



Water: An Amazing and Precious Resource

Brenna Holzhauser

INTRODUCTION

In this lesson, students will begin with a water audit pre-lesson to determine their own personal water usage. They will then participate in a class activity to learn how water's physical properties and chemical composition are essential to life on Earth. Once they understand water's importance, they will debate water distribution issues, have an understanding of the consequences of water scarcity, and come up with ways to conserve water in their own lives.

LESSON OVERVIEW

Grade Level & Subject: Grades 9-12: Science and Social Studies

Suggested Length: 2 Class Periods (Class 1: Warm-up through Activity Two, Class 2: Activity Three and Wrap-up)

Objectives:

After completing this lesson, students will be able to:

- Make an assessment of their own personal water usage
- Understand the unique properties of water and why it is important to life on Earth
- Understand how much water is available on Earth and why it is scarce
- Use their critical thinking skills to debate water scarcity in the U.S.
- Come up with ways to conserve water in their own lives

National Standards Addressed:

This lesson addresses the following National Education Standards¹

- **Content Standard:** [NS.9-12.6 Personal and Social Perspectives](#)
As a result of activities in grades 9-12, all students should develop understanding of
 - Personal and community health
 - Population growth
 - National Resources
 - Environmental quality
 - Natural and human-induced hazards
 - Science and technology in local, national, and global challenges
- **Content Standard:** [NSS-G.K-12.3 Physical Systems](#)

¹ <http://www.education-world.com/standards/>

As a result of activities in grades K-12, all students should

- Understand the physical processes that shape the patterns of Earth's surface.
- Understand the characteristics and spatial distribution of ecosystems on Earth's surface.
- **Content Standard: [NSS-G.K-12.5 Environment and Society](#)**
As a result of activities in grades K-12, all students should
 - Understand how human actions modify the physical environment.
 - Understand how physical systems affect human systems.
 - Understand the changes that occur in the meaning, use, distribution, and importance of resources.

Materials Needed:

- Reproducible #1 – **Personal Water Audit**
- Reproducible #2 – **Water Is Amazing!**
- Prize or reward for winning team(s) of **Water Is Amazing!** Game (optional)
- Reproducible #3 - **Energy versus Water: Solving Both Crises Together** article
- Reproducible #4 – **Lakeville vs. the Southwest** (optional)

Assessment: Students will be assessed through the following activities:

- Completion of pre-assignment: **Reproducible #1 – Personal Water Audit.**
- Participation in **Water Is Amazing!** game and ensuing discussion.
- Participation in **Water Distribution in the US** debate.
- Optional: Completion of **Reproducible #4 – Lakeville vs. the Southwest.**

LESSON BACKGROUND

Conversion Information:

- 1 U.S. liquid gallon is equal to 3.785411784 litres/liters
- 1 U.S liquid gallon is equal to 128 fluid ounces
- 1 cubic meter is equal to 264.172052 US gallons
- 1 kilogram is equal to 2.20462262 pounds

Relevant Vocabulary:

- **Specific Heat Index:** A measure of the amount of heat per unit (mass) required to raise the temperature by one degree Celsius.
- **Surface Tension:** The intermolecular forces (attraction of molecules to each other) at the surface of a liquid.
- **Capillary Action:** The intermolecular forces (attraction of molecules to each other) and surface tension of water result in the elevation or depression of water in capillaries; this allows water and its dissolved substances to move through plants' roots and animals' blood vessels
- **Solvent:** A liquid (or gas) capable of dissolving other substances, resulting in a solution. Water is an excellent solvent.

- **Solution:** A homogenous (or evenly mixed) mixture of two or more substances.

Information:

Water is arguably Earth's most precious resource. Unique physical and chemical properties such as high heat index, high surface tension, distinct phase changes, and molecular structure have made water an essential component to all life on Earth. We all use water in various means every single day – life without water would not just be inconvenient, it would be impossible. Despite water's role as the most important resource, it is often unavailable in many areas of the world and is squandered away in places where it exists. Water's distribution - especially fresh or potable water - is very uneven across our planet, and even within the United States. The issues associated with access to water are complex and varied. Because of its unique properties and importance in all aspects of life on Earth, water should be regarded as a precious resource and conservation efforts should be a priority.

Resources:

<http://ga.water.usgs.gov/edu/sc3.html> - US Geological Survey online quiz about water

<http://ga.water.usgs.gov/edu/watercyclehi.html> - USGS Water Cycle Diagram

<http://www.sciam.com/article.cfm?id=the-future-of-fuel> – Scientific American article on water versus energy

<http://www.globalwaternetwork.org/> - Global Water Statistics

http://www.educationworld.com/a_lesson/lesson/lesson304b.shtml - Education World information on running a classroom debate

LESSON STEPS

Warm-up: *Personal Water Audit – Pre-Assignment*

1. To be done as homework the night before the lesson, send students home with **Reproducible #1 – Personal Water Audit**. This will give students insight into their own daily water usage, and will be an indication of how much water is used on a daily basis.

Activity One: *Daily Water Usage - Discussion*

1. Begin by listing a range of student water usage totals (as calculated in their **Personal Water Audit** pre-assignment) on the chalkboard or whiteboard. Guide students in determining the class average of daily water usage (personal domestic use and total daily water use).
2. Lead a discussion of the **Personal Water Audit** results, water use, and availability. Use the following questions and answers as a guide:
 - a) Were you surprised by your daily personal water usage? Did you imagine that you used more or less water each day? How does your personal total differ from the class average?
 - b) How much of your total water was actually *used* and how much was wasted down the drain?
 - c) How much more water do you use than what actually comes from the faucet? How do you think this water is used? (*Remind students that a large majority of water used in the U.S. is in agriculture and industry. For example, it takes thousands of gallons of water to raise a*

cow to make a pound of beef or a carton of milk, and nearly all of their food and drink required water to process. In addition, almost every product they use required water to make, transport, etc.)

- d) What factors affect the totals calculated today?
- e) How would your audit look if you did it on a weekday vs. a weekend? (*Think about washing a car, doing laundry, running the dishwasher, etc.*)
- f) What about summer vs. winter? (*Think about playing with a sprinkler or filling a pool, watering a garden or yard, etc.*)
- g) How do you think your water usage compares to other people in the U.S.? (*Ex: Southwest is very dry, Northwest is very wet, urban vs. rural, poverty levels, etc.*)
- h) How do you think your water usage compares to people in other countries? (*Consider climate, cost, availability, access, etc.*)
- i) Conditions such as drought, pollution, rising population, and unequal distribution of natural resources threaten our water supply, even in the U.S. What might happen if we were faced with extreme water shortages? (*Cost would go up, our usage would have to go down, access would be less reliable, conservation practices would become more common, etc.*)

Activity Two: *Water Is Amazing!* - Game

1. Divide the class into two or more teams.
2. Ask the following True/False Questions of the class.
Questions and Answers:
 - 1) Water dissolves more substances than any other liquid. **True**
 - 2) A water molecule consists of 2 atoms of oxygen and 1 atom of hydrogen. **False**
 - 3) Water has high surface tension, and is one of the more “sticky” liquids. **True**
 - 4) Water is the *only* substance found naturally on Earth in all three states (solid, liquid, and gas). **True**
 - 5) Human blood is composed of 75% water. **False**
 - 6) Water has a low specific heat index, and the temperature rises quickly when heat is absorbed. **False**
 - 7) Like most liquids, water contracts (gets smaller) when it freezes. **False**(See **Reproducible #2 – Water Is Amazing!**)
3. Have each team make their guess, and keep track of correct answers. Each correct answer is worth one point. (Optional: have a prize or reward for the winning team(s) at the end.)
4. Pass out copies of **Reproducible #2 – Water Is Amazing!** to each student (and/or project for the class) and discuss. Go over questions and answers. Remind students that water really is amazing and has many incredible, unique properties without which life on Earth would not exist.
5. Have each team choose the most surprising, interesting, or favorite fact about water.

Activity Three: *Water Distribution in the US* – Article and Debate

1. Now your class should understand how important water is, not only to their own daily lives (**Personal Water Audit**), but to all life on our planet (**Water Is Amazing!**).

2. Individually (in class or as homework the night before) or together in class, have your students read **Reproducible #3 – Energy versus Water: Solving Both Crises Together**.
3. Ask your class what they think of this article and discuss. Are there any new concepts they were surprised to learn about? Is your school located in or near any of the places mentioned in the article?
4. Divide the class according to the following: about 1/3 of your students will be citizens of the imaginary northwestern U.S. town of Lakeville, and about 2/3 will be residents of the southwestern U.S., living downriver from Lakeville.
5. Explain the following hypothetical scenario to the class:
 - a. The residents of Lakeville are lucky enough to have access to great freshwater resources. Located on Lakeville Lake at the foot of the Rocky Mountains, the town usually receives snowmelt runoff year-round. Lakeville Lake feeds into the Freshwater River, a major source of water for all of the states to the south.
 - b. However, due to rising global temperatures, the snowmelt has begun to decrease during summer months every year. As a result, Lakeville is considering building a dam on the Freshwater River to control their water access year-round.
 - c. The residents of the Southwest have already been experiencing water issues. Dependent on the resources of the Freshwater River, Southwesterners have been rationing water during summer months for years as the river has dried to a trickle during July and August.
 - d. Now that Lakeville is considering building their dam, the Southwesterners are in an uproar. This will cut off their already dwindling summer water supply, and restrict their access to water all year round.
6. Thinking of the concerns presented in the article, **Reproducible #3 – Energy versus Water: Solving Both Crises Together**, have the Lakvillians and Southwesterners debate these issues, representing their respective points of view. They should consider the following:
 - a. Who has control over water resources? Should water regulation be managed by local, state, or federal government?
 - b. If Lakeville has control over the water in Freshwater River, should they consider selling the resources to other cities and states?
 - c. If so, how will the Southwestern citizens pay for this extra expense? Will they need to implement new taxes? Or should it be up to individuals to pay the increased costs? What about those who cannot afford to pay for water?
 - d. Is it more important to have water in order to produce energy, or to have energy in order to clean and transport water?
 - e. What regulations would the Southwestern states need to pass to conserve their water supply and ration its use? Consider the water uses in the **Personal Water Audit**, in addition to agricultural, economic, domestic, industrial and transportation impacts.
 - f. If the residents of Southwestern states are having so many water issues that will only continue to increase, should they move to a new location with better access to water resources? Where would they go? Is this feasible?

- g. How will changes to the flow of Freshwater River impact the plants and animals in the watershed? Should regulations be considered to protect these species?
 - h. What are the moral and ethical concerns of resource management?
7. Each student in the class should be active in the debate. Encourage participation by having every student present one problem and one possible solution to these issues. Optional: Have students write down their ideas using **Reproducible #4 – Lakeville vs. the Southwest**. These can be collected and graded.

Wrap Up: *Water as a Resource* – Discussion

1. Thinking back to their **Personal Water Audit** and discussion in Activity One, have your students think about how and when they use water in their daily lives. Remind students of the **Water Is Amazing!** game and the unique properties that make water essential to life. Think about how many organisms and lifecycles around them depend on water, and how catastrophic it would be if clean, accessible freshwater were no longer available to us and other living things.
2. Think about other ways water's properties are important (review **Reproducible #2 – Water Is Amazing!**). For example, think about how easily water absorbs and dissolves substances. This is one reason why water pollution is such an issue. Think also about water's specific heat index and its relationship to global climate regulation.
3. Thinking of the **Energy versus Water** article and the class debate over water distribution in the U.S., what were some of the major problems presented? What were some of the solutions discussed?
4. Transition into a discussion of what students could do to reduce their daily water usage. Remind students about the class average of daily water usage, as calculated from the **Personal Water Audit**, and brainstorm ideas of how this could be reduced. (*For example, do not let water run when brushing teeth or washing dishes, take shorter showers, do full loads of laundry or dishes, use rainwater to water lawns, etc.*) You may wish to write these ideas on the board, or have students make their own lists.
5. Empower students to share these ideas with friends and family. Remind them of the lessons learned and the importance of water around the world.

Extension:

1. Further Research – Have students research one of the issues presented in the **Energy versus Water** article (i.e. water reservoirs and nuclear power in the southeastern U.S., hydroelectric power at the Hoover Dam, drinking water in San Diego or Phoenix, agricultural issues in Kansas and Missouri, water rationing in California and Texas, etc.), or find a similar water issue in your home state. Students should write a report presenting the facts, and a persuasive argument. They could argue both sides, or choose one or the other. (Note: the full article excerpted in Reproducible #3 can be found at <http://www.sciam.com/article.cfm?id=the-future-of-fuel>.)

2. *Water Inequality on a Global Scale* - Based on the debate in Activity Three, have students research the water availability in other countries and regions around the world. Visit www.globalwaternet.org for global water statistics, data and other information.

CONCLUSION

After completing this lesson, students will have conducted a water audit to explore their personal water usage and learned some of the important characteristics of water and why it is so important to us and the planet. They will also have read about some of the water scarcity issues currently being faced around the United States, and debated some of the problems and solutions to water distribution and resource management. These issues will have been tied together in the wrap-up discussion, along with the take-home message of the importance of water conservation and some ways to reduce water consumption.



Personal Water Audit



Name: _____ Date: _____

Answer the following questions about your water usage today.
If you do not know the exact numbers, please estimate as well as you can.

Pre-Question: Before completing the chart below, take a guess at how many gallons of water you use in 1 day ____
Compare your guess with totals below when you finish your water audit and calculations!

Question	Answer	Calculation - Try not to use a calculator!	Answer
1. How many times today have you flushed your toilet?		Multiply this number by 3. The average toilet uses 3 gal of water per flush.	Gal
2. Did you take a shower or bath?		Write down 40 gal if you took a bath. Write down 7 gal for every minute you were in the shower. You may adjust your number if you did not fill the tub all the way or if you have a low-flow showerhead.	Gal
3. How many times did your family run the dishwasher today?		Account for about 10 gal per load.	Gal
4. How many loads of laundry did your family do today?		Multiply this number by 40. (If you have a front-loading washer, multiply by 25 per load.)	Gal
5. How many minutes today did you run your sink faucet? Think about brushing teeth, washing hands and face, washing dishes, shaving, etc.		Factor 4 gal per minute.	Gal
6. Check the faucets in your house to see if any are leaky. Count the number of drips per minute.		For every 10 drips in a minute, multiply by 1.4. This should be done for each leaky faucet.	Gal
7. How many glasses of water did you drink today?		Multiply each glass by 0.0625. There are about 8 oz in an average glass. 128 oz = 1 gal (or about 16 glasses of water).	Gal
8. Did you use a hose today? Think about watering a garden, washing a car, or bathing a pet.		Factor 10 gal per minute.	Gal
Daily Total		Add up the numbers in the right-hand column. This is how many gallons of water you used today domestically.	Gal

Figures for calculations estimated from "Conducting a Household Water Audit," Maryland Department of the Environment, .

This is your **personal daily domestic water usage**. Remember that this does not include the general water used to run your household, school, car, or other shared space. In addition, water is used to produce almost everything you buy, eat or drink.

To find your approximate **total water footprint per year**, visit www.waterfootprint.org.

Find "Your Footprint Calculator" on the left and choose the Extended Calculator. Fill this in and find your total.
(Note: 1 kilogram = 2.20462262 pounds.)

My total water footprint in cubic meters per year is: _____.

Multiply this by 1000 to find your usage in liters: _____.

Divide this by 3.785411784 to find your **average yearly water usage** in gallons: _____.

Divide this number by 365 to find your **average daily total water usage** in gallons: _____.

Compare this to your original guess at the top. Are you surprised? In addition to your **personal daily domestic water usage** total, how much water do you use each day without turning on a faucet? _____



Water Is Amazing!

- 1. True or False:** Water dissolves more substances than any other liquid.
TRUE! *Water takes along anything that it passes by or that enters into it. This means it can carry nutrients and minerals, and will also carry chemicals and other harmful substances.*
- 2. True or False:** A water molecule consists of 2 atoms of oxygen and 1 atom of hydrogen.
FALSE! *A water molecule has 2 atoms of hydrogen and 1 atom of oxygen, making its chemical compound H₂O.*
- 3. True or False:** Water has high surface tension, and is one of the more “sticky” liquids.
TRUE! *H₂O has a positive charge on the hydrogen side and a negative charge on the oxygen side. Because opposites attract, the molecules bond with each other (+/-) and clump together with comparably strong elasticity. Just think of a raindrop! Surface tension is also responsible for capillary action which allows water and its dissolved substances to move through plants’ roots and animals’ blood vessels.*
- 4. True or False:** Water is the *only* substance found naturally on Earth in all three states (solid, liquid, and gas).
TRUE! *Think about what you know of the water cycle (evaporation, condensation, freezing, and precipitation). Earth needs water in all three states for this cycle to continue, and for living things to survive. We are very lucky to live on the “water planet”!*
- 5. True or False:** Human blood is composed of 75% water.
FALSE! *Our blood is about 95% water! Different parts of the body contain more or less - overall, the human body is composed of about 60% water. Think about how essential water is in every function of your body... it makes you thirsty just thinking about it!*
- 6. True or False:** Water has a low specific heat index, and the temperature rises quickly when heat is absorbed.
FALSE! *Think about how much hotter other materials like metal get when exposed to increased temperatures (and how much more quickly!). This makes water very important as a temperature regulator in everything from your car radiator to the planet! Water’s high specific heat helps regulate air temperature, keeping seasonal changes gradual and Earth’s overall temperature more constant.*
- 7. True or False:** Like most liquids, water contracts (gets smaller) when it freezes.
FALSE! *This is another of water’s unique and important characteristics. Water’s molecular composition actually expands when it freezes, making it less dense. Ice is one of the few substances that floats as a solid, because water as a liquid is more dense than water as a solid. Think of lakes and rivers – how would the aquatic life survive if the ice sank to the bottom and froze upwards?*

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Energy versus Water: Solving Both Crises Together

Water is needed to generate energy. Energy is needed to deliver water. Both resources are limiting the other—and both may be running short. Is there a way out?

By Michael E. Webber

In June the state of Florida made an unusual announcement: it would sue the U.S. Army Corps of Engineers over the corps's plan to reduce water flow from reservoirs in Georgia into the Apalachicola River, which runs through Florida from the Georgia-Alabama border. Florida was concerned that the restricted flow would threaten certain endangered species. Alabama also objected, worried about another species: nuclear power plants, which use enormous quantities of water, usually drawn from rivers and lakes, to cool their big reactors. The reduced flow raised the specter that the Farley Nuclear Plant near Dothan, Ala., would need to shut down.

Georgia wanted to keep its water for good reason: a year earlier various rivers dropped so low that the drought-stricken state was within a few weeks of shutting down its own nuclear plants. Conditions had become so dire that by this past January one of the state's legislators suggested that Georgia move its upper border a mile farther north to annex freshwater resources in Tennessee, pointing to an allegedly faulty border survey from 1818. Throughout 2008 Georgia, Alabama and Florida have continued to battle; the corps, which is tasked by Congress to manage water resources, has been caught in the middle. Drought is only one cause. A rapidly growing population, especially in Atlanta, as well as overdevelopment and a notorious lack of water planning, is running the region's rivers dry.

Water and energy are the two most fundamental ingredients of modern civilization. Without water, people die. Without energy, we cannot grow food, run computers, or power homes, schools or offices. As the world's population grows in number and affluence, the demands for both resources are increasing faster than ever.

Woefully underappreciated, however, is the reality that each of these precious commodities might soon cripple our use of the other. We consume massive quantities of water to generate energy, and we consume massive quantities of energy to deliver clean water. Many people are concerned about the perils of peak oil—running out of cheap oil. A few are voicing concerns about peak water. But almost no one is addressing the tension between the two: water restrictions are hampering solutions for generating more energy, and energy problems, particularly rising prices, are curtailing efforts to supply more clean water.

The paradox is raising its ugly head in many of our own backyards. In January, Lake Norman near Charlotte, N.C., dropped to 93.7 feet, less than a foot above the minimum allowed level for Duke Energy's McGuire Nuclear Station. Outside Las Vegas, Lake Mead, fed by the Colorado River, is

now routinely 100 feet lower than historic levels. If it dropped another 50 feet, the city would have to ration water use, and the huge hydroelectric turbines inside Hoover Dam on the lake would provide little or no power, potentially putting the booming desert metropolis in the dark.

Research scientist Gregory J. McCabe of the U.S. Geological Survey reiterated the message to Congress in June. He noted that an increase in average temperature of even 1.5 degrees Fahrenheit across the Southwest as the result of climate change could compromise the Colorado River's ability to meet the water demands of Nevada and six other states, as well as that of the Hoover Dam. Earlier this year scientists at the Scripps Institution of Oceanography in La Jolla, Calif., declared that Lake Mead could become dry by 2021 if the climate changes as expected and future water use is not curtailed.

Conversely, San Diego, which desperately needs more drinking water, now wants to build a desalination plant up the coast, but local activists are fighting the facility because it would consume so much energy and the power supply is thin. The mayor of London denied a proposed desalination plant in 2006 for the same reason, only to have his successor later rescind that denial. Cities in Uruguay must choose whether they want the water in their reservoirs to be used for drinking or for electricity. Saudi Arabia is wrestling with whether to sell all its oil and gas at record prices or to hold more of those resources to generate what it doesn't have: freshwater for its people and its cities.

We cannot build more power plants without realizing that they impinge on our freshwater supplies. And we cannot build more water delivery and cleaning facilities without driving up energy demand. Solving the dilemma requires new national policies that integrate energy and water solutions and innovative technologies that help to boost one resource without draining the other.

Vicious Cycle

The earth holds about eight million cubic miles of freshwater—tens of thousands of times more than humans' annual consumption. Unfortunately, most of it is imprisoned in underground reservoirs and in permanent ice and snow cover; relatively little is stored in easily accessible and replenishable lakes and rivers.

Furthermore, the available water is often not clean or not located close to population centers. Phoenix gets a large share of its freshwater via a 336-mile aqueduct from, of course, the Colorado River. Municipal supplies are also often contaminated by industry, agriculture and wastewater effluents. According to the World Health Organization, approximately 2.4 billion people live in highly water-stressed areas. Two primary solutions—shipping in water over long distances or cleaning nearby but dirty supplies—both require large amounts of energy, which is soaring in price.

Nationwide, the two greatest users of freshwater are agriculture and power plants.... At the same time, we use a lot of energy to move and treat water, sometimes across vast distances. The California Aqueduct, which transports snowmelt across two mountain ranges to the thirsty coastal cities, is the biggest electricity consumer in the state. As convenient resources become tapped out, providers must dig deeper and reach farther.... In addition, local municipalities have to clean incoming water and treat outgoing water, which together consume about 3 percent of the nation's electricity. Health standards typically get stricter with time, too, so the degree of energy that needs to be spent per gallon will only increase....

New Mind-set Needed, Too

Regardless of which energy source the U.S., or the world, might favor, water is ultimately more important than oil because it is more immediately crucial for life, and there is no substitute. And it seems we are approaching an era of peak water—the lack of cheap water. The situation should already be considered a crisis, but the public has not grasped the urgency.... Peak oil might cause some human suffering, but peak water would have more extreme consequences: millions already die every year from limited access to freshwater, and the number could grow by an order of magnitude.

Perhaps signposts will wake our collective minds. Kansas lost a lawsuit to Missouri recently over interstate water use, causing Kansan farmers to reconfigure how they will grow their crops. Rationing should certainly put society on notice, and it is beginning. My hometown of Austin, Tex., now imposes strict lawn-watering restrictions. California, suffering record low snowfalls, has issued statewide requirements for municipal water conservation and rationing of water that are reminiscent of gasoline controls in the 1970s.

Someday we might look back with a curious nostalgia at the days when profligate homeowners wastefully sprayed their lawns with liquid gold to make the grass grow, just so they could then burn black gold to cut it down on the weekends. Our children and grandchildren will wonder why we were so dumb.



Name: _____

Class: _____

Date: _____

Lakeville vs. the Southwest – Water Distribution Issues in the U.S.

I am a resident of: Lakeville the Southwest (please circle)

One issue with the distribution of water resources is:

One potential solution to this problem is: