Laboratory Exercise #3 – The Hydrologic Cycle and Running Water Processes

Section A - The Hydrologic Cycle

Figure 1 illustrates the hydrologic cycle which quantifies how water is cycled throughout the earth. The hydrologic cycle can be divided into two components:

(1) Reservoirs - which can be thought of as containers of water and
(2) Fluxes – processes that transfer water between the reservoirs.

There are five major reservoirs that comprise the hydrologic cycle, listed in descending order of mass of the reservoir below:

(1) Ocean (97% of earth's water)
(2) Glaciers (2% of earth's water)
(3) Groundwater (0.6% of earth's water)
(4) Surface Water (water in lakes, rivers, and soil; all << 1% of earth's water)
(5) Atmospheric Water (<<< 1% of earth's water)

There are four major fluxes that can move water between reservoirs within the hydrologic cycle.

(1) Precipitation – transfers water from the atmosphere to the ocean, glacier, or surface water reservoirs in the form of liquid (rain) or solid (snow) water.
(2) Evaporation – transfers water from the ocean, glacier, or surface water reservoirs to the atmosphere in the form of water vapor.
    Biologically mediated transfer of water to atmosphere is called transpiration and on land physical and biological transfer of water to atmosphere is commonly combined defining evapotranspiration.
(3) Runoff – transfers water from the glacier, groundwater, and surface water reservoirs to the ocean in the form of liquid water.
(4) Infiltration – transfers water from the glacier and surface water reservoirs to the groundwater reservoir in the form of liquid water.

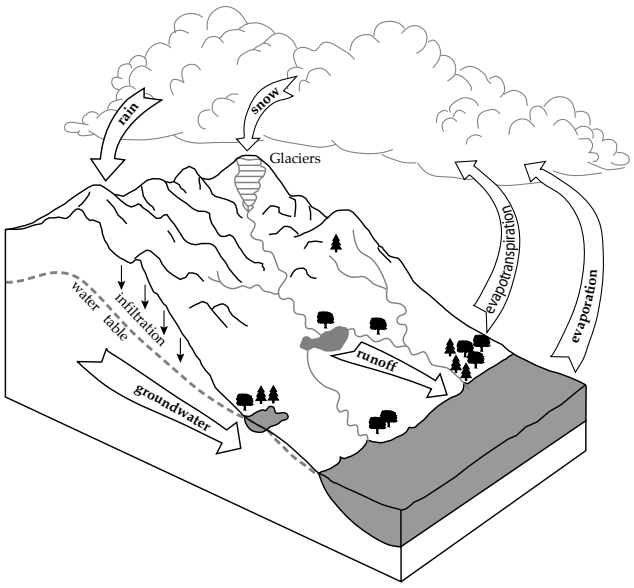

Figure 1. Simplified illustration of the hydrologic cycle.

Questions:

1. In inland areas of South Texas (away from the ocean) such as Laredo, TX.

   Name 3 reservoirs that are present:

   _____ _____ _____

   Name 2 reservoirs that are not present:

   _____ _____

2. In inland South Texas which fluxes of the hydrologic cycle are present?

   _____ _____ _____

3. In inland South Texas almost all the surface water in the region is derived from local precipitation; ignoring the waters of the Rio Grande which are sourced outside the region. What fluxes (evaporation, runoff &/or infiltration) can transfer water out of the surface water reservoir in inland South Texas?

   _____ _____ _____

4. List, from greatest importance to least importance, the fluxes that can remove water from the surface water reservoir in inland South Texas?

   _____ > _____ > _____

Section B – Overview of River Systems

Rivers and streams are organized within a drainage basin (also known as a watershed (Figure 2). A **drainage basin** is the geographic area that captures precipitation and funnels runoff into a specific stream or river. The main stream in a drainage basin into which all the water of the basin will ultimately drain is called the **trunk stream**. The area where the trunk stream exits the drainage basin defines the lowest point of the basin. Smaller **tributary streams** feed runoff into the trunk stream. The boundary of the drainage basin is called the **drainage divide**, which typically consists of the highest elevations that defines the top of the basin.

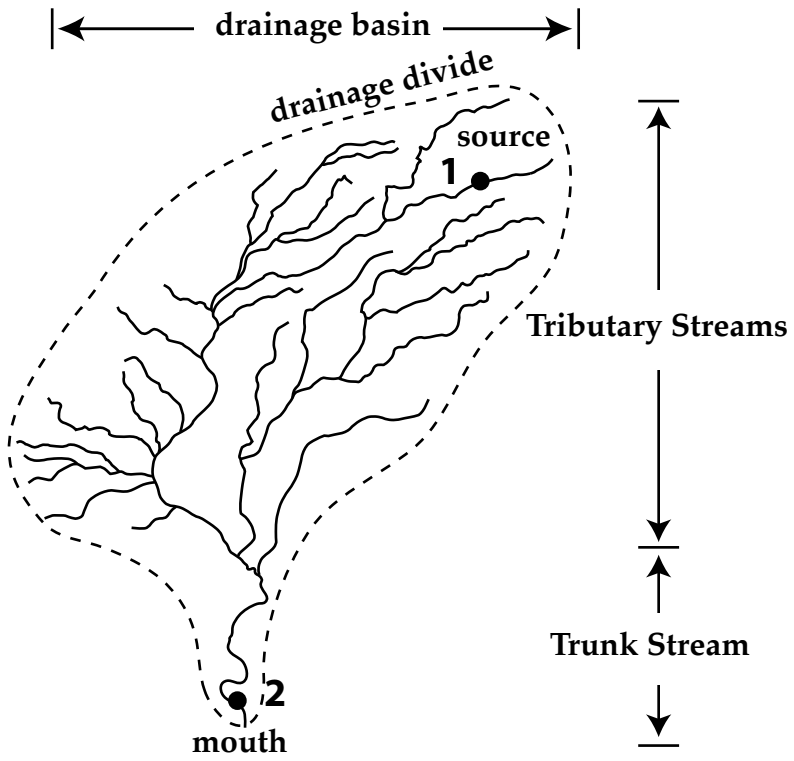

Figure 2. Drainage basin with trunk stream and tributary streams illustrated.

Drainage basins are a scalable feature. This means that small drainage basins can be combined together to define larger drainage basins (Figure 3). Major rivers such as the Mississippi or Rio Grande can cover a significant portion 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**.

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 3. 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 and can be visualized as the number of cubes that are 1 foot X 1 foot X 1 foot that pass a given point on a stream each second (Figure 4). Generally, discharge increases towards the mouth of a stream.

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 5. 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.

Load is the material carried by the stream besides water. There are three types of load (Figure 6). Bed load consists of large-grained sediment (typically sand and gravel) that is transported in contact with the bottom of the channel. Suspended load consists of small-grained sediment (typically clay and silt) that is mixed with the water traveling downstream and commonly imparts a muddy appearance to the water. Dissolved load consists of materials broken down at the molecular level and typically consists of discrete ions. Common positive ions (cations) in river water include Na, Mg, Ca, and K and negative ions (anions) are Cl, sulfate, and carbonate ions.

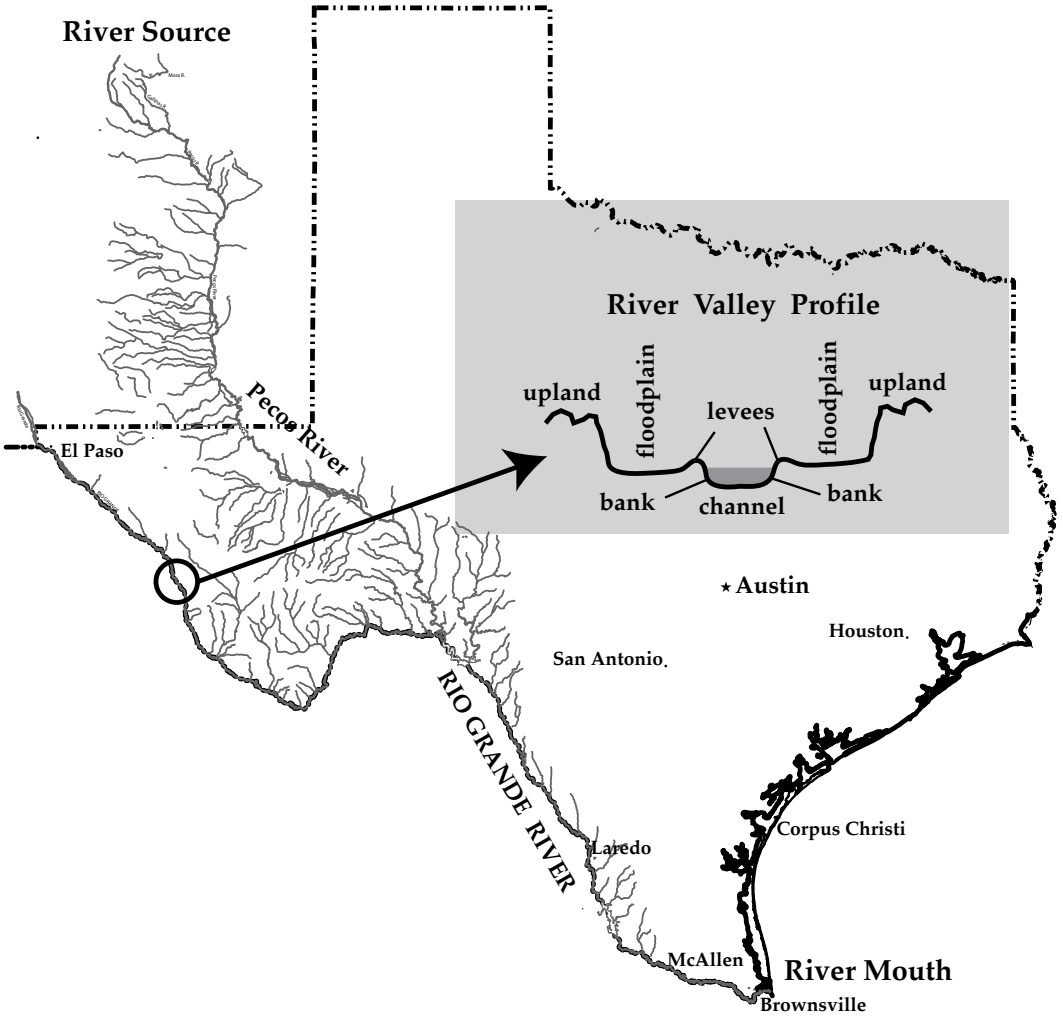

Figure 3. Rio Grande drainage basin illustrating river source and mouth with inset showing a stream profile.

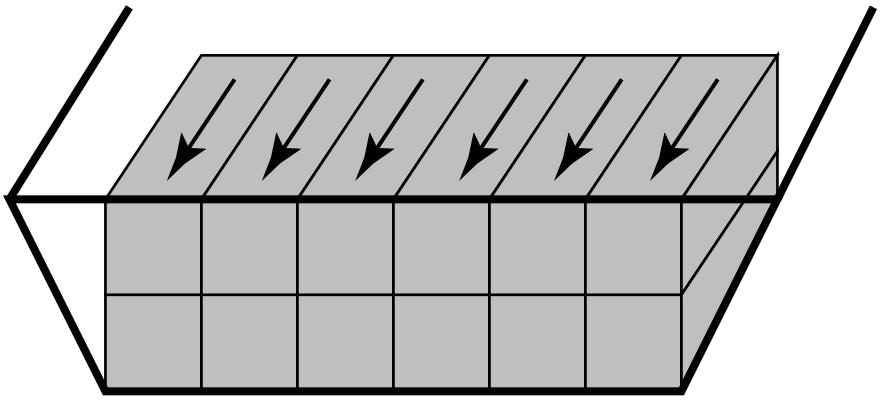

Figure 4. Discharge illustrated as boxes moving through a channel in profile.

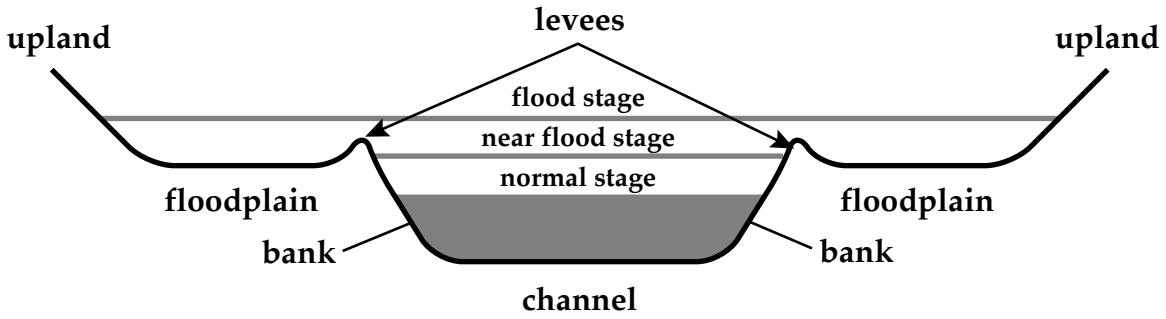

Figure 5. Diagram illustrating normal, flood, and near-flood stages in profile.

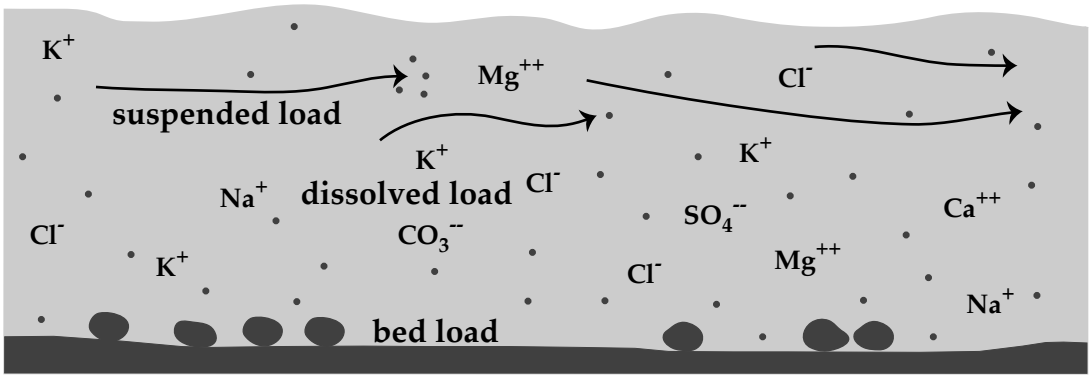

Figure 6. Stream profile illustrating relative positions of bed, suspended, and dissolved loads.

Questions: [Refer to Figure 2., page 3 Simplified drainage basin]

5. Which points 1 or 2 will have the most discharge? Explain in detail.

6. Where is the highest elevation in the drainage basin located? Explain in detail.

7. What type of sediment and load is typically present within the flowing water of a stream?

   Sediment _____ Load _____

8. What type of sediment and load is typically present on the bottom of a flowing stream bed?

   Sediment _____ Load _____

9. Ultimately, what happens to the dissolved load in streams and in rivers (where does it end up)?

Section C –Upland River Systems

The source of many major river systems is located in mountainous regions. River systems in upland regions have a number of common characteristics as listed below (Figure 7).

(1) Steep slope
(2) Straight channel
(3) Narrow or no floodplain
(4) Sharp V-shaped valley profile with very high banks
(5) Erosion dominates over deposition
(6) Erosion is dominantly downcutting.

Landscape (or geomorphic) features associated with upland river systems are mainly features generated by erosion such as waterfalls and rapids.

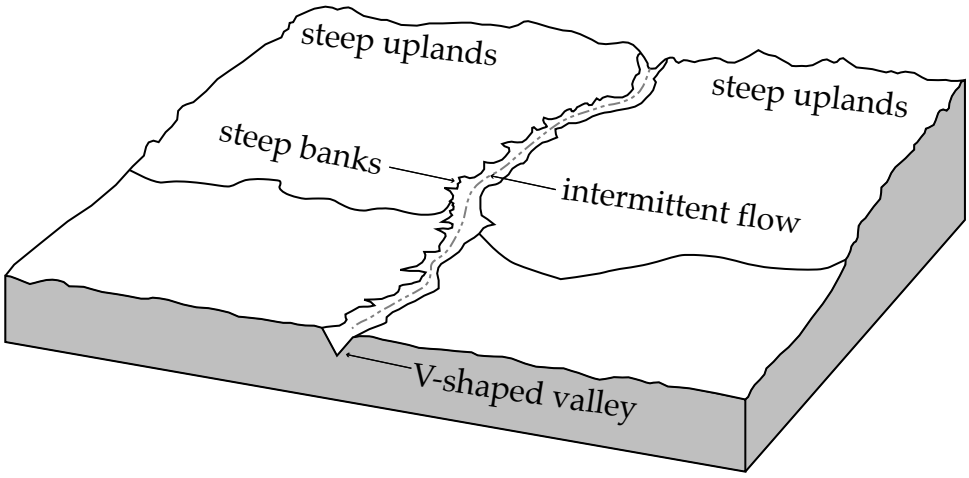

Figure 7. Schematic diagram showing features associated with upland river systems.

Questions: [Refer to The Basin 7.5 minute USGS map from west Texas]

10. Are the upland streams on this map permanent or intermittent? Refer to figure 7 above.

Permanent or Intermittent

11. Give the latitude and longitude of point A (as precisely as possible).

12. What is the elevation of points B and C and determine the relief between these points?

B _____ C _____ Relief _____

13. What compass direction does the stream at point B flow in? How did you determine your answer? (Hint:point C has the same elevation as point A) Explain in detail.

14. What is the slope of the stream between points B and C? Is this a steep slope (note: any slope >100 ft/mile is considered steep)? Explain in detail.

15. Does the stream at point B – C meander significantly or does it have a relatively straight channel?

16. Does the stream at point B – C have a wide floodplain adjacent to the channel or is the channel confined to a canyon within a narrow V-shaped valley? Specifically, examine the stream in the vinicity of the area labeled "The Window."

Section D –Lowland River Systems

As rivers flow toward the ocean the topography of the land becomes more subdued. River systems in lowland regions have a number of common characteristics as listed below.

(1) Gentle slope
(2) Meandering channel
(3) Wide floodplain
(4) Rounded and subdued valley profile
(5) Erosion equals deposition
(6) Erosion is dominantly sidecutting

Landscape (or geomorphic) features associated with lowland river systems are both erosional and depositional (Figure 9).

There are two types of banks associated with a meandering river. The inner bank, where deposition dominates, is referred to as the **point bar**. The outer bank, where erosion dominates, is the **cut bank**. Additionally, levees and floodplains are common features associated with lowland streams. **Backswamps** can occur in poorly drained floodplains especially in regions that have a humid climate. Finally, **oxbow lakes** are formed when a river abandons a meandering channel in favor of a newer straighter channel.

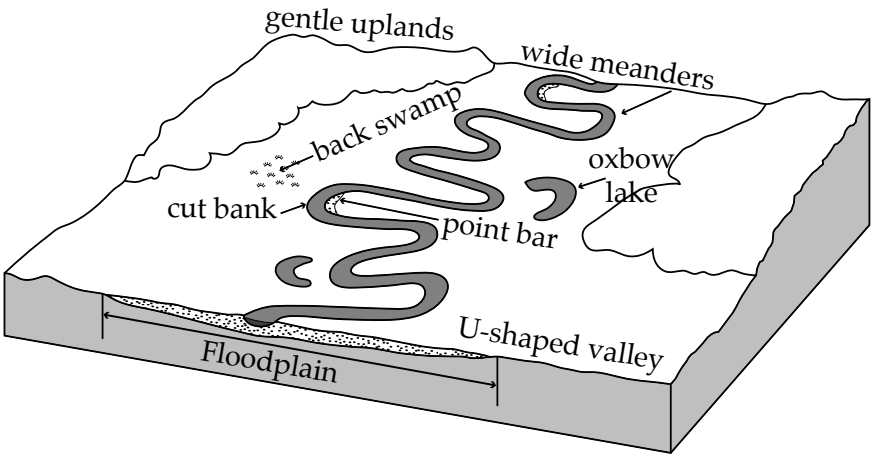

Figure 9. Schematic of a lowland stream.

Questions: [Refer to Davis Hill 7.5 minute USGS map from east Texas]

17. Give the latitude and longitude of points A and B (be as precise as possible).

Point A _____ Point B _____

18. What is the relief of the Trinity River between points A and B if point A is at 38 ft and point B is at 33 ft?

19. What compass direction does the stream that passes point A flow in? How did you determine your answer (please support your answer with some HARD evidence)?

20. What is the slope of the river? Is this a steep or gentle slope? Explain in detail.

21. Measure the width of the floodplain associated with the rivers on this map from approximately 1 mile east of Davis Hill to 1 mile west of Grand Cane (between points E & F) What is the width in **miles**?

22. Discuss the origin of Horseshoe Lake near the middle of the map.

23. Locate the middle of the land between the feature mentioned in Question #22 using latitude and longitude as precisely as possible.

24. Find points C and D that define two adjacent banks of the channel. Which bank is the point bar and which bank is the cut bank? Fully justify your answer.