Environmental Geology Lab 2 - Flooding and Extreme Precipitation Events

Rivers and streams are defined by the drainage basin that serves as the source for all of the water within the stream. Drainage basins are a scalable feature. This means that small drainage basins can be combined together to define larger drainage basins (Figure 1). Major rivers such as the Mississippi or Rio Grande can cover a significant fraction of a continent. The upland point at which a river or stream begins is defined as the **source**. The point where a stream empties into a lake or ultimately the ocean is defined as the **mouth** (or also sometimes called outlet).

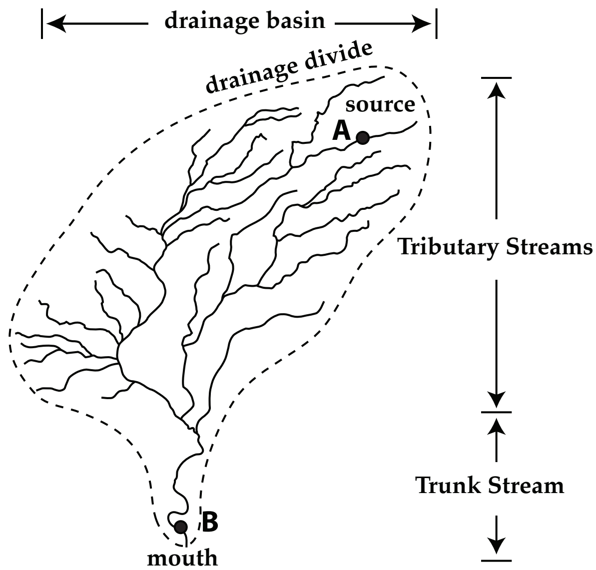

Figure 1. Simple drainage basin with trunk stream, tributary stream, and trunk streams illustrated.

At a smaller scale there are features observable when examining a specific segment of a stream, which are shown in profile view with the inset on Figure 2. The **channel** is the low area where water is normally confined. The **banks** of a channel define the edge of the channel. A **levee** is a ridge on the bank that is built-up above the elevation of the land that surrounds channel. The **floodplain** is the flat area beyond the levee, which in humid regions can be quite swampy. The **uplands** are the area of higher elevation beyond the floodplain.

Additional concepts associated with river systems include discharge, stage, and load.
Runoff, which is formally defined as **discharge** is the volume of water that is carried by a river as a function of time. Typically, discharge is measure in cubic feet per second (cfs) and can be visualized as the number of cubes that are 1 foot by 1 foot by 1 foot that pass a given point on a stream each second (Figure 3). Discharge can also be expressed in cubic meters per second (cms). Additionally, discharge can be related to the geometry of the channel and stream velocity as follows;

(1) $Q = A \times V$

where, Q is the discharge in cfs or cms, A is the cross-sectional area of the stream in ft^2 or m^2, and V is the stream velocity in ft / second or m / second.

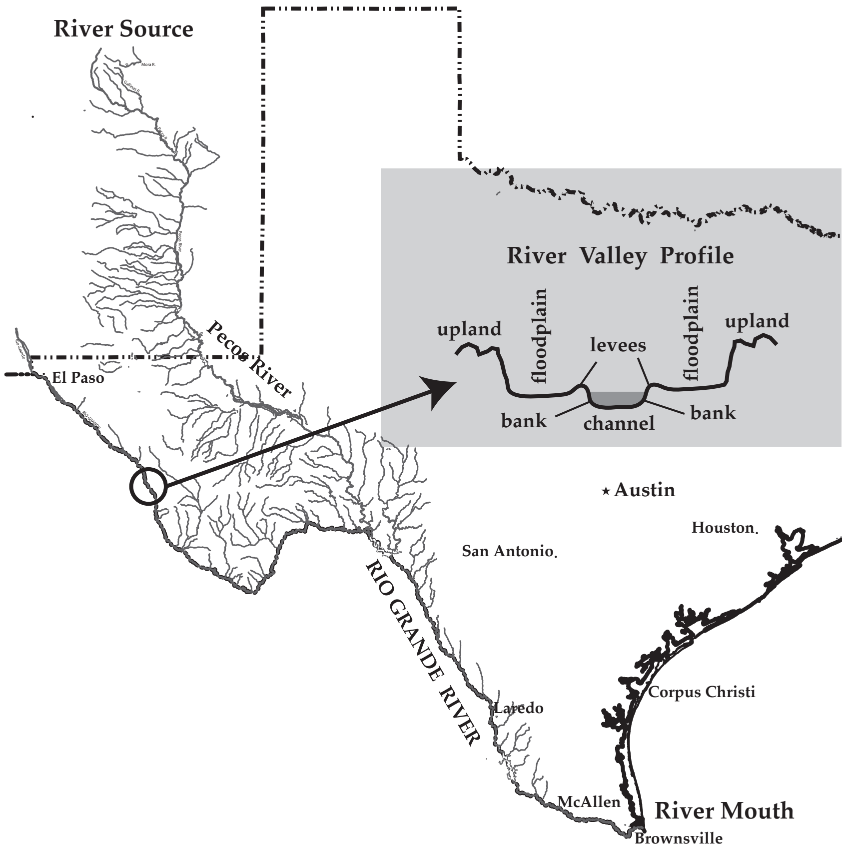

Figure 2. Rio Grande drainage basin illustrating river source and mouth with inset showing a stream profile.

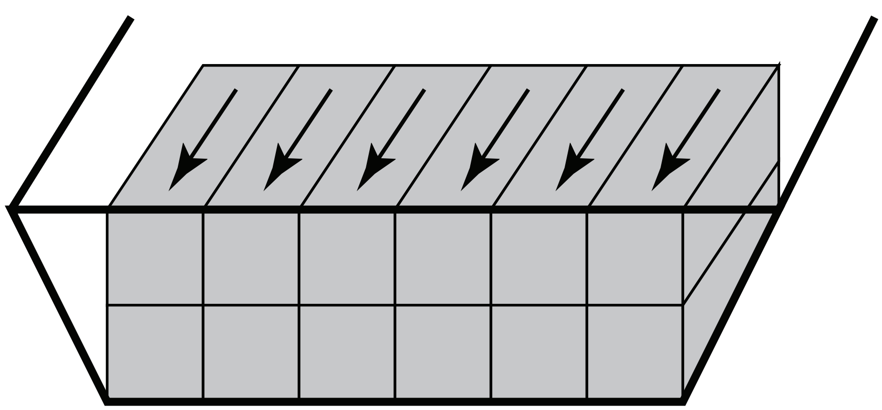

Figure 3. Discharge illustrated as boxes moving through a channel in profile.

Stage is simply the height of the water in the stream above the base of the channel. There are three types of stage as illustrated in Figure 4. Normal stage is when water is confined to the channel and has an elevation below the height of the floodplain. Flood stage is when the water is above the height of the levees obviously resulting in flooding. Near-flood stage is when the water is confined to within the channel but is above the height of the surrounding floodplain. In this instance flooding can occur if the levee fails.

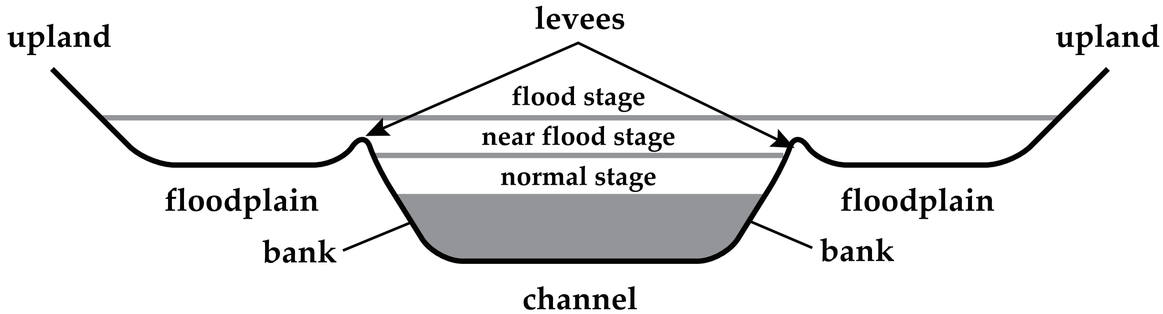

Figure 4. Diagram illustrating normal, flood, and near-flood stages in profile.

QUESTIONS BASED ON FIGURE 1:

1. Which points A or B will have the least discharge? Explain in detail.

2. Which elevation in the drainage basin is higher (A or B)? Explain in detail.

3. Into which geographic feature does all the runoff in the drainage basin illustrated in Figure 1 ultimately flow? Using a highlighter add arrows to indicate direction of water movement.

QUESTIONS BASED ON LAST WEEK'S LAB:

4. Record discharge from Lab 1 for: Q (m^3 / day)

September Tropical Storm ________________

5. Convert the daily discharge values (m^3/ day) for the three precipitation events to m^3 / sec by dividing these values by 86,400.

Q (m^3 / sec or cms)

September Tropical Storm ________________

6. Convert discharges from (m^3 / sec) to (ft^3 / sec), also known as cfs, by multiplying by 35.315!

Q (ft^3 / sec or cfs)

September Tropical Storm ________________

An important concept you should have noted is that of reccurrence interval, which can be thought of as the probability of flooding during a given year. The greater the reccurrence interval, the more severe the flooding associated with a given event. Commonly reoccurrence interval is expressed in years.

Most Severe
- 100 years flood (has a 1/100 chance of occurring during a year)
- 20 years flood (has a 1/20 chance of occurring during a year)
- 10 years flood (has a 1/10 chance of occurring during a year)
- 2 years flood (has a 1/2 chance of occurring during a year)

Least Severe

So the greater the discharge the greater the reoccurrence interval and vice versa as shown in Figure 5.

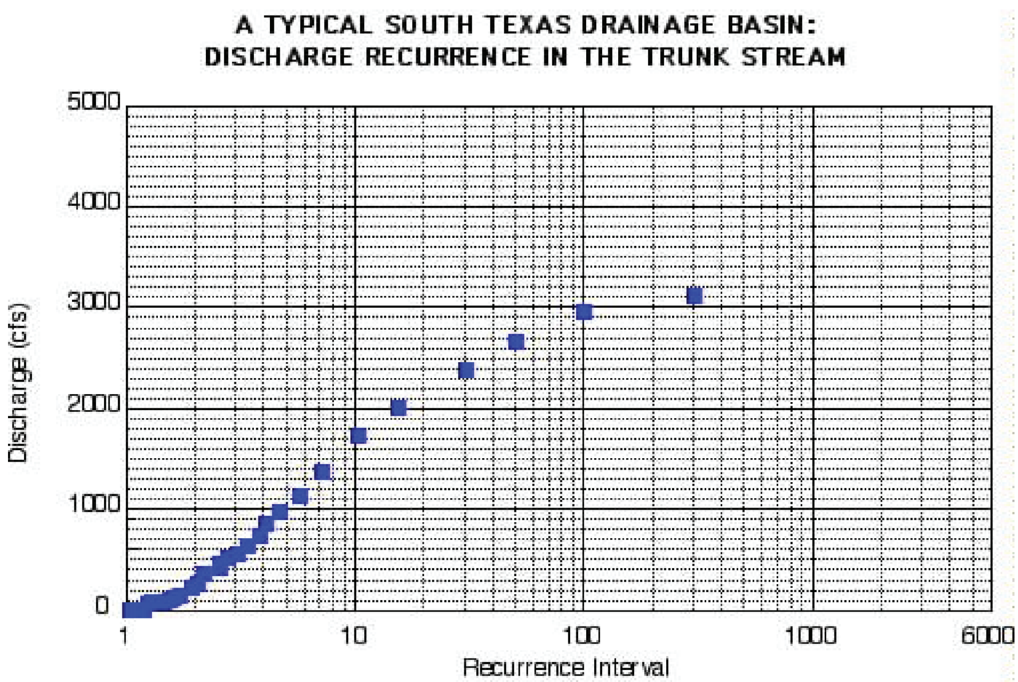

Figure 5. Probability of Discharge Recurrence.

Draw a smooth curve through the data points on Figure 5!
Do this very carefully.

QUESTIONS BASED ON FIGURE 5:

7. Discuss the meaning of a 100 year flood. Is this a flood that occurs every 100 years like clockwork? Explain the real meaning of this somewhat confusing term.

8. The discharge in a river increases with increasing recurrence interval.

True or False

9. Higher stage in a river are noted with decreased diascharge.

True or False

10. The greater the recurrence interval the higher the river's stage

True or False

11. Examine equation #1 on the bottom page 1. If a river flowed at a velocity of 2 ft / sec through a cross-section area of 10 ft^2 calculate the discharge in ft^3 / sec. **Show your work.**

12. Erosion widens the channel so that its cross-section area is now 20 ft^2. If the discharge you calculated in question 11 remains unchanged determine what the velocity is of the now widened channel. **Show your work.**

13. Does the answer in question 12 make intuititve sense, comment. Hint: think about how fast water moves when confined like in a garden hose versus not.

14. What is the discharge in (cfs) for the flood events with the following reoccurrence intervals based on using Figure 5. Be sure to ask your instructor how to correctly read a log scale.

200 yr ________________ 30 yr ________________

10 yr ________________ 5 yr ________________

15. Typically, streams overflow their banks on average of once every other year (once every 2 years). For the trunk stream of our drainage basin how much discharge (in cubic feet per second) is needed to achieve a bankfull state, which is almost the minimum discharge needed to cause flooding. Based on Figure 5 what is the discharge associated with a modest 2 year flood?

16. What is the recurrence interval for the September tropical storm example from lab 1 and is flooding likely to occur associated with this precipitation event?

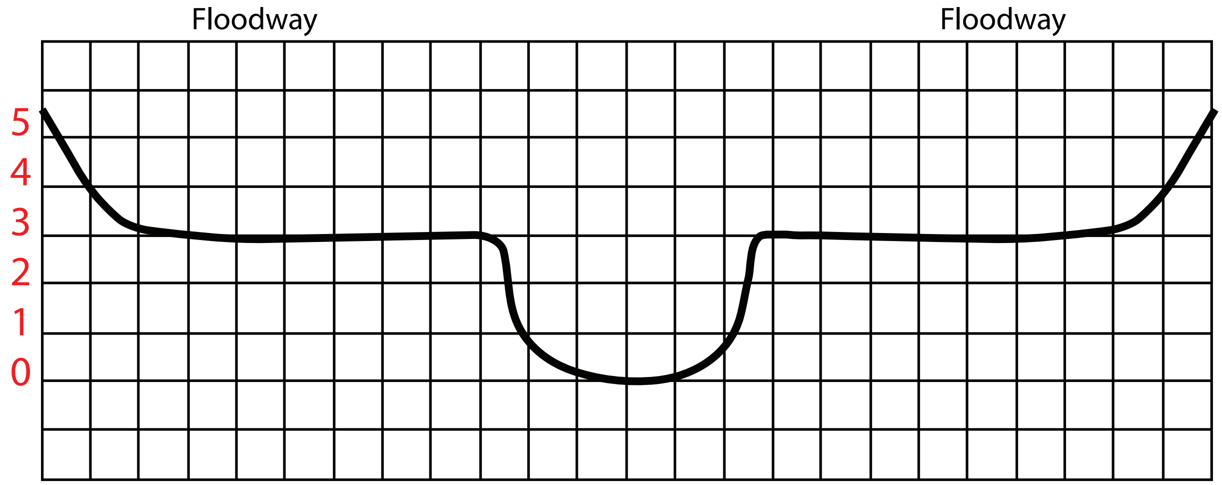

Figure 6. Cross-sectional view of typical South Texas stream that has data plotted for Figure 5. Each square on the grid is 5 ft X 5 ft, which equals an area (A) of 25 square ft.

Remember that discharge (Q) is the following

(1) $Q = V \times A$

So each square on Figure 6 effectively represents equals 25 ft^3 / sec of discharge.

Assume that the velocity in the following examples is a constant 1 ft / sec.

GETTING STARTED
Obviously at line 0 there is a discharge of 0 ft / sec. This is the bottom of the channel.

The discharge under line 1 can be determined by counting the squares below this line.

- There are two full sqaures and two half squares resulting in a total of three squares.
- From above each subdivided box equivalent to 5 ft (high) X 5ft (wide) or 25 ft^2.
- Assuming that the stream velocity is 1 ft / sec means that each square represents 25 ft^3 / sec of discharge.
- So, the discharge under line 1 is approximately 75 ft^3 / sec.

QUESTIONS BASED ON FIGURE 6

17. Draw a simple picture of a house that is 15 ft tall and 15 ft wide on the floodway (the lower part of the floodplain) immediately adjacent to the stream channel.

18. Calculate the discharge by counting squares for the following.

Between Lines 1 and 2 ___________ cfs

Between Lines 2 and 3 ___________ cfs

19. Which line represents bankfull conditions that can be expected with a reoccurence interval of two years. Line ____________

20. Add up all the squares below line 3 and determine the bankfull discharge in cfs.

$Q_{\text{Bankfull}} = Q_{\text{Below Line 1}} + Q_{\text{Between Lines 1 and 2}} + Q_{\text{Between Lines 2 and 3}}$

[75 cfs]

21. Calculate a hypothetical discharge just between lines 3 and 4. Do not consider anything above or below these lines. Just count the number of squares between these two lines.

Between Lines 3 and 4 ___________ cfs

22. Take the answer to question 6 (total discharge from September Tropical Storm Event) and subtract from it the backfull discharge from question 20.

$Q_{\text{Sept Tropical Storm}} - Q_{\text{Bankfull}}$

[Question 6] [Question 20]

23. Divide the answers from question 21 and 22. This fraction represents the water level of the September Tropical Storm between lines 3 and 4. Use a highlighter and indicate this stage on Figure 6.

24. Should you buy a house that was built on the floodway immediately adjacent to the trunk stream channel in Figure 6. Please explain in detail and relate your answer to the river stage obtained during the September Tropical Storm illustrated on Figure 6.

Flood frequency curves, like that plotted in Figure 5, are based on previous historical events and assume that climate is constant. However, with climate change the validity of flood frequency curves is cast in doubt. Emerging research suggests that rainfall intensities are increasing as the planet warms. While the impact of global climatic change is not fully understood, amplification of severe storms will likely increase the impact of weather-related hazards in the future. In addition, population growth and increased development in outlying combine to increase the frequency and severity of flooding. Land clearing for development and more concrete means less ground absorption; less absorption means more flooding. Therefore, a 100-year flood during the 20th century may now be equivalent to a mere 50 or even 20-year flood in the 21st century. Be sure to read the Scientific American article on flooding provided.

QUESTIONS:

25. As Laredo continues to grow, will the threat of flash flooding increase or decrease. Comment in detail.

26. You are buying a house. The city provides you a map that indicates your house is outside of the historical 100 year flood zone. Can you assume that your property is completely safe from any flooding in the future. **Write a one page essay that how flooding may change in the future and make reference to the lecture notes & Scientific American paper provided.**