Tracking Earth's Water Sources Unit Plan

Suggested Time Required: 8-10 class periods (45-50 minutes) **Grade Level:** 5th

Standards Addressed:

Common Core State Standards Mathematics:

- CCSS.MATH.CONTENT.5.G.A.2 Represent real world and mathematical problems by graphing points in the first quadrant of the coordinate plane, and interpret coordinate values of points in the context of the situation.
- CCSS.MATH.CONTENT.5.NBT.A.3 Read, write, and compare decimals to thousandths.
- CCSS.MATH.CONTENT.5.MD.C.3 Recognize volume as an attribute of solid figures and understand concepts of volume measurement.

Mathematical Practices:

- CCSS.MATH.PRACTICE.MP1 Make sense of problems and persevere in solving them.
- CCSS.MATH.PRACTICE.MP2 Reason abstractly and quantitatively.
- CCSS.MATH.PRACTICE.MP4 Model with mathematics.
- CCSS.MATH.PRACTICE.MP5 Use appropriate tools strategically

Next Generation Science Standards:

- 5-ESS2-1. Develop a model using an example to describe ways the geosphere, biosphere, hydrosphere, and/or atmosphere interact.
- 5-ESS2-2. Describe and graph the amounts of salt water and fresh water in various reservoirs to provide evidence about the distribution of water on Earth.
- 5-ESS3-1. Obtain and combine information about ways individual communities use science ideas to protect the Earth's resources and environment.
- 3-5-ETS1-1. Define a simple design problem reflecting a need or a want that includes specified criteria for success and constraints on materials, time, or cost.
- 3-5-ETS1-3. Generate and compare multiple possible solutions to a problem based on how well each is likely to meet the criteria and constraints of the problem.
- 3-5-ETS1-3. Plan and carry out fair tests in which variables are controlled and failure points are considered to identify aspects of a model or prototype that can be improved.

Science and Engineering Practices:

- Developing and Using Models: Develop a model using an example to describe a scientific principle.

- Using Mathematics and Computational Thinking: Describe and graph quantities such as area and volume to address scientific questions.
- Obtaining, Evaluating, and Communicating Information: Obtain and combine information from books and/or other reliable media to explain phenomena or solutions to a design problem.

Crosscutting Concepts:

- Scale, Proportion, and Quantity: Standard units are used to measure and describe physical quantities such as weight and volume.
- Systems and System Models: A system can be described in terms of its components and their interactions.
- Influence of Science, Engineering, and Technology on Society and the Natural World: Engineers improve existing technologies or develop new ones to increase their benefits, decrease known risks, and meet societal demands.

Objectives:

- Students are able to describe how water is distributed on Earth, using graphs and models.
- Students are able to interpret a heat map and collect data for one US city for one year, using the information to create and present a line graph.
- Students are able to describe trends in land water storage data over a 10 year period in the US.
- Students are able to use the engineering design process to demonstrate an understanding of how real-world water conservation problems can be solved.
- Students are able to work collaboratively with others.

Essential Questions:

- How is water distributed on Earth?
- What effect do humans have on the distribution of water on Earth?
- How does students' knowledge of fractional parts/percentages and graphing contribute to their understanding of this concept?

Statement of Purpose:

This integrated unit will enhance students' understanding of both graphical representations of data and how water is used and distributed across the Earth. The unit focuses primarily on the hydrosphere and its interactions with other Earth systems using real-world data from NASA's Jet Propulsion Lab giving students an authentic experience to discover the phenomena of the natural world. Students investigate quantities, distribution, and sources of water, by experimenting and looking for patterns, then applying that knowledge to acquire a conceptual understanding of Earth's processes.

This unit on the water cycle and Earth's processes is developmentally appropriate for fifth grade students because in general, fifth graders can engage in more complex work, are able to think more abstractly, and interact more with peers. In this unit, students work on tasks independently and collaboratively to make sense of complex data and the implications on a local and global scale. Additionally, the lessons are designed to provide opportunities for students to take part in thinking and working as mathematicians, scientists, and engineers through problem-solving tasks, modeling, and engineering a design solution in response to underlying scientific principles.

Upon completion of this unit, students will develop and understand the purposes of a number of mathematical skills including interpreting, creating, and analyzing graphs. In one lesson, students use estimation skills to understand percentages in worldwide distribution of water. Equally significant is the mathematical habits of mind students practice while engaged in this unit. Through significant and challenging real-world problems, students see the relevance and usefulness of the math concepts they are learning by seeking out patterns and structure in the data. Lessons in the Explore phase emphasize these habits of mind. Moreover, they build perseverance and curiosity to solve complex problems and are required to model and communicate their thinking to others.

Differentiation will be achieved in a number of ways throughout the unit by adjusting the learning activities to address individual needs and learning styles. One way to build differentiation is through flexible grouping in order to accommodate different skill levels and interests. For struggling students, small groups will be used to guide them towards understanding through mental math exercises, probing, and clarifying questions by the teacher. Another important tool to differentiate is the use of technology to help students stay engaged and can be used to individualize instruction. Ultimately, the inquiry-based approach to the lessons in this unit challenges students to use higher order thinking skills in order to see the depth and complexity of issues which naturally extends the thinking. An engineering design challenge is yet another way to provide for differentiation and enrichment.

Required Materials:

- Keith Kompoltowicz video clip: https://www.youtube.com/watch?time_continue=4&v=TRXw5KMiDec&feature=emb_logo
- News article: "Third Rail Proposal: Selling Great Lakes Water Proposed to Lower Lake Levels" by Gary Wilson
- Global water distribution table (full table and student copy with missing data)
- Drawing paper/tools
- Mystery Science "How Much Water is in the World?" PDF maps
- Lesson materials for "Tracking Water Using NASA Satellite Data" at https://www.jpl.nasa.gov/edu/teach/activity/tracking-water-using-nasa-satellite-

data/, including linked videos, graphing tools, GRACE heat maps, and map of major U.S. cities

- NASA water cycle animation at https://gpm.nasa.gov/education/videos/water-cycle-animation
- Recycled materials for the engineering challenge
- Teach Engineering "Designing Ways to Get and Clean Water" task scenario cards

Lesson Plan:

Engage

1. As an engaging context to this unit on water, students will be considering the water of the Great Lakes, surrounding their home state of Michigan. Currently, the lakes are experiencing record high levels. Play students a video clip (https://www.youtube.com/watch?time_continue=4&v=TRXw5KMiDec&feature=emb_logo, stop at 1:51) where Keith Kompoltowicz of the Water Hydrology Branch, U.S. Army Corp of Engineers explains why the levels are so high (Frauhammer, 2019). Ask students what they noticed about the graphs featured in the video. Have students brainstorm why high water levels could be a problem.
2. Share the article by Gary Wilson (2020), "Third Rail Proposal: Selling Great Lakes Water Proposed to Lower Lake Levels." While the article is written in advanced language not appropriate for fifth grade students, the article can be summarized. In essence, a law professor at the University of Chicago has proposed that because Michigan currently has too much water, we could sell some to states who do not have enough and profit from the surplus. Lead students in a debate about the topic, serving as a moderator for the discussion.
3. Once students have considered the freshwater source they are most familiar with, they will be assessed on their understanding of water distribution and the water cycle through two activities. The table below and on the left shows global water distribution. Students will be given the simplified table on the right to interpret in partners. They will be asked, "What is the table trying to tell us? What headings make sense for each row?" As the second part of the pre-assessment, students will be asked to draw a picture of what they know about the water cycle.

Water Source	Volume (1000 km^3)	% of Total Water
Oceans, seas and bays	1,338,000	96.5
Ice caps, glaciers and perm. snow	24,064	1.74
Groundwater	23,400	1.7
Fresh	(10,530)	(0.76)
Saline	(12,870)	(0.94)
Soil moisture	16.5	0.001
Ground ice and permafrost	300	0.022
Lakes	176.4	0.013
Fresh	(91.0)	(0.007)
Saline	(85.4)	(0.006)
Atmosphere	12.9	0.001
Swamp water	11.47	0.0008
Rivers	2.12	0.0002
Biological water	1.12	0.0001
Total	1,385,984	100.0

Source: Gleick, P. H., 1996: Water resources. In *Encyclopedia of Climate and W* S. H. Schneider, Oxford University Press, New York, Vol. 2, pp. 817-823.

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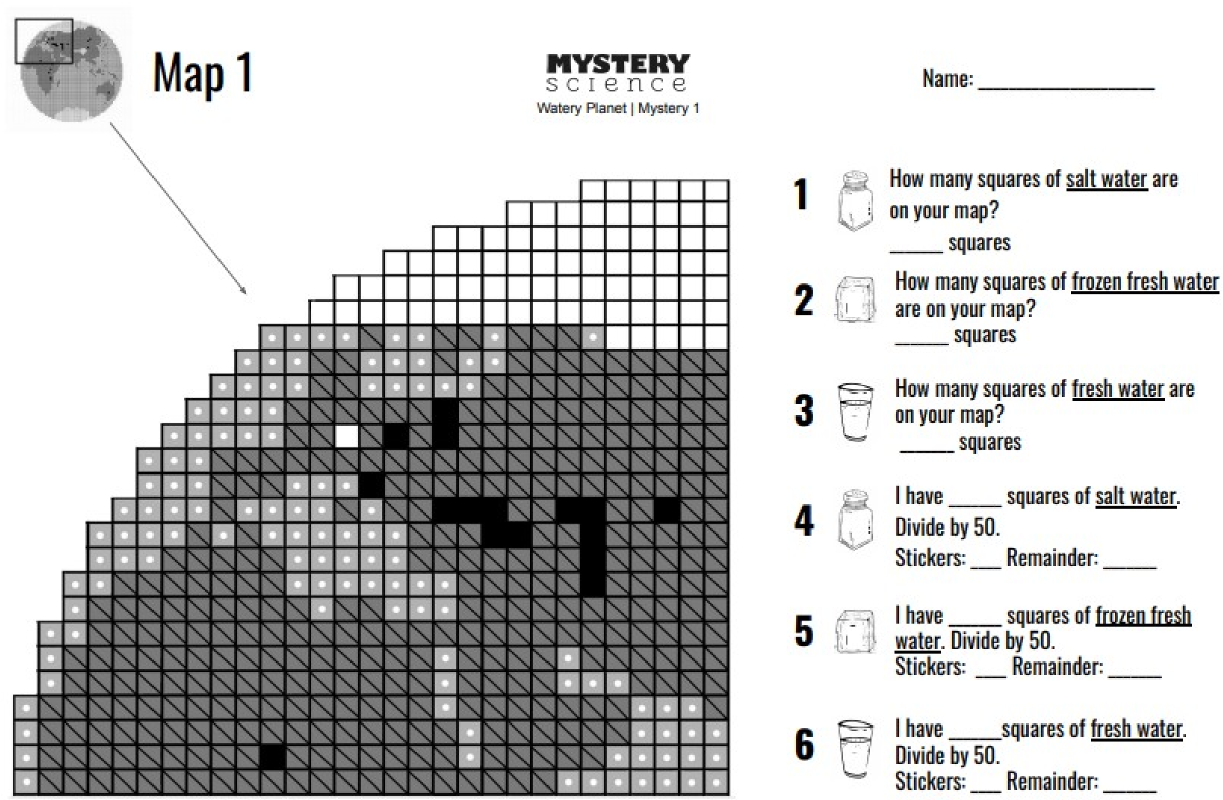
Total	1,385,984	100

Explore

1. In this stage, students will use estimation and graphing skills to learn about the difference between the distribution of salt and fresh water. Each student will be given a pixelated map that represents part of the globe, showing what is saltwater, freshwater, and ice. By counting each water type, students will be able to create fractions, percentages, and decimals from the data. Each student's data will be compiled with the rest of the class to find global totals of frozen water, freshwater, and saltwater. After allowing some work time, stop the class and ask students to share math strategies they developed for counting the squares quickly. For example, some students may have seen several equal rows of water and used skip counting rather than counting each individual box (Mystery Science, 2020).
2. Once students have completed the activity, their findings will be compared to the tables they were asked to label in the Engage stage. Since the original table was more specific than the Explore activity, students will have to add the freshwater and saltwater categories together. Lead a discussion, asking students questions such as: "How accurate was your understanding of the way water is distributed on Earth?" "Does any of this data surprise you?" "How else could we represent this data other than using a table like the one given?" "What questions do you still have about water on Earth?"



Sample map page for the first Explore activity.

3. Using the Jet Propulsion Laboratory resource, *Tracking Water Using NASA Satellite Data*, students will continue to explore the idea that water is not constantly located within one area.
    a. First, students will watch videos about groundwater and an introduction to GRACE: Gravity Research And Climate Experiment, whose mission is to record changes in water mass each day.
    b. Next, students will learn through an animation and videos how heat maps are created and what exactly mass is.
    c. Students will then focus on one area of the United States, choosing as a class one city for data analysis. In groups, students will be tasked with creating a line graph to show the water mass changes in the chosen city over the course of a year. Develop common scale and orientation for the graphs since they will all be combined into a classwide graph that will show GRACE data from 2003-2012.
    d. Before combining each group’s work into one graph, have students explain the trend they see in the year for which they were responsible. Once all graphs have been connected, engage students in discussion about overall trends they notice. Ask: “What is happening at the location over the 10-year time span?” “Why is this happening?”

e. Show students the Mascon Visualization Tool, which will allow them to compare their estimates with real data. Ask: “Are they similar?” “ How do they differ?” “ What accounts for the differences?” “What do these changes mean for individuals and communities?”
f. Finish by explaining that a new mission, GRACE-FO, continued to collect data in 2018, and share a JPL video about the mission (Pawlik, n.d).

Explain

After students have constructed an understanding about how water is distributed and that it is in motion, they will have an opportunity to connect this learning with the basic water cycle and figure out why the balance of water is so important.

1. Direct students to NASA’s Precipitation Education page to view an animation of the water cycle. https://gpm.nasa.gov/education/videos/water-cycle-animation
2. Under the animation, students will be directed to read the text version, and explore the clickable vocabulary links to enrich their understanding of the concept.
3. Engage students in a whole-class discussion to ensure an understanding of the process and provide opportunities to practice the vocabulary in the context of their own words.
4. Wrap up the Explain stage by partnering students and having them hold a productive talk about the following questions. Circulate the room to listen in on conversations and provide a wrap up summary when students have finished their individual discussions.
   a. Why is the water cycle important for life on Earth? Think about more than just humans.
   b. Why is water conservation important?
   c. If there was no way to increase the amount of fresh water here on Earth, what are some ways in which we can conserve the fresh water we do have?
   d. What has surprised you about the learning in this unit?

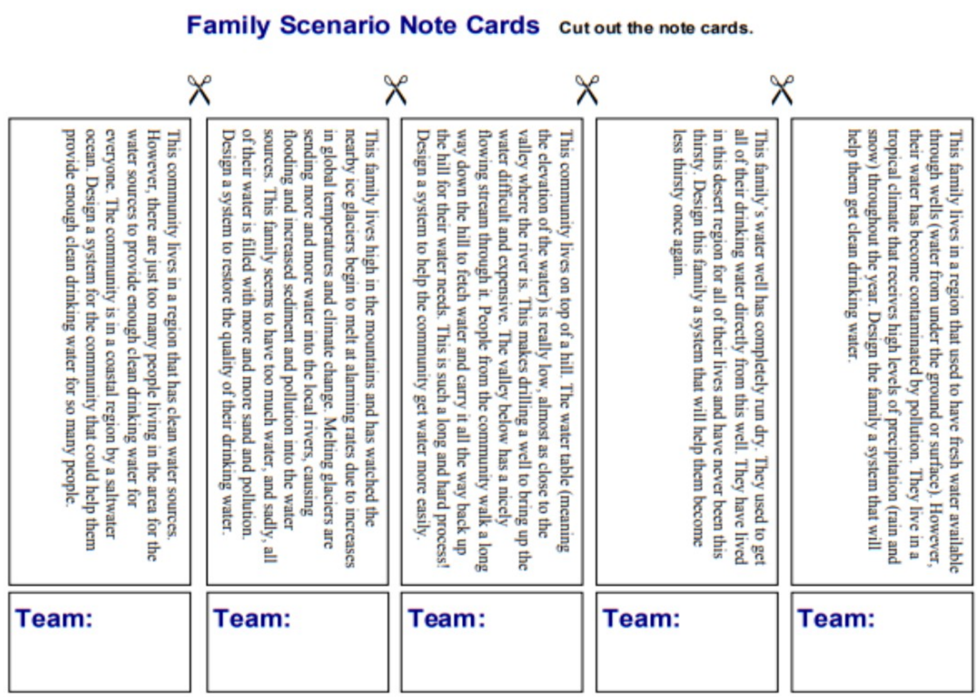
Elaborate

Students will use the knowledge gained from the unit to participate in an engineering challenge focused on how communities use and protect water resources.

1. Introduce the challenge by sharing with students some of the struggles people have around the world to get clean water, and to have water whenever they want it. For example, some people have to walk a long way to get water or a natural

disaster such as a hurricane can make water supplies unsafe for drinking until they are cleaned somehow.

2. Share with students that different kinds of engineers work together to solve these types of problems. These engineers include environmental engineers, water resource engineers, and chemical engineers. Students will be asked to take on the role of an engineer to help a family solve a water problem they are experiencing.
3. Divide the class into small groups and give each group a scenario card. On the card, they will read about a problem that needs to be solved. For example, a well may have been contaminated by pollution, or has run dry. Using an engineering design process, students will consider the problem they have been given, research the issue, brainstorm solutions, plan and create a prototype, and test and improve their original designs if feasible in the classroom setting.



4. At the end of the challenge, students will present their designs to the class by showing their model, explaining its features and why the design was chosen, and what mathematics skills were required to successfully complete the task (Shah, et al., 2006).

Evaluate

- Diagnostic Assessment (pre-assessment):
  - Use the phenomenon graphing activity from the Engage stage to assess student understanding of how water is distributed.
  - Assess student understanding of the water cycle through the drawing activity from the Engage stage.

- Formative Assessments:
  - During the Explore stage, students will be expected to accurately create percentages from their collected data. A rubric will be used to assess student understanding.

0	1	2
Students are unable to accurately collect data from the map and create percentages.	Students are able to collect data from the map, but unable to create percentages.	Students are able to accurately collect data from the map and create percentages.

  - During the Explore stage, students will be expected to understand how to interpret a heat map and graph related data. A rubric will be used to assess student understanding (Pawlik, n.d.).

0	1	2
Students are unable to articulate what a heat map communicates and did not graph data.	Students produced a graph but are unable to articulate what data the heat map provides.	Students are able to articulate the data presented in their heat maps and how the data translate to their graph.

  - During the Elaborate stage, students will be asked to self-assess using FlipGrid. They will be encouraged to consider how well they worked in the group, what contributions they made to the design, and how successfully they used engineering design best practices.

- Summative Assessment: Students will take a final test that covers the major topics of the unit. The test questions will ask students to apply the knowledge they have gained to new, but similar scenarios as discussed in class.

Watery Planet

Name: ______________
Date: ______________

Unit Assessment

It just stopped raining and now the Sun is shining, which is causing the air to warm up. Alisha decides to go outside and jump in the rain puddles on the pavement of the playground. When she comes back to the playground the next day, she notices that the puddles have all disappeared overnight, even though the puddles couldn't have soaked through the playground pavement.

1. Draw arrows and add words on the picture above to show how the puddles disappeared.

2. The Earth can be thought of as four systems (land, air, water, and living things). Two of these systems interacting caused the puddles to disappear from the playground. List which two systems you think they are and then describe how their interaction caused the puddles to disappear.

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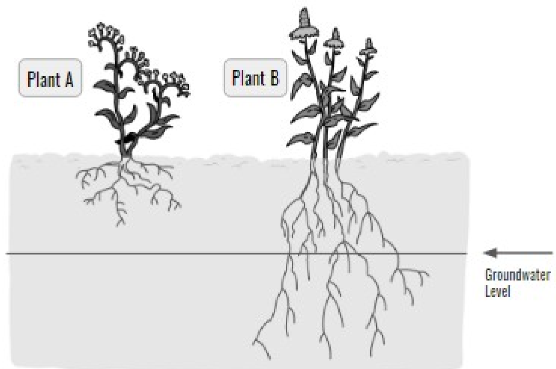

3. Jayden is trying to grow a flower garden in his town. He wants to grow two types of plants, Plant A and Plant B. Plant A has short, shallow roots and Plant B has long, deep roots. It hasn't rained in a very long time in Jayden's town. There is groundwater below the line shown in the picture above. Draw arrows and add words to the picture above to show how each plant does or does not interact with the groundwater.

4. Jayden wants to plant more flowers in his garden, but he also wants to conserve water. He wants to choose plants that won't need to be watered with a hose. Which plant, Plant A or Plant B, is a better option for Jayden's garden? Why? Use evidence from the model above to support your answer.

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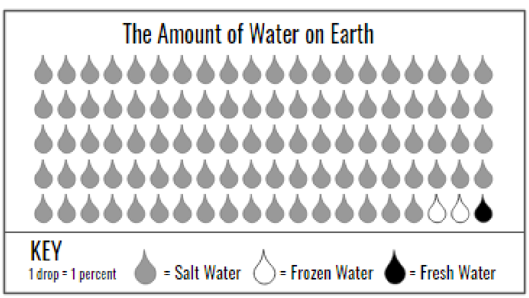

The picture above is a type of graph that shows information about the amount of water on Earth. There are 100 drops to represent 100% of the water on Earth Use this graph to help you answer Questions 7, 8, and 9.

7. How would you describe the Earth's water?
   a. Most of Earth's water is salt water. The little bit of fresh water on Earth is mostly frozen.
   b. Most of Earth's water is fresh water. The little bit of salt water on Earth is mostly frozen.
   c. Most of Earth's water is salt water. The little bit of fresh water on Earth is not frozen.
   d. Most of Earth's water is fresh water. Most of the salt water is frozen.

8. What percentage of Earth's water is NOT salt water?
   a. 1%
   b. 2%
   c. 3%
   d. 97%

9. Describe why it's important to protect the Earth's fresh water resources. Use the graph above and any other information that you know about Earth's water to support your reasoning.

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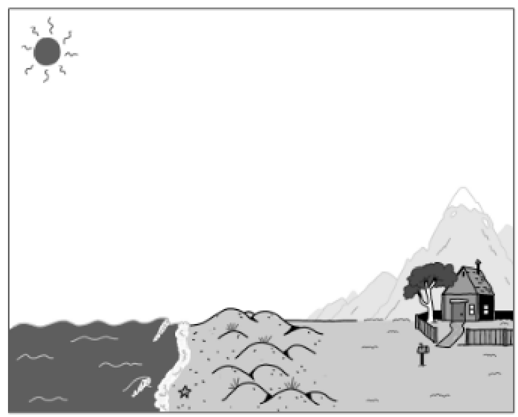
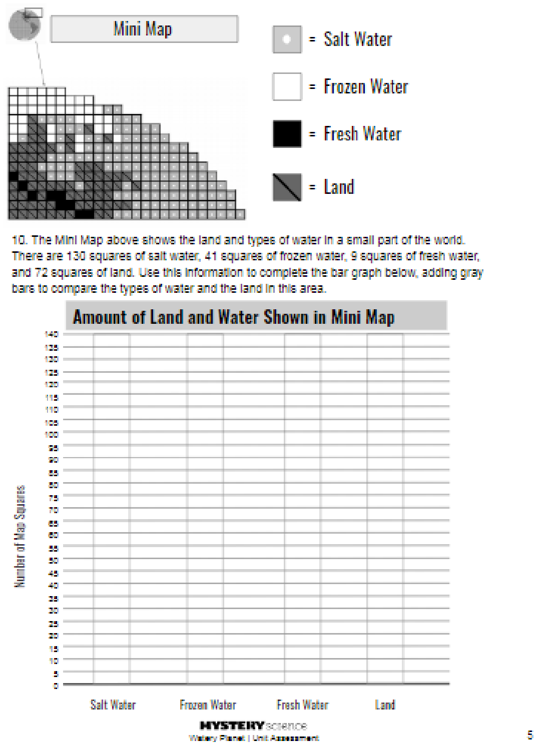


5. Sara lives in a house near the ocean. Both the air near her house and the ocean are very warm. Draw arrows on the picture above to show how the ocean (hydrosphere) can interact with the air (atmosphere) to eventually bring rain to Sara's yard. Add labels that include these words:

Condensation	Evaporation	Clouds	Rain

6. If the ocean stays the same temperature, but the air above the ocean changes to become very cold, what do you predict will most likely happen?

   a. It would probably rain less in Sara's yard because there will be less evaporation.
   b. It would probably rain less in Sara's yard because there will be less condensation.
   c. It would probably rain more in Sara's yard because there will be more evaporation.
   d. It would probably rain more in Sara's yard because there will be more condensation.


Mini Map

= Salt Water

= Frozen Water

= Fresh Water

= Land

10. The Mini Map above shows the land and types of water in a small part of the world. There are 130 squares of salt water, 41 squares of frozen water, 9 squares of fresh water, and 72 squares of land. Use this information to complete the bar graph below, adding gray bars to compare the types of water and the land in this area.

Amount of Land and Water Shown in Mini Map

Number of Map Squares

Salt Water Frozen Water Fresh Water Land

MYSTERY science
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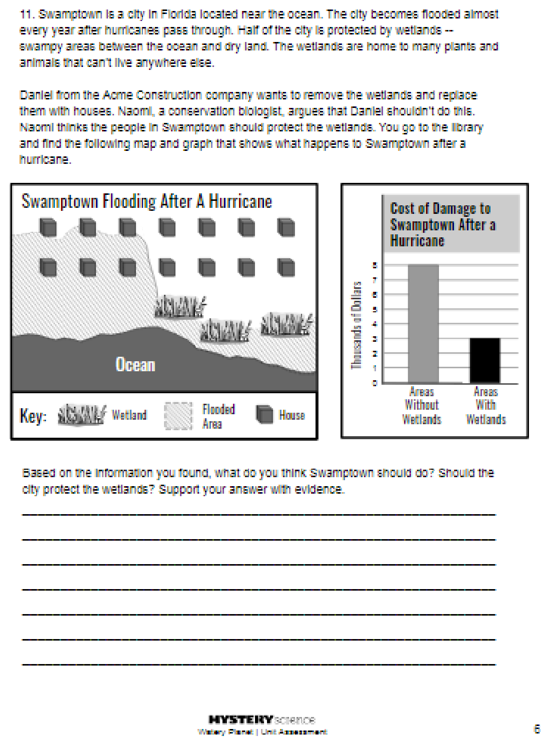
11. Swamptown is a city in Florida located near the ocean. The city becomes flooded almost every year after hurricanes pass through. Half of the city is protected by wetlands -- swampy areas between the ocean and dry land. The wetlands are home to many plants and animals that can't live anywhere else.

Daniel from the Acme Construction company wants to remove the wetlands and replace them with houses. Naomi, a conservation biologist, argues that Daniel shouldn't do this. Naomi thinks the people in Swamptown should protect the wetlands. You go to the library and find the following map and graph that shows what happens to Swamptown after a hurricane.

Swamptown Flooding After A Hurricane

Ocean

Key: Wetland Flooded Area House

Cost of Damage to Swamptown After a Hurricane

Thousands of Dollars

Areas Without Wetlands

Areas With Wetlands

Based on the information you found, what do you think Swamptown should do? Should the city protect the wetlands? Support your answer with evidence.

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MYSTERY science
Watery Planet | Unit Assessment 6

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