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STEM Connections and Scientific Literacy

Introduction

This guide focuses on science, technology, engineering, and mathematics (STEM) and scientific literacy opportunities within Environmental Science © 2011. It defines STEM education and identifies program activities, including Central Case and Find Out More, introduces the Design Process, focuses on scientific literacy skills, and explains how the program addresses key science and engineering practices.

What is STEM education?

The world is changing rapidly. Every day you hear of new and innovative advances in science and engineering. The STEM fields are interconnected and are at the core of these innovations.

STEM Initiative

Since the STEM fields are so important to the economy and society, politicians, educators, and economists have become increasingly concerned about three key issues. The first issue is that many STEM jobs have relocated from the United States to foreign countries. Next, fewer US students are choosing to enter the STEM fields of study. The last issue is that US students perform poorly on STEM subjects on international testing. As a result, the US government developed the STEM initiative. Over the past few years, there has been an increased interest in educational programs that support this initiative.

STEM Education

The STEM education movement recognizes that students are America's future scientists and engineers. This movement also recognizes that students need opportunities to integrate these fields of study into their learning experiences so that they develop the necessary skills to be competitive and successful in a rapidly changing world economy. One goal of the STEM education movement is to attract and retain students in the STEM fields of study.

Students as Designers

One way to help students develop STEM skills is to allow them to apply what they learn to unique design situations. By offering students design opportunities, they learn to apply science, technology, engineering, and math to solve real-world problems like global climate change, energy conservation, and water purification. Students learn to problem solve by applying the Design Process. The Design Process asks students to

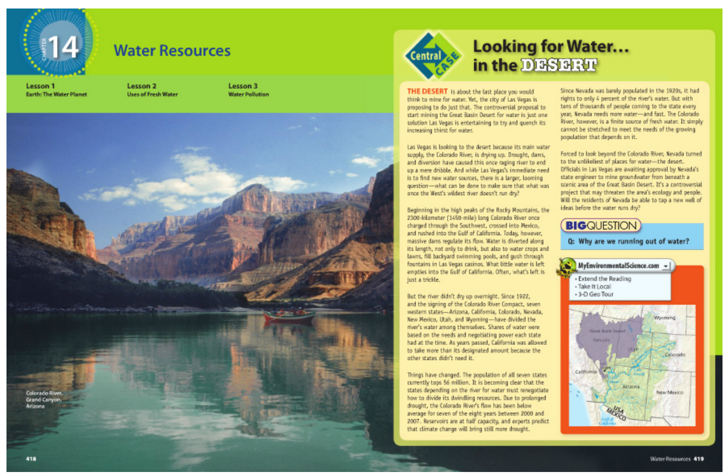
- identify the problem;
- do research;
- develop possible solutions;
- choose a possible solution;
- design and construct a prototype;
- test the prototype;
- communicate results; and
- evaluate and redesign.

STEM in Environmental Science

STEM activities are integrated throughout Environmental Science. Central Case, Find Out More, and Ecological Footprints are a few examples of these activities.

Central Case

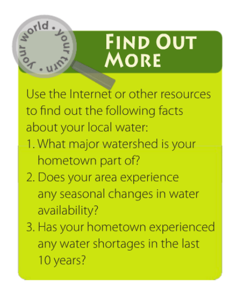
Each chapter begins with a Central Case that introduces a problem that is relevant to everyday living. These case studies help students focus on the Big Question of the chapter and help them guide their thinking throughout the chapter. Students have the opportunity to apply the Big Question at the end of the chapter.



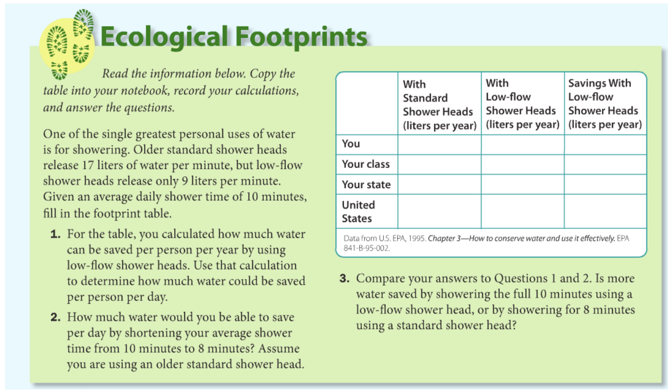
The Central Case for Chapter 14: Water Resources introduces the problem of water usage in the American Southwest. Students are asked, "Why are we running out of water?" This Central Case can easily be turned in to a design activity by asking students to research and design a solution for the shortage of water.

Find Out More

Find Out More helps students relate environmental science to their everyday lives. This feature is located throughout each chapter. This feature can be found in the context of a lesson. The purpose of Find Out More in the context of a lesson is to relate environmental science concepts to local conditions or issues. The Find Out More, on page 421, ask questions about local watersheds, water availability, and water shortages.



Ecological Footprints	Environmental Science seamlessly integrates science content with math concepts. The program features a wealth of math opportunities. One feature, Ecological Footprints, encourages students to complete data collection and analysis activities based on real world data and student data. On page 449, the Ecological Footprints activity asks students to gather data and calculate water usage based on different types of shower heads.



Ecological Footprints

Read the information below. Copy the table into your notebook, record your calculations, and answer the questions.

One of the single greatest personal uses of water is for showering. Older standard shower heads release 17 liters of water per minute, but low-flow shower heads release only 9 liters per minute. Given an average daily shower time of 10 minutes, fill in the footprint table.

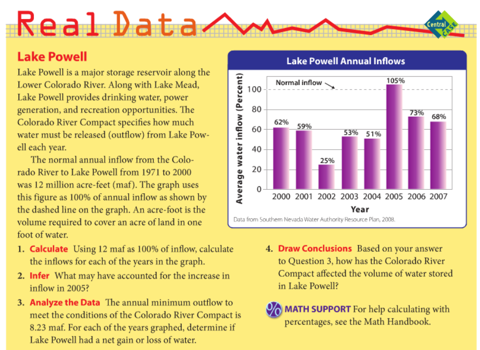
1. For the table, you calculated how much water can be saved per person per year by using low-flow shower heads. Use that calculation to determine how much water could be saved per person per day.
2. How much water would you be able to save per day by shortening your average shower time from 10 minutes to 8 minutes? Assume you are using an older standard shower head.

	With Standard Shower Heads (liters per year)	With Low-flow Shower Heads (liters per year)	Savings With Low-flow Shower Heads (liters per year)
You			
Your class			
Your state			
United States			

Data from U.S. EPA, 1995. *Chapter 3—How to conserve water and use it effectively.* EPA 841-B-95-002.

3. Compare your answers to Questions 1 and 2. Is more water saved by showering the full 10 minutes using a low-flow shower head, or by showering for 8 minutes using a standard shower head?

Real Data	Real Data is another feature that connects chemistry to math. Real Data, on page 431 of the Teacher's Edition, presents math concepts in the context of authentic data. In this example, actual data about the inflow of water into Lake Powell is used to make calculations with percentages, analyze, and draw conclusions based on the data.



Real Data

Lake Powell

Lake Powell is a major storage reservoir along the Lower Colorado River. Along with Lake Mead, Lake Powell provides drinking water, power generation, and recreation opportunities. The Colorado River Compact specifies how much water must be released (outflow) from Lake Powell each year.

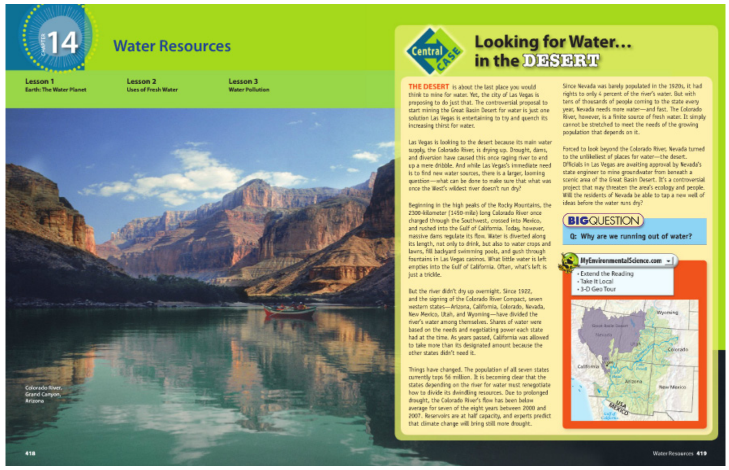
The normal annual inflow from the Colorado River to Lake Powell from 1971 to 2000 was 12 million acre-feet (maf). The graph uses this figure as 100% of annual inflow as shown by the dashed line on the graph. An acre-foot is the volume required to cover an acre of land in one foot of water.

1. **Calculate** Using 12 maf as 100% of inflow, calculate the inflows for each of the years in the graph.
2. **Infer** What may have accounted for the increase in inflow in 2005?
3. **Analyze the Data** The annual minimum outflow to meet the conditions of the Colorado River Compact is 8.23 maf. For each of the years graphed, determine if Lake Powell had a net gain or loss of water.
4. **Draw Conclusions** Based on your answer to Question 3, how has the Colorado River Compact affected the volume of water stored in Lake Powell?

MATH SUPPORT For help calculating with percentages, see the Math Handbook.

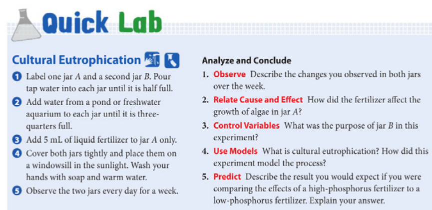
Scientific Literacy in Environmental Science	In the summer of 2011, the National Academy Press released A Framework for K–12 Science Education: Practices, Crosscutting Concepts, and Core Ideas. The framework lists eight practices for scientific and engineering. The purpose of these practices is to build an understanding of how scientists and engineers work, make knowledge more meaningful, and gain an understanding of the creative processes of science and engineering (National Academy Press 2011, 29–30). These eight standards provide the architecture for national science standards that will be released in 2012. Environmental Science addresses the following practices to build and encourage scientific literacy.
1. Asking Questions and Defining Problems	The Central Case of each chapter provides a starting point for asking questions and defining problems. Chapter 14, on pages 418–419, provides important background information to help students understand the Big Question but also allows them to begin asking

their own questions. Additionally, the Central Case guides students in defining a relatable problem and a purpose for investigating the concepts.



2. Developing and Using Models

Many of the Quick Lab sections include opportunities to develop and use models. Lesson 14, on page 437, includes an activity where students construct a model of cultural eutrophication. Students use jars, water, and fertilizer to model the process.



Quick Lab

Cultural Eutrophication

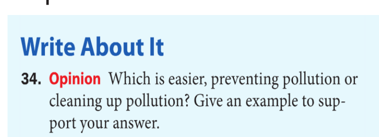
1. Label one jar *A* and a second jar *B*. Pour tap water into each jar until it is half full.
2. Add water from a pond or freshwater aquarium to each jar until it is three-quarters full.
3. Add 5 mL of liquid fertilizer to jar *A* only.
4. Cover both jars tightly and place them on a windowsill in the sunlight. Wash your hands with soap and warm water.
5. Observe the two jars every day for a week.

Analyze and Conclude

1. **Observe** Describe the changes you observed in both jars over the week.
2. **Relate Cause and Effect** How did the fertilizer affect the growth of algae in jar *A*?
3. **Control Variables** What was the purpose of jar *B* in this experiment?
4. **Use Models** What is cultural eutrophication? How did this experiment model the process?
5. **Predict** Describe the result you would expect if you were comparing the effects of a high-phosphorus fertilizer to a low-phosphorus fertilizer. Explain your answer.

3. Planning and Carrying Out Investigations

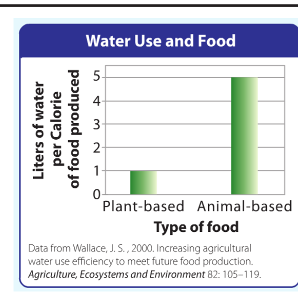
Write About It is a feature at the end of each chapter. These questions can easily be adapted to allow students opportunities to design their own experiments. Lesson 14, on page 449, asks, “Which is easier, preventing pollution or cleaning up pollution?” Students can plan their own investigations to explore the answers to this question.



Write About It

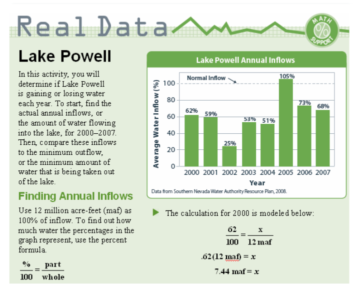
34. **Opinion** Which is easier, preventing pollution or cleaning up pollution? Give an example to support your answer.

4. Analyzing and Interpreting Data



Each chapter includes a variety of charts, tables, and graphs. As mentioned above, it also features Real Data. Students learn to read graphs, interpret data, and analyze the results. Lesson 14, on page 449, provides an Analyze Data activity. Using the Water Use and Food graph, students read the graph data to determine the number of liters of water needed to produce plant-based and animal-based food. They also calculate the number of liters of water that are needed for an average man’s daily caloric intake. Students are also given many opportunities to collect and analyze their own data in the program’s lab activities.

5. Using Mathematics, Information and Computer Technology, and Computational Thinking	Environmental Science has a wealth of resources for connecting science and mathematics. Resources include Math Support in the Study Workbook. The purpose of the Math Support is to model mathematical processes as they are applied to science concepts. On p. 254 of the Study Workbook, students learn how to calculate percentages based on graph data. MyEnvironmentalScience.com is the digital path for Environmental Science. Students are presented with many opportunities to use technology for research, tutorials, practice, data collection, and virtual lab activities.



6. Constructing Explanations and Designing Solutions	At the end of each chapter, students are asked to apply what they have learned about the Big Question. Students must explain chapter concepts to complete an activity. In Chapter 14, on page 449, students must write a public service announcement that teaches people about the effects that human activities have on fresh water.

> Apply the **BIG**QUESTION Write a public service announcement that teaches people about the effects human activities have on fresh water. The goal of the announcement is to explain the importance of sustainable water practices. Your intended audience is the general public, so you may need to provide background on why fresh water is a renewable, but limited resource. Present your announcement to the class. You may use visuals to support your ideas.

7. Engaging in Argument from Evidence	Throughout the program, students are asked to form an opinion on environmental issues based on chapter concepts. Page 448 asks students to give their opinion on whether communities should or should not limit water consumption.

> **Form an Opinion** To conserve water, should communities limit how often people can do things such as water their lawns or wash their cars? Why or why not?

8. Obtaining, Evaluating, and Communicating Information	Lab activities provide the perfect vehicle for obtaining, evaluating, and communicating information. Lab activities are available on MyEnvironmentalScience.com and on DVD-ROM. In Chapter 14, there is an In Your Neighborhood inquiry activity that allows students to collect data about their own tap water. In this activity, students not only obtain water quality data but they also evaluate the data, determine the quality based on Environmental Protection Agency (EPA) standards, and communicate explanations orally or in writing.

Data Table 1

Water Quality Test Results for (Distributor Name) ______________________

Regulated Contaminants Found	Average Level Found (include units)	EPA Maximum Contaminant Level (MCL) (include units)	Difference Between Average Level Found and EPA Maximum (include units)

Review

This guide discussed the STEM and scientific literacy opportunities in Environmental Science © 2011. It defined STEM education, the Design Process, and specific examples of STEM instruction in the program. In addition, it explored eight scientific and engineering practices that are used in the program to encourage scientific literacy.