

# Analyzing Groundwater

**SUBJECT:** Science

**GRADE:** 7<sup>th</sup>

**DURATION:** approximately two 60-minute periods

**ACTIVITY SUMMARY:** Students will compare the properties of different soil types including texture and particle size and the amount of time it takes for water to move through the different soil types. Students will relate the filtration rates to pollution and learn about aquifers and the impact humans can have on them.

**OBJECTIVES:**

Students will be able to:

1. Analyze different types of soil.
2. Model and describe the impact humans have on groundwater and surface water.

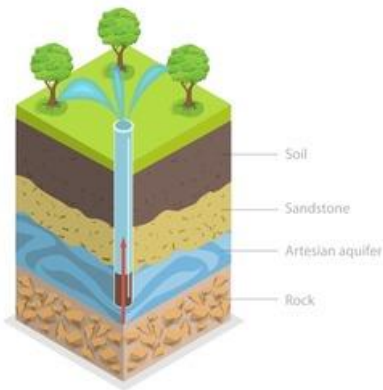
**MATERIALS REQUIRED:** (PER GROUP)

**Part 1:** four large paper (or plastic) cups, 1 cup gravel, 1 cup sand, 1 cup topsoil, 1 cup clay soil, shallow pan, food coloring, magnifying lens, quart of water, stopwatch, container of water, graduated cylinder

**Part 2:** one large soda bottle with the bottom cut off, rock and sand, measuring cup, 2 small pieces of cheesecloth or pantyhose, pump (like a hand lotion pump), container of water, glass or cup, additional cup of sand and gravel

**BACKGROUND:**

Groundwater is one of the Earth’s most valuable natural resources. Many people think of groundwater as underground lakes or streams. These primarily exist where an area is underlain by cavernous limestone or lava tubes. Most groundwater is simply water below the land surface that is filling all the spaces between rock grains or in the cracks and crevices in the rock. The boundary between the soil surface and the area where the groundwater saturates spaces between sediments and cracks in rocks is called the water table. Groundwater is brought from the earth as well water.



The word aquifer is used to describe the location of groundwater. An aquifer is an underground formation that stores and transmits water. Aquifers come in all shapes and sizes. Some may cover hundreds of miles while others may cover only a few square miles. Some areas may contain several aquifers located at different depths. The water quality and quantity in aquifers vary. The city of San Antonio gets its water from the Edward’s Aquifer (named for the type of limestone the aquifer is formed in). Natural Bridge Caverns is part of the Glen Rose or Trinity aquifer system.

How groundwater moves varies based on the rock material in the geologic formation where the water is located. Gravity and the pressure of overlying water cause the water to move. The water moves from a recharge area (where rain, streams, lakes, or karst areas carry it into the ground) to a discharge area (where the water leaves the ground via springs, lakes, streams, etc.).

Groundwater moves toward the areas of least resistance.

Karst is a geologic term that describes a special area with unique concerns. Karst areas are noted for their abundance of relatively pure layers of limestone rock. These limestone layers are protected by a cap rock that can repel water and protect the more soluble underlying limestone layers. This cap rock must be thick enough to prevent water from reaching and dissolving all the softer limestone layers but must be thin enough to form cracks and fissures as the earth’s crust shifts and moves.

When specialists analyze the quality of groundwater, they consider land-use practices in the watershed (an area of land that catches rain and snow and drains or seeps into a marsh, stream, river, lake or groundwater). If pollution, such as hazardous waste, chemicals, heavy metals, etc. collect on the surface, rain or runoff can carry these substances into the groundwater.

All land use can dramatically affect an area. This is particularly true in a karst area where an abundance of sinkholes can funnel not only surface water but also all types of pollution into the groundwater. A rainstorm within a karst region can swiftly wash soils, agricultural chemicals (fertilizers, insecticides, etc.), oil and gas from roads and railways, animal wastes from farms, and sewage from poorly performing sewer/septic systems into the underlying water table. On the way to its outlet, this underground water can be intercepted by residential wells where the water is collected and consumed without any filtration or cleansing. In a karst area, rainwater is often available for re-use within a matter of hours.

In a non-karst area, the same types of pollution can also be carried by surface streams to the controlling waterways, but water that seeps underground does not have the benefit of caves and cracks to speed it along. In a non-karst area, water molecules must seep around the particles making up the soil and solid rock on its way to an underground stream or aquifer. In a non-karst area, this groundwater becomes naturally filtered and emerges in a cleansed state. It takes a long time for water to travel through solid rock layers and it is not unusual for groundwater to take 300 years or more to reach the water table. In a karst area, groundwater movement is much faster and measured in miles per hour, compared to a non-karst area where groundwater movement is measured in centimeters per year!



The Glen Rose Aquifer rising into Natural Bridge Caverns.

## PROCEDURE:

### Part 1

1. Discuss various rock and soil types found in the ground above the water table. Some examples include sand, silt, clay, gravel, limestone, sandstone, and granite. Ask students if they think it is easy for water to reach the water table. Have them predict which of the soil types will be the fastest and slowest for the water to travel through. Students should record their hypothesis on their handout.
2. Students should examine each soil type. They should rub a pinch between their fingers. What do they feel like? What do they smell like? Which has the largest particle size? Which has the smallest? Students should record their observations for each type in the table on their handout. Also have them hypothesize about which soil type would hold more water between the particles. Students should record their hypothesis on their handout.
3. Punch four small holes in each of the plastic cups and fill each plastic cup with one type of soil material.
4. Place about 4 drops of food coloring in a quart jar of water. Place  $\frac{1}{2}$  cup of colored water into the measuring cup.
5. Have one of the students get ready with a stopwatch to time the procedure. Hold one of the cups over the pan and pour  $\frac{1}{4}$  cup of the colored water into the cup. Time how long it takes the first colored water to reach the pan (the pan represents the water table) and record the results in Data Table 2.
6. Measure the amount of water that collected in the pan using a graduated cylinder. Record this information in Data Table 3. Obtain a new soil sample (of the same soil type) and repeat this step once more for trial 2. Average the results for trials 1 and 2.
7. Repeat steps 5 and 6 for all soil types.

Part 2—all groups should be on the same step at the same time with pace controlled by teacher (or it can be done as a demonstration)

8. Using the 2-liter plastic bottle, construct a groundwater model. Cut off the bottom of the bottle. Cover the lid opening of the bottle with cheesecloth or a piece of old pantyhose. Put the lid back on the bottle. This opening will become the bottom of the groundwater model.
9. Discuss wells with the students and have them predict what will happen to their aquifer when they begin to use the pump on their well to draw water from the ground.
10. Put a small piece of cheesecloth or pantyhose on the bottom of the pump tube so it does not suck in soil or sand. Tape the pump to the side of the bottle so the pump is above and pointing out of the cut end of the bottle. Fill the soda bottle one-half full of small gravel and pour sand on top of that.
11. Have a student fill the bottle about half full of water. Have the students locate the top of the aquifer or water table.
12. Have a student begin pumping water from the aquifer into a glass. At certain intervals, have the students locate the top of the water table. Note the changes. Discuss the reasons.
13. How does the water get back into the well after it has been pumped up? (*rain, snowmelt, surface water returning to the soil, water can seep in from other aquifers, etc.*) Discuss recharge.

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14. Discuss that the water table is not level, so all wells will not be at the same depth even if they are close to each other. The water table will mimic the surface above, having hills and valleys. Water can dip where the land above does, or it can dip where a well has been pumping water out. In the experiment with the pump, as water was pumped out, the water level dropped. Water drops more rapidly near the well than away from it. Often the replacement water cannot return as quickly as water is being taken out. Most rainfall is evaporated or used by plants, some goes into rivers or streams and only about 1% of water returns to the water table directly.
  15. Have students guess, thinking of their own homes, how far a well should be from the following: septic tank, livestock yards, silos, septic leach fields, petroleum tanks, manure storage, pesticide and fertilizer storage handling. Soil is a filter, but it can only clean so much. After the students have made their guesses, tell them a well should be at least 25 feet from a septic tank; 50 feet from a livestock yard, silos, and septic leach fields; 100 feet from petroleum tanks, manure storage, pesticide and fertilizer storage and handling; 250 feet from manure piles. If a well is not carefully placed or is misused, anything from the surface can get directly into the water supply without ever passing through the ground.
  16. Students should then answer the analysis questions working individually, in small groups, or as a class discussion.

**EVALUATION:** Students can be evaluated through the answers to the Analysis and Application questions.

**RESOURCES:**

[Water Tables and Aquifers \(nationalgeographic.org\)](https://www.nationalgeographic.org/learn/science/earth-science/water-tables-and-aquifers/)

[Well Basics - What is a Well? - Well Water Testing – The Groundwater Foundation](https://www.groundwaterfoundation.org/groundwater-basics-what-is-a-well/)

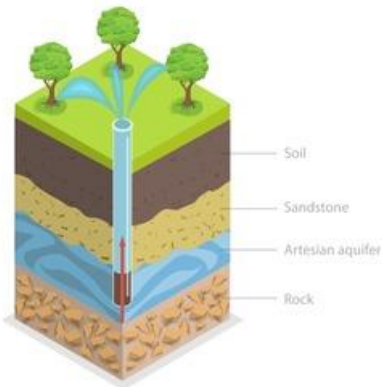
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Name: \_\_\_\_\_

# ANALYZING GROUNDWATER

## BACKGROUND:

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In a non-karst area, the same types of pollution can also be carried by surface streams to the controlling waterways, but water that seeps underground does not have the benefit of caves and cracks to speed it along. In a non-karst area, water molecules must seep around the particles making up the soil and solid rock on its way to an underground stream or aquifer. In a non-karst area, this groundwater becomes naturally filtered and emerges in a cleansed state. It takes a long time for water to travel through solid rock layers and it is not unusual for groundwater to take 300 years or more to reach the water table. In a karst area, groundwater movement is much faster and measured in miles per hour, compared to a non-karst area where groundwater movement is measured in centimeters per year!



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## Procedure

### Part 1

1. Predict which of the soil types will be the fastest and slowest for the water to travel through.  
Hypothesis: \_\_\_\_\_
2. Examine each soil type. Rub a pinch between your fingers. What does the soil feel like? What does the soil smell like? Which has the largest particle size? Which has the smallest? Record your observations for the characteristics of each type in Data Table 1. Hypothesize which soil type would hold more water between the particles: \_\_\_\_\_
3. Punch four small holes in each of the plastic cups and fill each plastic cup with one type of soil material.
4. Place about 4 drops of food coloring in a quart jar of water. Place  $\frac{1}{2}$  cup of colored water into the measuring cup.
5. One student should get ready with a stopwatch to time the procedure. Hold one of the cups over the pan and pour  $\frac{1}{4}$  cup of the colored water into the cup. Time how long it takes the first colored water to reach the pan (the pan represents the water table) and record the results in Data Table 2.
6. Measure the amount of water that is collected in the pan using a graduated cylinder. Record this information in Data Table 3. Obtain a new, dry soil sample (of the same soil type) and repeat this step once more for trial 2. Average the results for trials 1 and 2.
7. Repeat steps 5 and 6 for all soil types.

### Part 2—***STOP and wait for your teacher!!!***

1. Using the 2-liter plastic bottle, construct a groundwater model. Cut off the bottom of the bottle. Cover the lid opening of the bottle with cheesecloth or a piece of old pantyhose. Put the lid back on the bottle. This opening will become the bottom of the groundwater model.
  2. Put a small piece of cheesecloth or pantyhose on the bottom of the pump tube so it does not suck in soil or sand. Tape the pump to the side of the bottle so the pump is above and pointing out of the cut end of the bottle. Fill the soda bottle one-half full of small gravel and pour sand on top of that.
  3. Fill the bottle about half full of water. Locate the top of the aquifer or water table.
  4. Begin pumping water from the aquifer into a glass. At different intervals, locate the top of the water table. Note the changes.
  5. Answer the analysis and application questions.
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Data Table 1

Rock/soil type	Observations (Feel, Smell, large or small particles)
Gravel	
Sand	
Topsoil	
Clay soil	

Data Table 2

Rock/soil type	Time (sec) Trial 1	Time (sec) Trial 2	Average
Gravel			
Sand			
Topsoil			
Clay soil			

Data Table 3

Rock/soil type	Amount of water (mL) Trial 1	Amount of water (mL) Trial 2	Average
Gravel			
Sand			
Topsoil			
Clay soil			

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**Analysis Questions:**

1. Which rock/soil type took the longest for water to flow through? Why? Was your hypothesis correct?
2. Which type of soil returned the most water to the pan? Why?
3. What would happen to the amount of time it took the water to reach the water table if it were to intercept a cave?
4. Explain how the soil layers can clean the water.
5. Which soil type would be most efficient at cleaning water?
6. What events at the surface could cause the water to need to be cleaned?
7. Describe what can happen if the contaminants get into a cave.

**Application and Critical Thinking Questions****Part 1**

Recharge rates of water tables depend on the amount and rate of water moving through the subsurface, soil, and rocks beneath.

1. Which is better—a fast rate of recharge or a slow one? Why?
  2. Would water be more contaminated with faster or slower recharge? Explain why.
  3. What is the benefit of having a slower recharge rate? A faster one?
  4. What concerns could the above issues raise for a community (such as San Antonio) that relies on an aquifer for its drinking water?
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## Part 2

1. Imagine you are in a farming community. Will irrigation have an effect on your well? What about the use of fertilizers or pesticides? Would a drought affect your water supply? Will other wells from the surrounding area (farms or cities) impact your water supply?
  2. Will local industrial practices affect your water quality? What about dumping oil into the ground or dumping chemicals into nearby rivers? What effect would dumping wastes directly into old wells or sinkholes have?
  3. What are some of the problems with getting water from a well? What is the cost of installing a well?
  4. If two wells were placed close together, could this cause a problem? What if one of the wells was contaminated? Wells generally have casings, like a straw around your pump tube, which would not allow water from another aquifer to travel down the hole for your pump and pollute the new well or aquifer. However, if these casings don't go down far enough, polluted water can enter your new aquifer. State laws vary on how deep these casings must be. What if the length the law requires is not far enough to protect your well? Considering all these factors, how would you decide where the best place is to put your well?
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**TEKS ADDRESSED:****7<sup>th</sup> Grade Science**

**1(A)** ask questions and define problems based on observations or information from text, phenomena, models, or investigations

**1(B)** use scientific practices to plan and conduct descriptive, comparative, and experimental investigations and use engineering practices to design solutions to problems

**1(C)** use appropriate safety equipment and practices during laboratory, classroom, and field investigations as outlined in Texas Education Agency-approved safety standards

**1(D)** use appropriate tools such as graduated cylinders, metric rulers, periodic tables, balances, scales, thermometers, temperature probes, laboratory ware, timing devices, pH indicators, hot plates, models, microscopes, slides, life science models, petri dishes, dissecting kits, magnets, spring scales or force sensors, tools that model wave behavior, satellite images, hand lenses, and lab notebooks or journals

**1(E)** collect quantitative data using the International System of Units (SI) and qualitative data as evidence

**1(F)** construct appropriate tables, graphs, maps, and charts using repeated trials and means to organize data

**1(G)** develop and use models to represent phenomena, systems, processes, or solutions to engineering problems

**2(A)** identify advantages and limitations of models such as their size, properties, and materials

**2(B)** analyze data by identifying any significant descriptive statistical features, patterns, sources of error, or limitations

**2(C)** use mathematical calculations to assess quantitative relationships in data

**5(A)** identify and apply patterns to understand and connect scientific phenomena or to design solutions

**5(B)** identify and investigate cause-and-effect relationships to explain scientific phenomena or analyze problems

**5(C)** analyze how differences in scale, proportion, or quantity affect a system's structure or performance

**11(A)** analyze the beneficial and harmful influences of human activity on groundwater and surface water in a watershed