACC-RAIN-INCHES	OBSERVED-FLOW-CFS
0	0.000	0
1	0.000	0
2	0.000	0
3	0.000	0
4	0.000	0
5	0.000	0
6	0.000	0
7	0.000	0
8	0.091	1.42466349
9	0.096	0.31660086
10	0.101	0.3165874
11	0.105	0.31660086
12	0.110	0.3165874
13	0.110	0.403656
14	0.140	0.403656
15	0.740	25.161224
16	2.740	600.236472
17	2.930	825.207416
18	3.020	157.42584
19	3.020	96.608336
20	3.020	28.121368
21	3.080	36.867248
22	3.200	20.048248
23	3.259	7.1447112
24	3.259	0

Figure 7: Cumulative rainfall for a 24-hour period on watershed determined for Figure 4

a) Estimate the total **volume** of runoff in cubic feet from the storm. Describe how you made your estimate.

b) Convert the estimate of runoff volume from cubic feet into watershed inches.

c) How long (in hours) from the beginning of rainfall until the peak discharge occurs?

d) What is the fraction of rainfall that becomes runoff?