10. The Supply and Demand of Groundwater

Overview and Purpose

To introduce students to the impact that land development, e.g., residential and commercial, can have on the naturally available groundwater in an area.

Lesson Summary

Students will investigate solutions to groundwater shortage and be introduced to the story of Ottawa County, MI where a water shortage caused such water scarcity that taps ran dry for residents.

The purpose of introducing this context is for students to understand how supply and demand for groundwater affects a community and can impact other above-the-surface bodies of water in an area such as the Great Lakes region. They will get a sense of how important groundwater is to residents and business owners, as well as how much we depend on groundwater in various areas.

Students will engage in a series of activities, from Great Lakes Now and the US Geological Survey to understand the importance and vulnerabilities of groundwater. They will watch the story of Ottawa County, MI and their groundwater crisis. They will take a groundwater trivia quiz, experience a groundwater simulation, and analyze statistics from the Michigan Department of Environmental Quality on groundwater availability. They will finish the lesson by researching, evaluating, and discussing potential solutions to the groundwater shortage problem depicted in the video.

The background context that students should have is a basic understanding of the layers of earth directly below the surface as they relate to groundwater, as well as a knowledge of the principle of supply and demand.

ESSENTIAL THEMES	● Groundwater ● The impact of community development on groundwater ● Supply and demand

NEXT GENERATION SCIENCE STANDARDS	➔ MS-ESS3-2: Analyze and interpret data on natural hazards to forecast future catastrophic events and inform the development of technologies to mitigate their effects. ➔ HS-ESS3.1: Construct an explanation based on evidence for how availability of natural resources, occurrence of natural hazards and changes in climate have influenced human activity. ➔ MS-ESS3-1 Construct a scientific explanation based on evidence for how the uneven distribution of Earth's mineral, energy, and groundwater resources are the result of past and current geoscience processes. ➔ SEP4: Analyze and interpret data to provide evidence for phenomena. ➔ MS-ESS2-2: Construct an explanation based on evidence for how geoscience processes have changed Earth's surface at varying time and spatial scales. ➔ HS-ESS2.A.4: The geological record shows that changes to global and regional climate can be caused by interactions among changes in the sun's energy output or Earth's orbit, tectonic events, ocean circulation, volcanic activity, glaciers, vegetation, and human activities. These changes can occur on a variety of time scales from sudden (e.g., volcanic ash clouds) to intermediate (ice ages) to very long-term tectonic cycles. ➔ SEP8: Integrate qualitative and/or quantitative scientific and/or technical information in written text with that contained in media and visual displays to clarify claims and findings. ➔ SEP3: Develop and/or use a model to predict and/or describe phenomena.
OBJECTIVES	❑ Know the impact that humans can have on naturally occurring resources, such as ground water ❑ Understand how groundwater accumulates ❑ Create a written argument, in claim-evidence-reasoning format, to support the selection of potential solutions to an environmental problem
ESTIMATED TIME	❖ **3 class periods**

Materials Needed

- Video projection monitor or screen/speakers
- Internet access
- Notebooks and pencils
- Sponges
- Plastic wrap
- Dissection trays
- 100mL graduated cylinders

Facilitation Steps

WARM UP: Begin by asking students what they already know about the essential themes of the lesson and what they wonder about it. Have them turn and talk with a shoulder partner. Then, after a minute of conversation, elicit responses from a couple of volunteers and jot down 2-3 ideas on the board under the categories KNOW and WONDER. The teacher should help students clarify their ideas as they are shared by checking for understanding using a talk move such as "so you are saying..." or help students think together by asking for a show of hands of agreement from the class in response to what individual students share.

LAUNCH: Once the warm up has concluded, give a brief overview of the background context to students, making connections to their KNOW and WONDER responses as well as any other relevant prior knowledge they would have from other lessons they have learned. Describe the activities planned for this lesson to students.

ACTIVITY 1: Groundwater Basics

First, have students take the groundwater true/false quiz from USGS to assess their prior knowledge. You can have students take the quiz individually, with a partner to discuss, or you can go through the questions one-by-one with the whole class and have them respond by a vote of hands for each question. The answers at the end provide short explanations that can be helpful talking points to give students more background context.

Next, show the groundwater diagram from the USGS and have a volunteer read the paragraph description, which explains groundwater, to the class.

Then, do this sponge demonstration from the USGS for your class, or have students do the demonstration in a group of four students to model what happens in the earth to accumulate groundwater:

1. Get two sponges and lay one on top of the other in a dissection tray.
2. Pour water (precipitation) on top from the graduated cylinder and let it seep through the top sponge downward into the bottom sponge. If you stopped adding water, the top sponge would dry up and, as the water dripped out of the bottom sponge, it would dry up too.
3. Now, put a piece of plastic wrap between the sponges, creating your "confining layer" (making the bottom sponge an impermeable rock layer that is too dense to allow water to flow through it).
4. Now when you pour water on the top sponge, the water will seep downward until it hits the plastic wrap. The top sponge will become saturated, and when the water hits the plastic wrap it won't be able to seep into the second sponge. Instead, it will start flowing sideways and come out at the edges of the sponge (horizontal flow of groundwater). This happens inside the earth all the time -- and it is an important part of the water cycle.

Last, show the animation of groundwater video from PBS LearningMedia to the class. After the animation is complete. Do the quiz How Much Do You Know About Groundwater from PBS LearningMedia with the entire class, having groups nominate a reporter to raise their hand to volunteer answers to each question, after they confer with their group, as you go through them with the whole class.

ACTIVITY 2: The Day When the Drinking Water Ran Out

First, explain to students that they are going to be viewing an introductory video about a community that faces water shortage near the southeastern region of Lake Michigan. This video will provide some basic information to them and address some of their WONDERS from the warm up. Introduce students to the 4 Notes Summary protocol that they will use after the video is complete, where they write one of each of the following:

- Oooh! (something that was interesting)
- Aaah! (something that was an ah-ha moment)
- Hmmm... (something that left them thinking afterward)
- Huh? (a question they have afterward)

Ask students to give an example of each type of note that they will be making to check for understanding.

Next, have a volunteer read the introductory overview from the Out of Water article about the water shortage in Ottawa County, MI to the class before you show the video Out of Water from Great Lakes Now to the whole class. Follow up after the video by having students record in their notebooks a 4 Notes Summary.

Then, distribute copies of, or direct students to view online, the article from the Michigan Department of Environmental Quality about groundwater statistics in the state. Have students read over the statistics and do a turn-and-talk with a classmate to discuss how they relate to what they saw in the video.

Last, have students form a group of four to discuss their takeaways from the video using the Conversation Roundtable protocol. In this protocol, students take turns sharing what they wrote for their individual responses to the 4 Notes Summary with their group while each student writes down what they heard the speaker say. Then, each student writes their own "sum it up" statement of their group members' responses. After the Conversation Roundtable, have a whole-class share out. Choose a few students to each share their summaries from their group discussion aloud with the whole class. After each, ask students to raise hands if what was just shared matches something that came up in their group discussion as well.

ACTIVITY 3: Workable Water Conservation Solutions

First, students should stay with their Conversation Roundtable groups from the previous activity to work on this activity. Explain to them that they will be researching potential solutions to the groundwater shortage depicted in the video. Their task will be to identify what they think are the top three most workable solutions to the problem of the groundwater shortage that Ottawa County faces due to rapid development. Have students volunteer to share ideas for a solution with the whole class, as the teacher writes down their ideas in a list on the board. Take ideas until about five different suggestions have been given. Afterward, depending on student responses, ask them "what about…?" for any unmentioned ideas from the following list of possibilities and add them to the list for them to consider with their group. The class list should include at least:

- Zeroscapes (e.g., rock gardens instead of grass like they have in the southwestern U.S.)
- Water Restrictions/Allotments/Rations (e.g., property owners are allowed so much water)
- Building Regulations (e.g., limits to how much and what kind of building can take place)
- Reclaiming used water for certain non-drinking purposes (e.g., watering landscaping)
- Man-made lakes/ponds (e.g., to serve as additional reservoirs)
- Categorization and separation of water by type designation (e.g., drinking and non-drinking)
- Water diversion plans (e.g., divert water from outside sources into the area)

Next, instruct students that they will be researching some of the possible solutions and organizing their findings into a claim-evidence-reasoning poster for their top three choices on a chart paper poster or dry erase board. These tables should include the claim they make for each

potential solution, evidence that they found to support their claim, and the reasoning behind their claim. **Teacher tip: alternatively, you could assign groups three possible solutions to research.*

Then, allow students time to research the possible solutions online, discuss their findings and create their posters.

Last, give students the opportunity to present and share their posters with each other in a large circle discussion. In this presentation format, all students should sit in a circle with their posters visible to everyone (e.g., students hold them in front of them in the circle or they all are hung on the wall.) The teacher should facilitate productive academic talk in the discussion so that students identify similarities and differences between their posters, ask for and provide further clarification on their posters, and reach a consensus about what might be the most workable solution.

SYNTHESIS: Give students individual thinking and writing time in their notebooks to synthesize their learning by jotting down their own reflections using a Word, Phrase, Sentence protocol, with:

- A **word** that they thought was most important from the lesson
- A **phrase** that they would like to remember
- A **sentence** that sums up what they learned in the lesson

After the individual synthesis is complete, students should share their synthesis with a shoulder partner.

COOL DOWN: Have students complete a 3, 2, 1 Review protocol for the lesson with a partner, recording in their notebooks or, optionally, on exit ticket slips to submit, the following:

- **3** things that they liked or learned
- **2** things that make more sense now
- **1** question that they were left with

CLOSURE: Have one student share a response from each of the categories of the 3, 2, 1 Review. Depending on the available time, the teacher can make connections between the ideas students share and the learning objectives of the lesson, and respond to the question that is shared.

EXIT TICKET: Students write what solution to the groundwater shortage they think is least workable and explain why.

About the Author

Gary is an educational consultant, award-winning science educator and the author of *Science With Scarlett*. He is also a double cornea transplant recipient who, since having his sight restored, was moved to use his teaching gifts to make science fun for kids. He lives with his family near

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About Great Lakes Now

With a monthly magazine-style television program and daily online reports at GreatLakesNow.org, the ***Great Lakes Now*** initiative offers in-depth coverage of news, issues, events and developments affecting the lakes and the communities that depend on them, while capturing the character and culture of the region.