Lab 10 Student Answer Sheet

Landfills and Groundwater Resources

NAME (please print clearly) ____

Objective: **Understand how groundwater processes and systems work. Apply an understanding of groundwater processes to determine landfill risk.** For this lab, we use the scientific method to determine which of three areas would be best to build a new landfill. We will make some general observations, material specific measurements, look at groundwater movement using a contour map of a water table, and use our data to make a recommendation for which area would be best suited to build a sanitary landfill.

Materials: Ruler, graduated cylinders, and beakers.

Background: See your lab reading to learn about Groundwater Processes which provides a good background on how scientists measure rock porosity and permeability and how to understand groundwater movement. We will use these same ideas to understand how scientists can use these observations and measurements to determine where to build a sanitary landfill that will have the *lowest risk* of groundwater contamination.

In this lab, we will look at three areas described in the chart below and shown on the maps on the last page. All areas receive similar amounts of precipitation, approximately 40 inches of rainfall a year.

Area	Description	Overlying Soil	Underlying Bedrock
A	This area is located along the White River (in the White River floodplain) on the Southside of Indianapolis, Indiana but just north of the I-465 loop. The White River is at least a third order stream at this point. To the east of the area is an active quarry where sand and gravel is mined. (In the picture on the next page, you can see that the pits have filled with water.) In terms of topographic relief, the area is very flat, with a slope of less than 1%. The elevation of this area is 500 feet above sea level. In the 1970s, the area was used as farmland, supplying Indianapolis with vegetables. It is currently owned by the South Side Landfill, Inc. and may be used for future expansion.	Sample A	Sample A
B	This area is located on the hilltops in Brown County, Indiana, just east of Brown County State Park, along State Road 135. It is in the Salt Creek/Lake Monroe drainage basin. The streams are small, first order streams in this area. In terms of topographic relief, the area is located on a relatively flat area over several hills with an elevation of 800 feet above sea level. This area has never been developed. The area is currently covered by a deciduous forest.	Sample B	Sample B
C	This area is located in a valley that forms the headwaters (first order streams) to Blue Creek (which eventually flows into Lake Monroe, the largest lake completely within Indiana). The area would be in the Blue Creek floodplain. This area is just east of Brown County State Park, along State Road 135. In terms of topographic relief, the area is very flat, with a slope of less than 1%. The elevation of this area is 680 feet above sea level. Since the 1970s, the area has been used to grow corn and soybeans.	Sample C	Sample C

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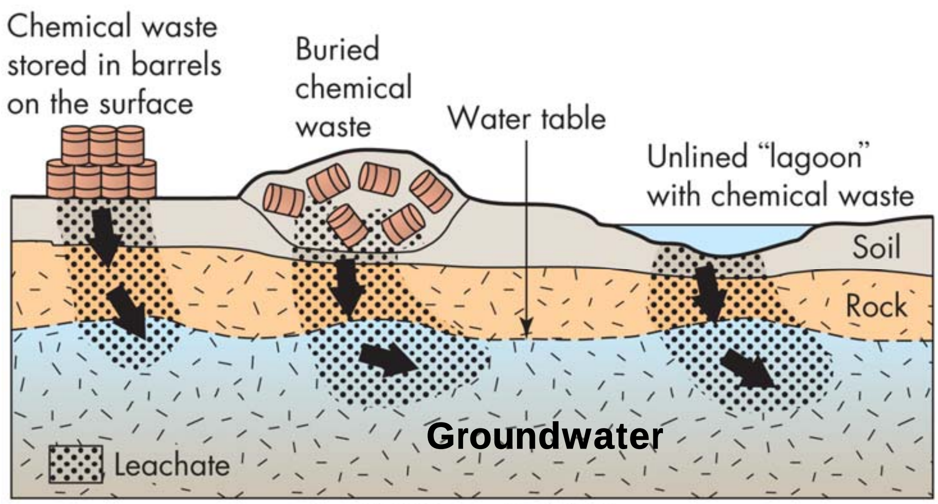
Background (continued): When scientists are looking to site a landfill, they must consider five site characteristics: (1) *topographic relief*; (2) *proximity to surface and groundwater resources*; (3) amount of *precipitation*; (4) *type of soil and rock*; and (5) possible location of the proposed disposal zone in the surface-water and groundwater flow system or *depth of water table*. An ideal place to build a landfill would be an area where the natural site characteristics would prevent or significantly hinder the movement of *leachate* (the noxious, often toxic liquid that forms as wastes mix together, decompose/disintegrate, and/or change form). See figure below to see how leachate can move from open waste disposal areas into groundwater.



To protect groundwater resource, an idea place to put a landfill would be an area with low topographic relief (flat), located away from surface water and groundwater resources; in a dry environment; in soils of very low hydraulic conductivity over consolidated, non-porous or permeable bedrock; and where the water table is very deep, well below the surface.

Using the five characteristics, describe a non-ideal place to site a landfill. What natural characteristics could result in a *high risk* of groundwater contamination with leachate?

Characteristic	**Your description of a non-ideal place**
Topographic relief	
Proximity to surface and groundwater resources	
Amount of precipitation	
Type of overlying soil	
Type of underlying bedrock	
Depth of water table	

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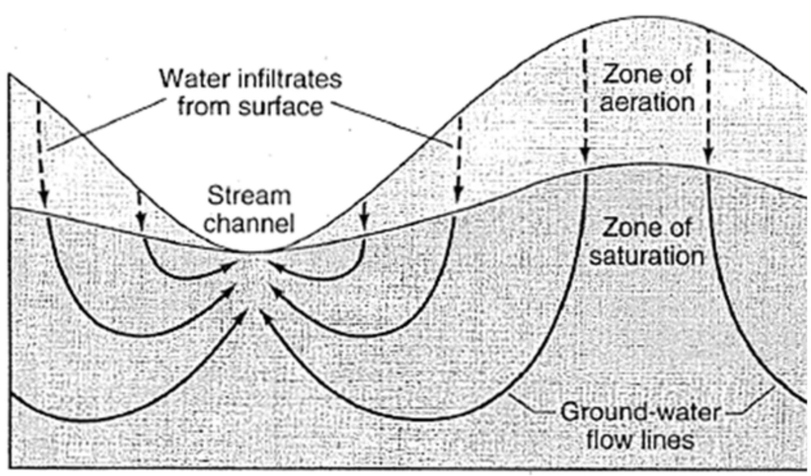
Practice: Start with some simple observations. Study the maps and the descriptions given. Based on what you know about these sites and what you know about an ideal and non-ideal location for a landfill, form a tentative hypothesis to answer the question: If we were to build a landfill, which area would have *the lowest risk* of groundwater contamination? To help you get started, discuss the following with your group then *circle* your answer. (You do not need to write an explanation.)

Based on topography, which would be the best site?	**A**	**B**	**C**
Based on proximity to surface and groundwater resources, which would be the best site?	**A**	**B**	**C**
Based on the amount of precipitation, which would be the best site?	**A**	**B**	**C**
Based on overlying soil type, which would be the best site? (Think about how soils form. What type of soil would you expect in each area?)	**A**	**B**	**C**
Based on underlying bedrock type, which would be the best site? (Think about what type of rocks you would expect in each area.)	**A**	**B**	**C**
Based on depth of water table, which would be the best site?	**A**	**B**	**C**

Hypothesis: Using initial observations and how you answered the questions above, which area do you think would be the most ideal place to build a landfill. (Which area did you circle the most in the previous question?) Write your hypothesis below:

Observations and Measurements:

Topography – To the right is a figure showing a generalized cross section of a groundwater system in relationship to topography. Draw and label where you think sites A, B, and C would be on this generalized figure.



Observations and Measurements (continued):

Proximity to surface and groundwater resources – First, you need to determine how close your proposed landfill area is to surface water resources. In all three cases, the landfills are near a stream. Fill out the table:

Area	Distance to stream* (ft)	Stream order
A		
B		
C		

* Find the closest stream. Measure the shortest downslope distance from the edge of the proposed site to the stream.

What does this tell you about possible runoff from the landfill? (If it rained, how quickly do you think runoff contaminated with leachate would get to the nearby stream?)

Second, you need to determine the *hydraulic gradient* or the direction in which groundwater will move. For the map with site A (page 10, top), *draw* in the missing 490 and 480 feet water table contours. For the map with sites B and C (page 10, bottom), *draw* the missing 670 and 680 feet water table contours. Just like at the surface, water moves down gradient in the most direct way possible. This means that water will move in a direction perpendicular to the water table contours. *Draw* an arrow showing the movement of water from the red stars to the streams. This is the direction in which groundwater flows.

In terms of volume of water being transported in the stream, why do you think it is important to consider stream order?

Type of soil and rock – Look at the soil textures for the provided sample of the overlying soils. You may need to refer back to your soil lab. Based on the soil textures, which has the highest hydraulic conductivity? Which has the lowest?

Area	Soil Texture (description)	Relative hydraulic conductivity (high/medium/low)
A		
B		
C		

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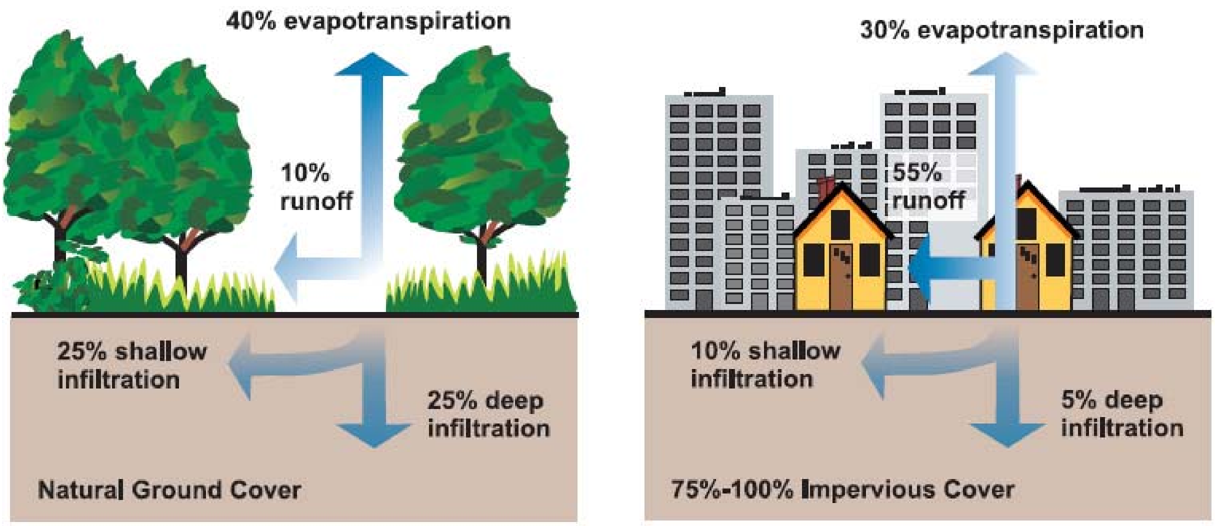
Type of soil and rock (continued) – Look at the figure below that shows runoff and infiltration behavior for two different landuse areas. What doesn't runoff has the potential to be absorbed into the ground and become groundwater. The figure shows how water at the surface can move from the surface, through the *zone of aeration*, to the *zone of saturation*. Areas A and C are low sloped agricultural areas. Area B would be a forested area.



Based on your observations and knowledge of how water moves from the surface to the underlying soil and rock layers, which area would be at the lowest risk for groundwater contamination by leachate? Explain.

Type of soil and rock (continued) – Look at the provided sample of the underlying rock type. Make some observations. Describe each.

Area	Rock Description	Porosity and Permeability (high/medium/low)
A		
B		
C		

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Now, you will measure the porosity. Porosity is the percent by volume of pore space.

Practice: Fill out the table by completing the calculations.

Question Set 2: Calculating Porosity

The easiest way to measure porosity is to saturate a sample with water. The amount of water that the material will hold when it is saturated is a measure of the volume of the pore space. The table below gives volumes of samples of different Earth materials and examples of the pore space for each.

Determine the percent porosity for each sample in the space provided.

Type of Material	Volume of Sample (cm3)	Volume of Pore Space (cm3)	Porosity (%)
i. Gravel	500	210	
ii. Medium-grained sand	600	270	
iii. Poorly cemented sandstone	650	163	
iv. Well-cemented sandstone	800	40	
v. Clay	825	404	
vi. Shale	435	57	
vii. Limestone	950	123	
viii. Unfractured granite	500	5	
ix. Fractured granite	700	35	

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Second, we need to determine the porosity of your actual samples. Obtain the three samples, a beaker, and a graduated cylinder. Follow the instructions:

(1) Fill the beaker up to 250 mL with your underlying rock sample.
(2) Fill the graduated cylinder with exactly 200 mL of water.
(3) Carefully pour water from the graduated cylinder into the beaker until all of the pour space is filled with water and water just reaches the 250 mL line on the beaker.
(4) Determine the amount of water you poured into the beaker by subtracting the amount you have now from the original amount of 200 mL.
(5) Fill out the table and calculate the porosity.

Area	Rock Volume (mL or cm^3)	Volume of Water (mL or cm^3)	Porosity (%)
A	250		
B	250		
C	250		

Depth of water table – Fill out the table below. The elevations of the areas are found on page one in the table describing each area.

Area	Elevation (ft)	Water Table Elevation (ft)	Depth of Water Table (ft)
A			
B			
C			

Look at the figure on the next page, showing how a sanitary landfill is built. Label the Zone of Aeration (Vadose Zone) and the Zone of Saturation (groundwater). Looking at the data you have regarding the depth of the water table, which area would allow you to build the deepest landfill? Explain.

Now think about the type of soil and rock that the area has. Which area would pose the lowest risk of groundwater contamination with leachate? Explain.

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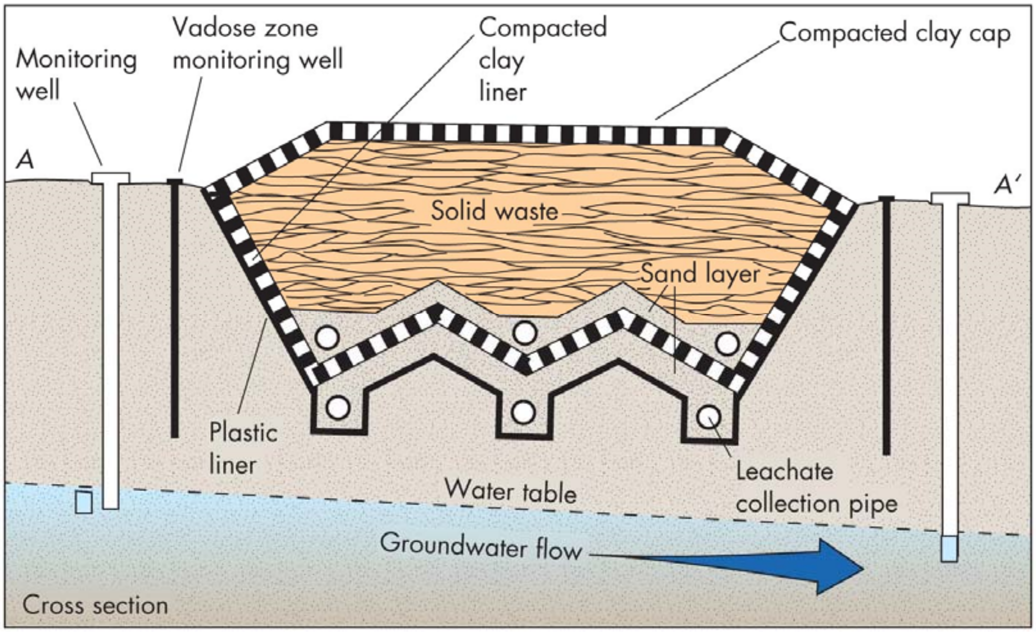

Summary and Conclusion: Given what you have learned about your sites, re-evaluate your original answers. Provide explanations if necessary.

Based on topography, which would be the best site? Explanation:	**A**	**B**	**C**
Based on proximity to surface and groundwater resources, which would be the best site? Explanation:	**A**	**B**	**C**
Based on the amount of precipitation, which would be the best site? Explanation:	**A**	**B**	**C**
Based on overlying soil type, which would be the best site? (Think about how soils form. What type of soil would you expect in each area?) Explanation:	**A**	**B**	**C**
Based on underlying bedrock type, which would be the best site? (Think about what type of rocks you would expect in each area.) Explanation:	**A**	**B**	**C**
Based on depth of water table, which would be the best site? Explanation:	**A**	**B**	**C**

Given your observations and measurements, would you accept or reject your hypothesis? (Circle one.)

ACCEPT REJECT

Historical contamination of groundwater resources from case histories like Love Canal, New York, and the South Side Landfill, Indianapolis, Indiana, have shown that preventing the leachate from escaping the landfill area is the best way to protect groundwater resources. When recommending this area, would you have any specific concerns? Explain.

Reflection and Learning: *Environmental Unity* is the idea that all Earth spheres are connected. The atmosphere, biosphere, hydrosphere, and lithosphere are all connected and you cannot affect one without affecting all of the others (which then again affects all others). Why is it important to understand the concept of *Environmental Unity* when deciding where to build a landfill and how it should be built? (Hint: Landfills are built in the lithosphere. What other Earth spheres are affected and how?)

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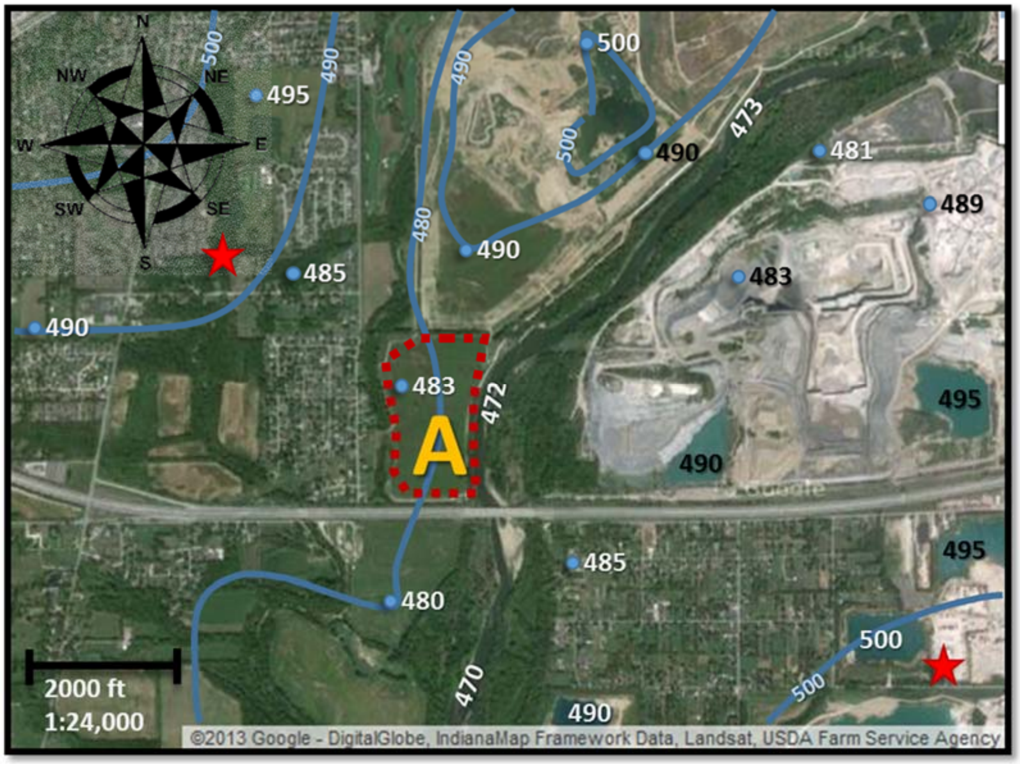

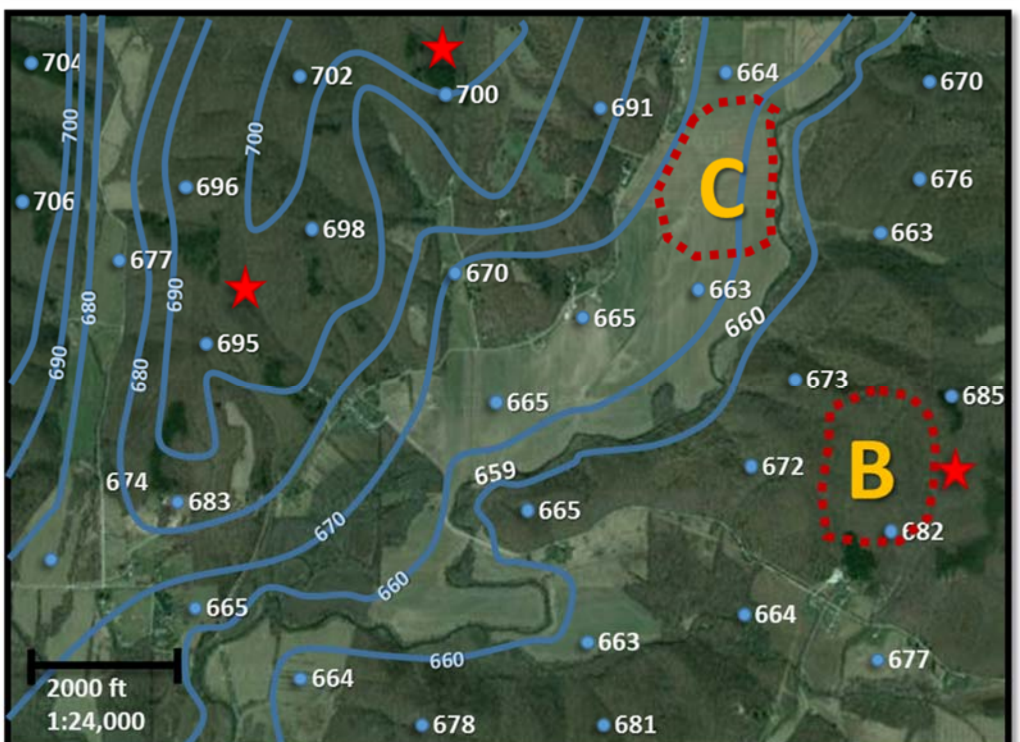

Maps: Each area denoted by dashed red lines is approximately 100 acres. Blue lines are water table contours. Dots show the water table depth at a well or open water.