

Exercise 4 - Streams

ENV 601

Show all work. Keep units with your numbers.

Part A

1) Consider the following three streams.

Grand River has a cross-sectional profile that is approximately rectangular with a width of 50 m, an average depth of 8 m, and an average velocity of 1.5 m/s.

Medio River has a cross-sectional profile that is approximately rectangular with a width of 18 m, an average depth of 3 m, and an average velocity of 1.5 m/s.

Mezzaluna River has a cross-sectional profile that is approximately semicircular with a width of 8 m, a maximum depth of 4 m, and an average velocity of 1.5 m/s.

- a) Calculate the cross-sectional area, wetted perimeter, hydraulic radius, and discharge for each. Make a table of the calculated results. Make sure to give proper units.
- b) Which has the greatest discharge? What does that mean?
- c) Which has the greatest hydraulic radius? What does this mean?
- d) Which stream likely lies on the steeper slope? Explain.
- e) Which stream likely lies on the gentlest slope? Explain.

2) Division River has an irregular cross-sectional profile. It was measured in a transect with the following results for water depth and velocity (taken at 0.6 of the water depth) measured at even distance increments across the 15 ft wide river:

depth (ft)	1.5	1.2	2.3	3.5	5	4.2	5.5	3.8	1.4
velocity (ft/s)	0.9	0.7	1.1	1.5	2.3	1.9	2.5	1.6	0.8

- a) Determine the average depth and velocity of Division River.
- b) Determine the discharge of Division River.

Part B Complete the following problems (modified from Rahn, 1996).

- 3) “One of the unresolved problems of flood forecasting is the precise determination of how often a flood (having a given discharge) can be expected to occur. Because only a small percentage of all the streams in the United States have been gaged for more than a few decades, it is difficult to determine, for example, the 100-year or 500-year flood.” The data below are annual peak discharges recorded on Rapid Creek, (USGS site no. 06412500), near Rapid City, SD.

water year	discharge (m ³ /s)
1951	4.05
1952	73.6
1953	4.30
1954	3.90
1955	9.23
1956	3.68
1957	12.3
1958	2.29
1959	2.32
1960	2.32
1961	2.82
1962	37.1
1963	5.41
1964	7.59
1965	17.4
1966	3.96
1967	12.4
1968	5.61
1969	3.94

water year	discharge (m ³ /s)
1970	6.94
1971	10.9
1972	885.0
1973	4.9
1974	14.6
1975	2.61
1976	18.0
1977	5.49
1978	12.3
1979	4.75
1980	3.37
1981	3.74
1982	7.48
1983	8.01
1984	7.05
1985	3.79
1986	2.52
1987	2.80
1988	3.57

water year	discharge (m ³ /s)
1989	3.14
1990	3.51
1991	5.69
1992	2.97
1993	9.29
1994	5.61
1995	13.6
1996	18.5
1997	29.7
1998	14.2
1999	18.2
2000	5.41
2001	3.03
2002	3.94
2003	3.26
2004	2.83
2005	2.94
2006	3.31
2007	4.50

- a) “Included in the data is the exceptionally large flood of 1972, which killed 238 people in the Rapid City area. Based simply on the number of years of record and the fact that the 1972 flood occurred one time during this interval, how often would a flood of this magnitude be expected?”

b) Rahn (1996) only included data through 1993 (for obvious reasons). How would your answer to *a* have differed using only those data?

c) Rank the data from greatest peak discharge to smallest and calculate the recurrence interval for each annual peak discharge record. Prepare a table of your results. To make it easier, I have posted a tab-delimited file with the data which you can import into a spreadsheet program like Excel.

d) Using the supplied graph paper, plot peak discharge against recurrence interval. Draw a best fit straight line through most of the data, ignoring extreme data that don't appear to be part of the trend defined by most of the data.

e) What is the 100 year flood discharge as predicted by your straight line fit?

f) What is the recurrence interval for the 1972 flood peak discharge as predicted by your straight line fit?

g) Considering the difference between the calculated recurrence interval in your table (and your answer in *a* above) and the prediction in *f* above, discuss the discrepancy and what you can say about the true frequency for this magnitude of flood.

- 4) "Angostura Dam was built on the Cheyenne river in South Dakota, in 1956. The Cheyenne River carries in the reservoir an average suspended load of 1.45×10^6 tons per year. The average discharge of the Cheyenne River is $4.8 \text{ m}^3/\text{s}$. Clear water flows over the spillway and into the irrigation canal downstream. The volume of the Angostura Reservoir when first formed was $2 \times 10^8 \text{ m}^3$."

How long will it take for the reservoir to completely fill in with sediment assuming that all incoming sediment is deposited before the water flows over the spillway? The sediment density is 0.88 g/cm^3 . The suspended load is given in metric tons (1000 kg) per year.

- 5) Pennsylvania experienced flooding in June of 1972. The Juniata River and Bald Eagle Creek are part of the drainage basin of the Susquehanna River. Peak discharge from this flood and the drainage area of each stream are given below.

<u>stream</u>	<u>drainage area</u>	<u>peak discharge</u>
Bald Eagle Creek	115 km ²	143 m ³ /s
Juniata River	5,280 km ²	3540 m ³ /s
Susquehanna River	67,600 km ²	30,500 m ³ /s

- Calculate the ratio of peak discharge to drainage area for each stream.
- Using the hydrographs below, describe how the streams are related in terms of the timing of the peak discharges.
- Discuss why the shapes of the three hydrographs are different.
- Discuss why the ratios calculated in *a* are different.

