WE CARE ABOUT WATER.
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AMERICAN WATER

Climate Change

Weather Patterns and Drinking Water Resources

- **Grade Level:** 9-12
- **Objective:** Students will explore the potential impacts of climate change on drinking water resources.
- **Subjects:** Mathematics, Environmental Science, Geography

INTRODUCTION

The topic of climate change is one that has been debated extensively in the public. Proponents of climate change advocate the position that human activities contribute to changes in our global climate and that immediate and drastic cuts in the emissions of greenhouse gases are necessary. Skeptics question some of the methodologies used to reach this conclusion and suggest that other factors, such as the influence of natural climate cycles, be taken into account before a consensus can be reached.

The purpose of this lesson plan is not to support or question the concept of climate change, but utilize the topic as a springboard to discuss how weather patterns impact drinking water sources.

Certainly, a link can be made between changes in temperature and precipitation patterns to the availability of reliable drinking water supplies. For example:

- A rise in temperature may result in increased evaporation rates from surface waters, as well as from ground substrate that absorbs water and recharges aquifers.
- Reduced precipitation can result in a drop of water levels in surface water bodies. Elevated temperatures along with reduced precipitation can exacerbate potential water shortages.
- Conversely, too much precipitation within a short period of time can cause problems, including flooding and drastic changes in the quality of the source water.

Regardless of your position, climate change is a topic worth exploring and debating, and one that can be used to further the awareness of water resource sustainability.

For this lesson plan, students will explore the possible impacts of weather patterns on drinking water supplies. Follow-up lessons could involve a discussion of how changes in human activity could help mitigate potential adverse impacts of climate change, as well as alternative methods using technology, including desalination and grey water recycling, to reduce our reliance on our freshwater supplies.

DID YOU KNOW?

If every household in the U.S. replaces conventional bulbs in their five most used light fixtures with ENERGY STAR bulbs, it would prevent greenhouse gases equivalent to the emissions from nearly 10 million cars.

MATERIALS NEEDED

- Piece of paper
- Pen or pencil
- Calculator
- Enclosed data sheets

EXERCISE

To fully grasp the potential impact of climate change, we need to investigate how our freshwater supplies are tied to climate. In this activity, both human use and natural processes of the hydrologic cycle will be studied. After reviewing and analyzing the data sets, potential impacts of climate change will be established.

TASK 1: SURFACE WATERS

Table 1 summarizes major North American rivers and their corresponding drainage basins and average discharge.

- In Table 1, rank the rivers based on human use of freshwater supplies. Consider both population and agriculture in your ranking.
- In Table 2, using the provided climate model predictions, rank the rivers based on potential reduced flow.
- Create a column graph in Excel of the discharge rates for these rivers and a second graph for the drainage areas for these rivers. On both graphs, rank them in order from largest to smallest. Note: If students do not have access to Excel, graph templates are provided on the following page.
- On page 5, identify the general area where each river is found.

TABLE 1: DRAINAGE AREA AND AVERAGE DISCHARGE

River	Drainage Area (square miles)	Average Discharge (cubic feet/second)	Ranking Based on Human Activity (1=most impacted; 7=least impacted)
St. Lawrence	498,000	500,000	
Columbia	258,000	256,000	
Yukon	360,000	180,000	
Mississippi	1,244,000	611,000	
Susquehanna	27,500	40,100	
Colorado	246,000	17,850	
Mackenzie	697,000	280,000	

TABLE 2: MEAN PRECIPITATION RATIO AND TEMPERATURE

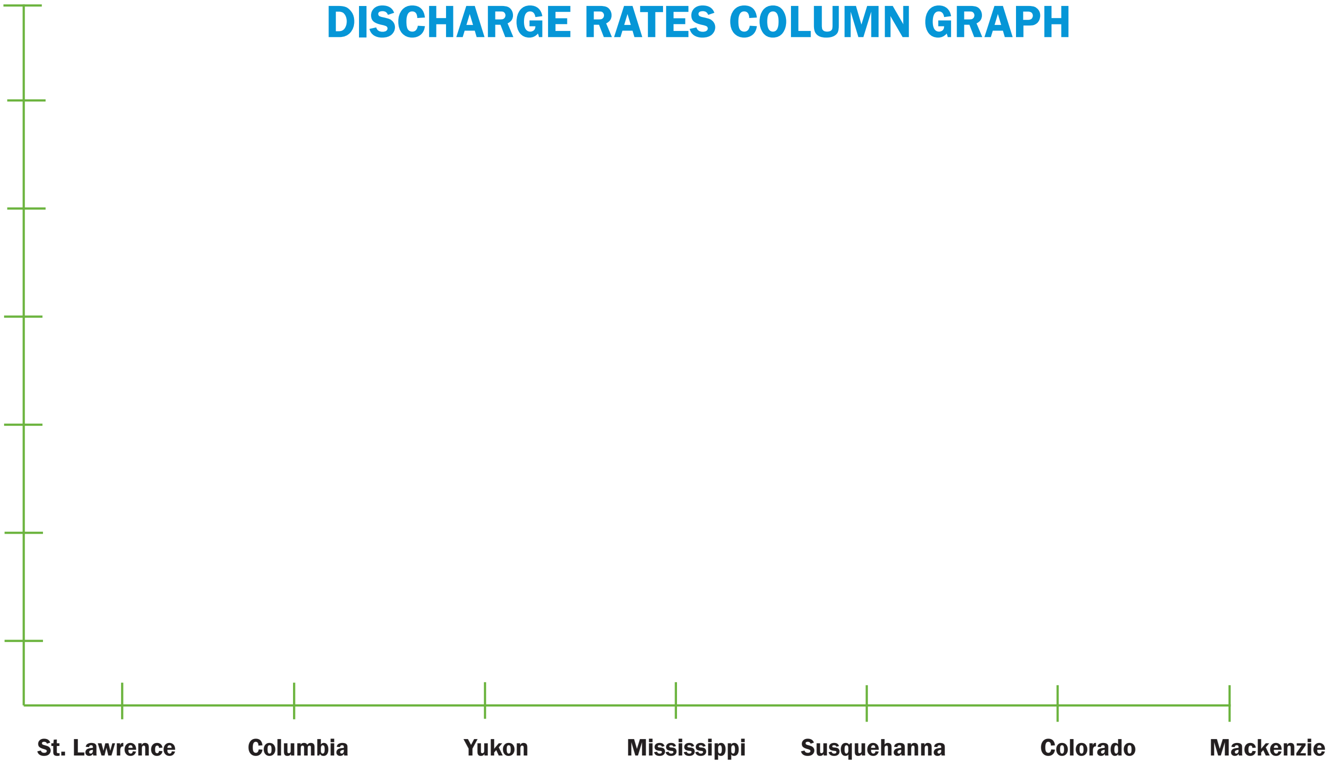
Region	Annual Mean Precipitation Ratio	Change in Annual Mean Temperature (C)**	Ranking Based on Reduced Flow (1=most reduced; 6=least reduced)
Northwest	1.08	1.8	
Southwest	1.16	2.0	
Great Plains	0.98	2.2	
Great Lakes/Midwest	0.98	2.4	
Southeast	0.81	1.8	
Northeast	0.94	1.8	

* The precipitation ratio is determined by dividing the predicted precipitation in 2030 by the current modeled precipitation. For example, if the model in 2030 predicts 40 inches and the current precipitation is 44 inches, the precipitation ratio would be 0.91 (40/44=0.91).

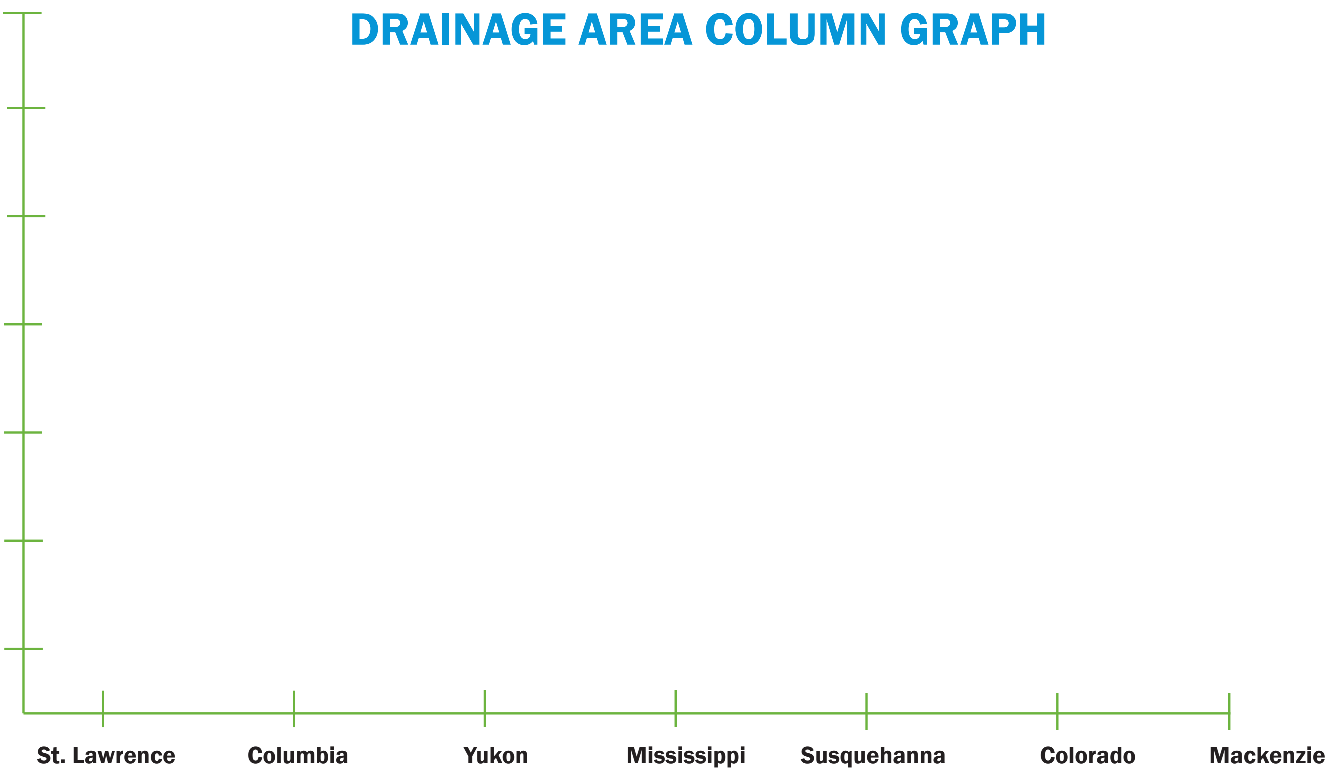
** Temperatures are compared to current values.

Note: The model referenced is one of a few used to predict temperature and precipitation patterns. Not all models predict changes as referenced in this table.

DISCHARGE RATES COLUMN GRAPH



DRAINAGE AREA COLUMN GRAPH



RIVER LOCATION

In the space provided below, describe the general location where the river can be found.

St. Lawrence

Columbia

Yukon

Mississippi

Susquehanna

Colorado

Mackenzie

TASK 2: GROUNDWATER

The following table provides the recharge rate and well yield data for several groundwater regions in the United States. Recharge rates, or inches per year, refers to the amount of water that can return to the ground layers in a given year. Well yield (cubic ft. per minute) refers to the range of water volume that can be extracted from the groundwater in that region. Use the date provided to complete the following:

- Using Excel or the graph provided on the following page, create a column graph of the top five regions with the highest potential recharge rates. Use the maximum values from the table for your calculations.
- Using Excel or the graph provided on the following page, create a column graph of the top five regions with the highest potential well yields Use the maximum values from the table for your calculations.
- Establish a ranking of the top five most important regions for water use. Indicate whether the use is for domestic supply, agriculture or both. Provide support for your ranking. Map references and other geographic based data will be needed for this graph.
- Given the temperature and precipitation changes from the model in Task 1, rank the five most threatened regions for potential reduced recharge. Consider rainfall and temperatures potentially increasing evaporation from the soil and surface waters that will support recharge.

TABLE 3: MEAN PRECIPITATION RATIO AND TEMPERATURE

Region	Recharge Rate (inches/year)	Well Yield (ft 3/minute)	Location
Columbia Lava Plateau	0.2 - 10	30 - 6,400	Northwest
Colorado Plateau/Wyoming Basin	0.1 - 2	2 - 70	Colorado/ Wyoming
Central Valley/Pacific Coast Range	0.4 - 4	20 - 700	California
Great Basin	0.2 - 2	20 - 350	Utah/ Nevada
Central Alluvial Basin	0.2 - 2	20 - 350	Southwest
Central Glaciated Plains	0.2 - 12	7 - 70	Iowa to Pennsylvania
High Plains	0.04 - 6	14 - 350	Central United States
Northeastern Appalachians	1 - 12	3.5 - 70	New England
Appalachian Plateau/Valley and Ridge	1 - 12	3.5 - 35	Southern Appalachians
Piedmont and Blue Ridge	1 - 12	3.5 - 35	East of S. Appalachia
Atlantic and Eastern Coastal Plain	2 - 20	18 - 700	Mid to Southeast Coast
Gulf of Mexico Coastal Plain	2 - 20	18 - 700	Gulf States
Southeastern Coastal Plain	1 - 20	180 - 1800	Florida

REGIONS WITH THE HIGHEST POTENTIAL RECHARGE RATES

REGIONS WITH THE HIGHEST POTENTIAL WELL YIELDS

QUESTIONS

1. Based on the data provided in Table 1, is there a consistent relationship between discharge rate and drainage area for the rivers? Explain.
2. Why are some of these large rivers not used heavily by people?
3. Some climate models predict increased precipitation in these regions. It is possible that even under these conditions that water shortages could occur. Explain.
4. What other factors should be considered when ranking rivers threatened by climate change?
5. Without considering climate change, why would it not be a recommended practice to maximize well yield in given area?
6. What factors influence recharge rate in a given area? Describe them.
7. Given the ranking produced in Task 2, which strains water resources more: agriculture or domestic/municipal use?
8. What are some measures that could be employed to reduce the threat to ground water resources? Discuss three.

EXTENSIONS

1. Identify the river, watershed and groundwater region in which you live. Record the following:
   - drainage area and discharge rate for the river
   - well yield and recharge rate for the groundwater region
   - How extensive are the human pressures on freshwater from surface and groundwater sources?
2. Consider the potential for climate change in your region. Produce a report that identifies and describes the potential impact.
3. Research how climate models work. How do scientists determine their accuracy? Discuss the variation in the data they produce.
4. Research the other effects of climate change. Water impacts all of these potential changes. Explain how this is so.

NOTES

DEFINITIONS

- **Climate Change Model:** A model that uses quantitative methods to simulate the interactions of the atmosphere, oceans, land surface, and ice in order to predict precipitation and temperature patterns.
- **Groundwater:** Water that sinks into the soil and is stored in slowly flowing and slowly renewed underground reservoirs called aquifers; underground water in the zone of saturation, below the water table.
- **Groundwater Recharge:** From surface water and/or precipitation, the volumetric flow rate of groundwater through the substrate and into an aquifer.
- **Groundwater Well Yield:** A water well is an excavation or structure created in the ground by digging, diving, boring, or drilling to access groundwater in an aquifer. The yield refers to the supply that can be removed from a given location.
- **River Discharge:** In hydrology, discharge is the volume rate of water flow, including any suspended solids, dissolved chemical species, and/or biologic material, which is transported through a given cross-sectional area- often at a river mouth or confluence.
- **River Drainage Basin (Watershed):** Land area that delivers the water, sediment and dissolved substances via small streams to a major stream (river).

RESOURCES

- www.IPCC.org
- climate.nasa.gov
- www.noaa.gov
- Climate Change Adaptation in the Water Sector edited by Ludwig, Kabat, van Shaik and van der Valk
- The Nature of North America by David Rockwell

In a world where everything we touch frequently changes, water is our constant. We've never stopped needing it to drink, to cook, to clean, to live. We'll always need it for sanitation, for fire protection, for watering our lawns and washing our cars.

It's easy to take water for granted. And because so many do, we don't.

We are scientists, environmentalists, innovators, and protectors. We are also residents and employees in the communities we serve. We understand how important, how precious, and how critical water is to daily life.

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Visit **www.amwater.com** to learn more about our company and our years of tradition of reliability, responsibility, service, innovation and excellence.

A special thanks to Ron Smith for developing the core content of this lesson plan. Ron Smith, a science educator from NJ, has been teaching biology, environmental science and interdisciplinary studies in the classroom, lab and field for 18 years. It was important for us that our lesson plans be crafted by an educator for educators. We appreciate his hard work.

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