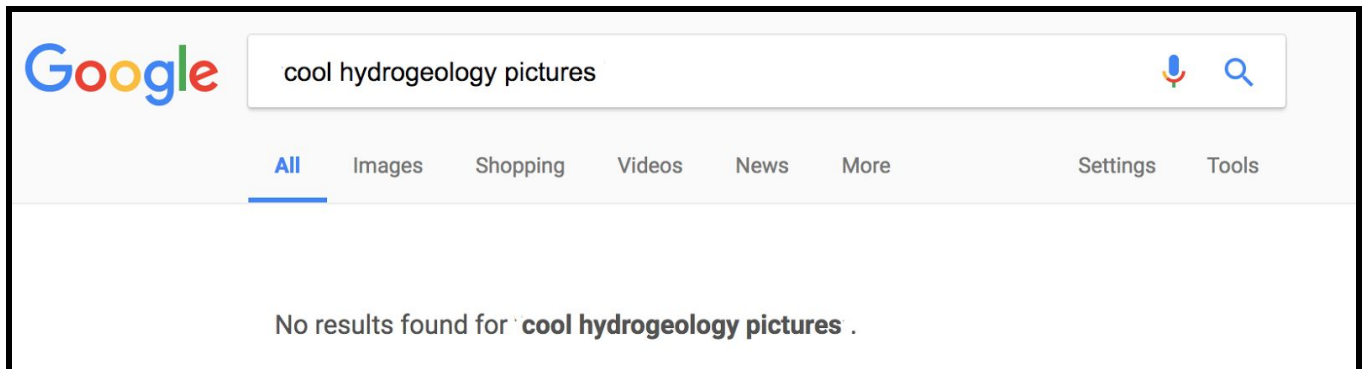




# Hydrogeology

Princeton University Science Olympiad  
Invitational Tournament

February 4, 2017



Team Name: \_\_\_\_\_

Team Number: \_\_\_\_\_

Part 1: / 59

Part 2: / 26

Part 3: / 115

Total: / 200

**WRITE ALL ANSWERS ON THE ANSWER SHEET  
ONLY THE ANSWER SHEET WILL BE GRADED**

**Part 1: Aquifers and Wells (59 pts)**

1) (1 pt each) Identify the terms that correspond with the following definitions:

- a) Liquids that dissolve substances in the soil and carry them as they percolate through the soil
- b) Groundwater flow from an aquifer to a surface water source (such as a stream or lake)
- c) Treated wastewater that can be used for other beneficial purposes (e.g. irrigation)
- d) An aquifer that supplies 50% or more of the drinking water in an area

2) (2 pts each) Define the following terms:

- a) Groundwater Divide
- b) Cone of Depression
- c) Watershed
- d) Monitoring Well

3) (2 pts) Describe the difference between Porosity and Permeability

4) (1 pt each) Classify each of the following Hydraulic Conductivity constants (in m/s) as characteristic of an aquifer, aquiclude, or aquitard:

- a)  $K = 1$
- b)  $K = 0.001$
- c)  $K = 0.0000001$
- d)  $K = 0.0000000001$

5) (2 pts) Describe how the grain size of a material determines if it will be an aquifer or aquitard

6) (4 pts) (tiebreaker) Describe the difference between the Piezometric Surface and the Water Table

7) (2 pts each) Match each of the following four terms with their correct description:

**Field Capacity**

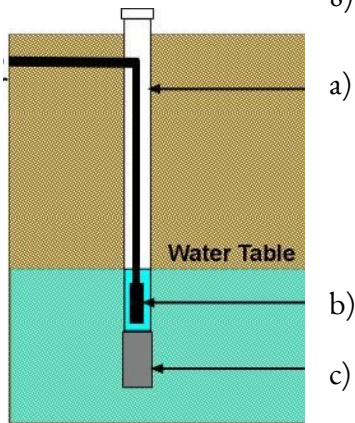
**Available Water Capacity**

**Total Soil Water Capacity**

**Drainable Porosity**

- a) May be expressed as the sum of two other values in the above list
- b) Represents the amount of water that may be extracted by plants
- c) Measured 2-3 days after precipitation with a standard hydraulic head
- d) May also be called Specific Yield

8) (1 pt each) Name these three parts of a well:



(Source: groundwater.org)

9) (1 pt each) Identify if each of the following factors will INCREASE or DECREASE the amount of groundwater recharge

- a) Increased Precipitation
- b) Dense Vegetation
- c) Urban Environment
- d) Hills and Valleys

10) (3 pts) Describe a recharge well and describe how it affects groundwater recharge

11) (1 pt each) Identify the type of well that fits each of the following descriptions

- a) A well that transports water to deeper soil layers
- b) A vertical well that has water flowing out of the top
- c) A well that collects storm runoff
- d) A well that disposes of wastewater

12) (8 pts) (tiebreaker) The hydraulic head of a 1 square meter section of an aquifer is reduced by 1 meter. As a result, 1 liter of water is released from the aquifer. The effective porosity of the aquifer is 0.1.

- a) (3 pts) What is the storativity of the aquifer?
- b) (3 pts) What is the upper limit of the storativity for this aquifer?
- c) (2 pts) What type of aquifer is this?

13) (1 pt each) Identify the geographic location of the following aquifers

- a) Ogallala Aquifer
- b) Great Artesian Basin
- c) McMurray Formation
- d) Guarani Aquifer
- e) Edwards Aquifer

## Part 2: Hydrogeology Challenge (26 pts)

The following is the link the Hydrogeology Challenge.

Pick Wells A, B, and D, with wells A and D pumping, and complete all the steps.

Submit your answer with the following information:

Name: [Insert your Team's name]

Location: Princeton 2017

<http://groundwater.beehere.net/#test/aoea73ff-f612-4b84-b00a-655f4e076e71>

**Part 3: Groundwater Use and Remediation (115 pts)**

14) (2 pts each) Classify the contaminant that is likely to come from each of the following contamination sources as one of the following:

**VOCs      SVOCs      Petroleum Byproducts      Inorganics      Explosives      Pathogens**

- a) Leaking underground tank of BTEX
- b) Agricultural Field w/ Pesticides
- c) Faulty septic tank
- d) Industrial Solvent Plant leaking Freon-11
- e) Factory producing RDX
- f) Car batteries in landfills

15) (1 pt each) Identify each of the following contaminants as a DNAPL or an LNAPL:

- a) Diesel
- b) Trichloroethylene
- c) Chloroform
- d) Coal Tar

16) (4 pts) Are DNAPLs or LNAPLs more expensive to remove from groundwater? Justify your answer.

An industrial factory situated at Well A building fluorescent lights spills PCBs (Polychlorinated Biphenyls), contaminating the well. Wells A and D are pumping. Answer the following questions about possible remediation solutions:

17) (3 pts) List all of the wells (including Well A) that are at risk of being affected by the spill

18) (5 pts) (tiebreaker) Well B begins pumping. Would its risk change, and if so, how? Justify your answer.

19) (5 pts) Identify the material, hydraulic conductivity, and porosity (with proper units) present at the water table under Well A while pumping.

(Note: If you need a fresh well map from the Hydrogeology Challenge for Part 3, use the Part 2 link in a fresh tab to reload the page.)

20) (20 pts) Complete the following remediation table on your answer sheet:

Technique	In-situ/Ex-situ (Or both)	Type (Bio, Chem, Physical)	Cost (Low, Med, High)	Applicable to Contaminant?
Air Stripping (without Pumping)				
Activated Carbon Treatment (w/ Pumping)				
Phytoremediation				
Reduction/Oxidation				
Incineration				

(Note: A technique can be both In-situ and Ex-situ)

21) (3 pts each) Describe each of the five remediation techniques

- a) Air Stripping
- b) Activated Carbon Treatment
- c) Phytoremediation
- d) Reduction / Oxidation
- e) Bioremediation

22) (11 pts) (tiebreaker) Permeable Reactive Barriers (PRBs) are placed around Well A to remediate the spill.

- a) (4 pts) Describe where (with respect to Well A) these barriers should be placed to maximize their effectiveness. Justify your choice of location.
- b) (4 pts) If Well A were to cease pumping, how would the rate of remediation be affected? Justify your answer.
- c) (3 pts) Many Permeable Reactive Barriers use Iron as their active material. Briefly describe how Iron may be used to remediate the spilled PCBs.

23) (3 pts each) Describe each of these remediation techniques

- a) Bioslurping
- b) Electrokinetic Separation
- c) Thermal Desorption
- d) Rhizofiltration

24) (2 pts) Around how many gallons of water does the average American use per day?

- a) 40 gallons
- b) 60 gallons
- c) 90 gallons
- d) 130 gallons

25) (2 pts each) Groundwater in the United States is used for a variety of purposes. Order the following four uses in decreasing order of the volume of groundwater used for that purpose.

(1 = uses the most groundwater, 4 = uses the least groundwater)

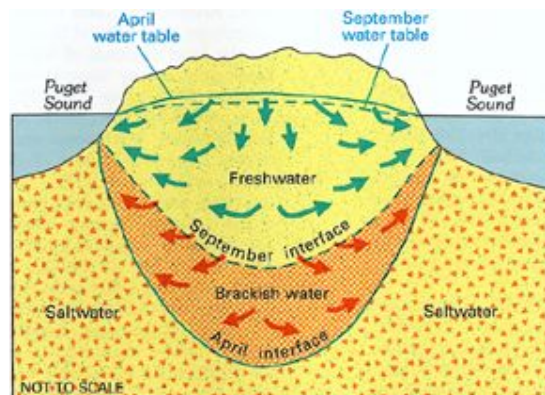
- a) Industrial Usage
- b) Drinking Water
- c) Livestock
- d) Irrigation

26) (8 pts) (tiebreaker) Oxygen-18 is a tool commonly used to analyze the groundwater recharge and movement.

a) (4 pts) Two soil samples from two different regions are tested for Oxygen-18 presence. The sample from Region A has a significantly higher concentration of Oxygen-18 than Region B. Describe the difference in precipitation between the two regions, and justify your answer.

b) (4 pts) Using Oxygen-18 to track levels of groundwater recharge is more accurate in some environments than others. Describe the type of region and climate in which using Oxygen-18 to model groundwater recharge is most effective. Justify your answer.

27) (6 pts) (tiebreaker) The following is a diagram of the groundwater underneath Puget Sound, Washington:



(Source: U.S. Geologic Survey)

Explain why the freshwater-saltwater interface changes between April and September.