Environmental Geology Lab 4 - South Texas Water Resources

Our society uses many natural resources to support of modern way of life. Resources include mineral, fossil fuel, agricultural, and most fundamental of all, water. A resource can be classified as either renewable or non-renewable. A renewable resource can be replenished as long as it is carefully managed. A clear example of a renewable resource includes trees and crops, which can be harvested and replanted thus forming a sustainable resource. Conversely, mineral and fossil fuel resources are non-renewable meaning once used they are effectively gone forever. Water is interesting because depending on the regional climate and geology water can be either a renewable or a non-renewable resource.

In humid regions (Precipitation > Potential for Evapotranspiration; P > PET)

> Water is essentially a renewable source but with growing populations you still need to manage this resource carefully and prevent pollution that can impair water quality

In dry regions (P < PET)

> Water, especially groundwater, can be depleted and once it is gone it will take thousands of year to replenish

Water resources can be divided further divided into surface and groundwater resources. Surface water generally is a renewable resource but it also susceptible to climatic fluctuations. For example, severe drought can result in service outages dramatically impacting quality of life. Groundwater tends to be a more stable resource; however excessive pumping, called groundwater mining, can deplete this resource that in some cases require thousands of years to develop. Groundwater without careful management can become a non-renewable resource especially in arid and semi-arid regions like Texas. Specifically, the Ogallala aquifer, which underlies much of the high plains from South Dakota to northern Texas, receives very little natural recharge and the water is being extensively mined for irrigation. In many areas wells are already going dry and within about 20 years the aquifer will be drained, which will have a major social and agricultural/economic impact on the region.

The well yield is the amount of water that can be pumped from an aquifer. If the well yield is in excess of the recharge rate then groundwater resource will be non-renewable and ultimately will be depleted. In this situation the water table level will drop and this will cause land subsidence; a drop in the elevation of the land surface. In places where there is excessive depletion of groundwater the land surface can subside up to 10 to 15 m.

QUESTIONS:

1. In West Texas what type of resource is groundwater (renewable or non-renewable)? Justify your answer.

2. If actual long-term well yield excedes the recharge rate what will happen to the level of the water table?

3. If excessive water is removed from the ground what will happen to the level of the land surface.

In Laredo, fortunately we have the Rio Grande, which is sourced from more humid mountainous regions in Mexico. In terms of groundwater it is an interesting question to consider whether they are renewable versus non-renewable.

The average precipitation (P) is 18 inches per year. To determine whether potential groundwater resources in the region are renewable or non-renewable the we need to know the value for PET.

QUESTIONS:

4. Convert the above P value into mm by multiplying by 25.4. _____ mm

5. Determine the monthly PET value from examining figure 1 from lab 1. You will have to multiply the values on this figure by the number of days in each month.

Jan	_____	July	_____
Feb	_____	Aug	_____
Mar	_____	Sept	_____
Apr	_____	Oct	_____
May	_____	Nov	_____
Jun	_____	Dec	_____

6. Determine total annual PET value by summing all the monthly values from question 5. **Show your work.**

7. Potential water resources in the Laredo region, such as groundwater in aquifers, are?

Renewable or Non-Renewable

To really understand water as a resource you need to develop an appreciation for how much water we use on a daily basis. Currently, the City of Laredo obtains all of its water from the Rio Grande River. For years the city has realized that this is a vulenability and has sought to find a secondary water supply. Early in these discussions it was thought that Lake Casa Blanca might serve as an emergency supply for the city. The waters that drain into Lake Casa Blanca come from a drainage basin roughly the same size as the watershed examined from labs #1 and 2.

8. Record the discharge from Lab 1 produced. by the September Tropical Storm _____ Q (m^3 / day)

9. Convert the discharge from question 8 into liters by mutliplying by 1000. _____ Q (liters)

10. Determine the daily consumption of water in Laredo. Assume that each person uses 750 liters / day and the population of Laredo is 250,000. Multiply these two values. **Show your work.**

11. Determine how long (in days) the discharge from the September Tropical Storm can supply the city of Laredo. Hint: take the answer from question 9 and divided it by the answer to question 10 and the answer should be in days. **Show your work.**

12. Based on the answer to question #11 comment whether Lake Casa Blanca could act as a viable secondary water supply for the city of Laredo

Next let us consider the worst possible case for Laredo, a severe drought that lasts over a decade. In such a scenario the Rio Grande River would nearly disappear. With this threatening possibility in mind answer the following questions.

The average daily discharge of the Rio Grande is 100 cubic meters per second. The following set of questions considers an extreme drought scenario when discharge is decreased to 5% of its normal value, which would be a value of 5 cubic meters per second (m^3 / sec).

13. Convert 5 m^3 / sec into cubic meters per day by multiplying by 86400 (sec/day) _____ Q (m^3 / day)

14. In the future assuming that the population of Laredo is now 300,000 and that the average person uses 700 liters per day determine the total amount of water used by the city. Multiply these two values and **show your work.**

15. Let assume that the answers to questions 13 and 14 reflects the worst-case scenario for drought in Laredo in the future. How much of the river would be used by the city on a percentage basis? **Hints: Take water consumption value from question 14 and divide by the total amount of water in the river during sever drought from question 13. Multiply your answer by 100% and show your work.**

During low discharge conditions there is less water to dilute raw sewage and other pollutants added into the river. Significant, quantities of raw sewage are dumped into the river from the Mexican side. Therefore, during drought not only water quantity but also water quality may be adversely affected.

16. How would the cities downstream of Laredo, such as Zapata, fare in such the worst-case drought scenario outlined above. Comment in detail based on the consideration that over 10,000,000 liters of raw sewage is dumped into the river per day from the Mexican side. Would you want to drink this water?

Because of the susceptibility of the Rio Grande River to extreme fluctuations during drought the City of Laredo has been looking for a secondary water supply for decades. Since our water supply is surface-based, which is subject to our highly variable climate it makes sense to consider groundwater as a potential secondary (emergency) water source despite the fact that this is a non-renewable resource. Make sure you examine the lecture PowerPoint presentation on this topic.

The Possibilities:

Edwards/Trinity Aquifers	(Using the Rio Grande to transport the water from Kinney County North of Webb County outside of the area of the map in Figure 1; freshwater). NOTE THAT THE EDWARDS AQUIFER IS THE SAME THAT PROVIDES WATER TO SAN ANTONIO
Laredo/Carrizo Aquifers	(Within 10 miles of the city; brackish water; confined aquifers)
Carrizo Aquifer	(Northwest Webb County at its recharge area; freshwater; unconfined aquifer)

Note that geologic units indicated in Figure 1 are listed in order from oldest on the bottom to younger on the top. These rocks on Figure 1 have a slight tilt (1°) toward the east so that the Carrizo Formation is 2000 to 3000 ft below the surface of Laredo. Note that the greater distance that groundwater travels the greater the interactions with rocks that increase the dissolved solid content (TDS) of the water. Basically, rocks partially dissolve as groundwater travels through them increasing the TDS content.

Major Difficulties with Any Soluton:
There are significant problems with all of these possibilities in that the cost is 3 to 6 times more than obtaining and treating water directly from the Rio Grande. Why? Cost results from either transportation of water long distances using a pipeline or desalination of brackish water available in the immediate Laredo area.

The water in the Laredo/Carrizo Aquifers within 10 miles of the City of Laredo is not freshwater but has a high total dissolved solid (TDS) or salt content.

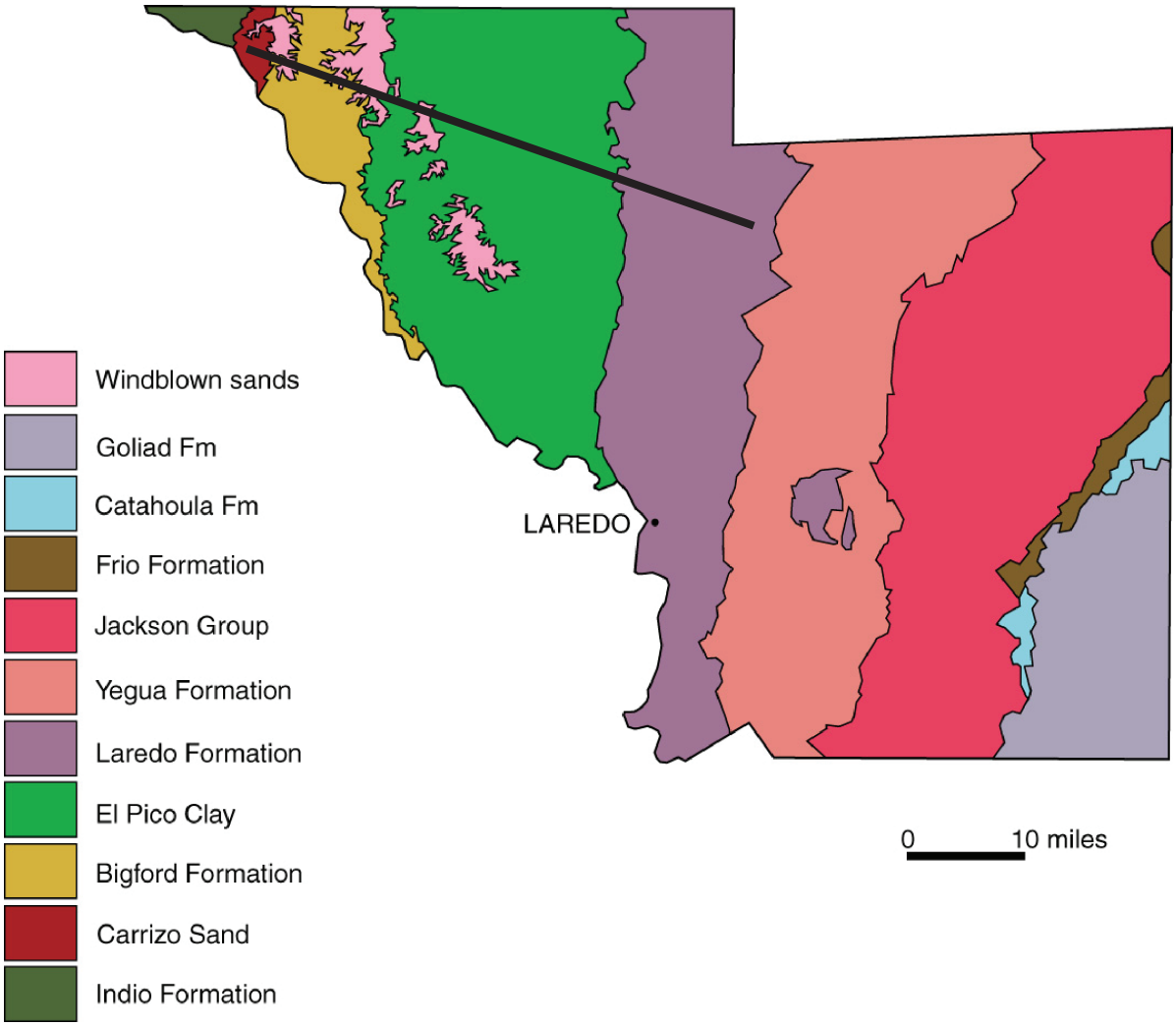

Figure 1. Webb County Surface Geology

QUESTIONS

17. The El Pico Clay is an?	Aquifer	or	Aquitard
18. Laredo Formation is which type of aquifer?	Confined	or	Unconfined
19. The Carrizo Aquifer in the Laredo area is which type of aquifer?	Confined	or	Unconfined
20. The Carrizo Aquifers in extreme northwest Webb county is which type of aquifer?	Confined	or	Unconfined

21. What problems may occur with using the Rio Grande River to transport water from the Edwards/Trinity or Carrizo Aquifers downstream during a severe drought, especially during a long hot summer? Hint: refer to your answer to quesiton #5.

22. What are the issues associated with using water from the Carrizo Sand aquifer both from its recharge zone in northwestern Webb County and in the Laredo area?

23. What are the issues associated with using water from the Laredo Formation aquifer?

24. Describe the type of processing required to make the water from the Laredo/Carrizo Aquifers from the immediate Laredo area drinkable. Hint: think about the TDS content of this water.

25. Why is groundwater a much more important resource in San Antonio versus Laredo? Think about the promixity of the Edwards Aquifer relative to these two cities. Hint: Look at the box in the textbook that dicusses the Edwards Aquifer. Also consider how the water quality of the Edwards Aquifer is different from the aquifers around Laredo.