Aquifers and Springs

Springs have attracted humans to settle nearby where water is abundant, but careful use is necessary to balance the recharge of aquifers with the use by people. Aquifers and springs also provide aquatic habitats where unique species live on the brink of extinction.

Chapter 7

Grade Levels/Courses

6th, 7th, 8th, Aquatic Science, Environmental Science

Chapter Objectives

Students will:

1. Work in small groups to make mind maps about aquifers and springs.
2. Collaborate to make a class mind map about aquifers and springs.
3. Read the chapter and answer the questions.
4. Make a drawing with labels of an organism that would be adapted for living in an underground aquifer or a spring.
5. Answer questions about the interrelationship of their organism and its habitat.
6. Identify ways that humans might affect the environment where these organism might live.
7. Identify how increasing human populations in their organism's habitat could change the carrying capacity.
8. Take part in a simulation demonstrating how water moves through various types of rocks and soil.
9. Compare movement of water through various types of rocks and soil.
10. Identify types of permeable rocks and soils.
11. Identify impermeable natural materials such as clay and granite.
12. Explain how water moves through aquifers.
13. Draw a diagram showing movement of water through at least three kinds of natural materials.
14. Make a diagram of aquifers and a spring.
15. Build a model of aquifers and a spring.
16. Identify the parts of different types of aquifers.
17. Use their aquifer model to see how species may be affected by changes caused by humans in springs and aquifers.
18. Take part in a simulation to see how habitat changes influence species viability.

19. Use the library and Internet to research an endangered species that lives in Texas' aquifers and streams.
20. Write a report of at least six paragraphs on their organism.
21. Include information on the specialized habitat needs of organisms that live in aquifers and springs.

Texas Essential Knowledge and Skills in Science

6.1 A, B; 6.2 A, C, D, E; 6.3 A, B, C; 6.4 A; 6.12 D, E, F; 7.1 A, B; 7.2 C, D, E; 7.3 A, B, C; 7.4 A, C; 7.8 B; 7.10 A; 7.11 A; 7.12 A; 7.13 A; 7.14 A, C; 8.1 A, B; 8.2 C, D, E; 8.3 A, B, C; 8.4 A; 8.11 A, B, C

Aquatic Science: 1 A, B; 2 F, H, J; 3 A; 4 A; 7 A, B, C; 10 B; 11 A, B; 12 A, B, C, D

Environmental Science: 1 A, B; 2 F, I, K; 3 A, B; 4 A, B, D, F, G, H; 7 A, C; 9 A, B, E, J

Materials Needed

Activity 7.1

Chart paper

Markers

Science journals

Activity 7.2

Chart paper

Markers

Science journals

Activity 7.3

<u>For each group of 4</u>

Plastic jars or beakers

225 ml. gravel

225 ml. sand

225 ml. clay

225 ml. water for each soil and rock sample

Porous limestone (optional)

<u>For the Class</u>

Science journals

Pencils/pens

2 rolls of blue crepe paper streamers

Activity 7.4

Science journals

For each Pair of Students

Oil based clay (not Playdough)

Sand

Gravel

Plastic rectangular lettuce keeper or other container

Water in a spray/squirt bottle

Plastic people, plants and animals (optional)

Activity 7.5

Science journals.

Pencils/pens

Aquifer and spring models built in Activity 7.4

Food coloring

20 dice per group of four students

Copies of the Rules for the Extinction Game

Data Sheets (optional–Students may make their own data tables in their journals.)

Graphs (optional–Students may make their own graphs in their science journals.)

Blue, green, and red pens for the graph

Activity 7.6

Library

Internet

Computer

Science journal

Pencils/pens

Endangered and Threatened Animals of Texas by Linda Campbell from Texas Parks and Wildlife Department

Safety Precautions

Remind students that while they will be close together in some of the activities, they should be careful to keep each other safe.

Vocabulary

Adaptation

Alien

Aquifer
Competition
Confined
Contaminants
Ecologist
Ecology
Endangered
External stimuli
Extinction
Groundwater
Habitat
Headwater
Herpetologist
Impermeable
Invasion
Karst
Nonrenewable
Permeable
Recharge
Recharge zone
Recovery
Runoff
Spring
Status
Structures
Taxonomy
Threatened
Unconfined

Enrichments

Videos

Texas the State Springs

Teacher Resources

Endangered and Threatened Animals of Texas by Linda Campbell, Texas Parks and Wildlife Department

Lesson 7.1: What Springs to Mind?

Essential Concept

Springs and aquifers are important sources of water for Texas.

Objectives

1. Students will work in small groups to make mind maps about aquifers and springs.
2. Students will collaborate to make a class mind map about aquifers and springs.

TEKS

6.2 C; 7.2 C; 8.2 C

Aquatic Science: 2 J

Environmental Science: 2 K

Estimated Time

30 minutes

Materials

Chart paper

Markers

Science journals

Special Instructions

Prepare chart paper for groups by drawing 2 circles. In one circle put aquifers and in the other circle put springs. Connect the 2 circles with a line.

Procedure

1. Mind Mapping Aquifers and Springs

Most of Texas land surface lies above aquifers and aquifers supply about 60% of the water we use in Texas. Springs are the places where water from aquifers comes to the surface. Ask students to work in groups of 4 and draw a mind map of what they know about springs and aquifers.

Provide chart paper with “aquifers” and “springs” circles for each group. Ask students to attach any words they think of that pertain to aquifers or springs around each circle. Give students about 10 minutes to produce their mind map. Then have each group share their ideas with the class. Have group one start a class mind map by putting one of the words from their mind map on the board. Ask each group to add a new word to the mind map as

they report their group's work to the class. Continue from group to group until all the words from the mind maps are on the board.

Students may generate a wide variety of ideas such as underground, caves, rocks, drinking water, swimming, cool water, pristine, endangered species, groundwater, pollution, recharge zone, sinkhole, headwaters, limestone, reservoir, saturated, surface water, stream, wetland, etc. If students don't know a lot about aquifers and springs, that is all right. The purpose of the activity is to find out what students know so that the teacher has a place to start providing new information.

2. Gaining Understanding

Have students discuss each of the ideas from the class mind map to be sure that students understand how each word is related to aquifers and springs. Have students copy the class mind map in their science journals.

3. Looking Forward

Tell students that you will be learning more about different kinds of aquifers and some of Texas' best known springs, as well as unique ecosystems that exist in these aquatic habitats.

Vocabulary

Aquifer

Groundwater

Headwater

Recharge zone

Spring

Lesson 7.2: Reading and Research

Essential Concept

Aquifers and springs are complex systems with delicate communities of aquatic organisms.

Objectives

1. Students will read the chapter and answer the questions.
2. Students will make a drawing with labels of an organism that would be adapted for living in an underground aquifer or spring.
3. Students will answer questions about the interrelationship of their organism and its habitat.
4. Students will identify ways that humans might affect the environment where their organism might live.
5. Students will identify how increasing human populations in their organism's habitat could change the carrying capacity.

TEKS

6.2 C; 6.12 E; 7.2 C; 7.10 A; 7.11 A; 7.12 A; 7.13 A; 8.2 C; 8.11 C

Aquatic Science: 2 J; 10 B; 11 B

Environmental Science: 2 K; 4 H; 7 A; 9 A, B, E

Estimated Time

Varies. Time may be allowed in class to read and answer questions as cooperative groups or it may be done as homework.

1 period for discussion and drawing a picture

Materials

Student Chapter

Science journals

Pencils

Markers and paper

Procedure

1. Student Reading

Have students read *Chapter 7: Aquifers and Springs*. Introduce vocabulary terms as needed.

2. Questions to Consider

Assign the *Questions to Consider* as homework or use them in a cooperative learning activity.

1) What is an aquifer? What is groundwater?

An aquifer is an underground reservoir. Water in an aquifer is called groundwater.

2) What are the kinds of aquifers and how do they differ?

There are three types of aquifers. Unconfined aquifers are directly connected to the surface and have water levels dependent on relatively constant recharge. Confined aquifers are saturated layers of permeable rock materials bounded above and below by largely impermeable rocks, which can squeeze the aquifer and cause it to be under pressure, which is called an artesian aquifer. Artesian flow feeds many of Texas' famous springs. Karst aquifers are contained in limestone and marble rocks that are filled with many small channels and, in some cases large underground caverns and streams.

3) How do aquifers recharge?

Water from rainfall seeps into the aquifer through the ground.

4) What kinds of aquatic ecosystems exist in groundwater? What adaptations enable aquatic life to exist underground?

Aquifers are dark, nutrient poor, anaerobic ecosystems where microorganisms such as bacteria, protozoans, and other unicellular life may live.

Karst aquifers' caves, caverns, and underground rivers can support entire ecosystems that include invertebrates, fish, and amphibians. There is no light so there are no plants. The animals that live there are small and there are few of any one species. These animals are adapted to living in the dark and have no eyes, but they have other sensory adaptations such as antennae, chemreceptors, and touch receptors to help them find food. They also have a very low metabolism allowing them to use the food available efficiently in an environment with a constant temperature and predictable environment.

5) What is a spring? What are headwaters?

Springs are where aquifers emerge naturally on the land's surface forming a pool or stream. Headwaters are the places where rivers start and are sometimes formed by springs discharging large amounts of water.

6) How have springs influenced Texas' history?

Many springs were sites of Native American and later pioneer settlements. They are where cities later developed. Springs have played a large role in the economic development of Texas.

7) How can we help conserve groundwater?

We must limit the amount of water we take from aquifers so that they are able to recharge and maintain necessary water levels. We must also be careful with what we do to the land so that oil, gasoline, fertilizers, chemicals and other hazardous substances do not contaminate and lower the quality of our water.

3. Underground Ecosystems

Have you ever been in a cave? Discuss what it is like underground (dark, stable temperature, no plants). In addition, if it were an aquifer, there would be water. Ask students to think about descriptions in the reading and use the information to help them think about adaptations of organisms.

What kinds of organisms could live in this underground environment?

Have students imagine an animal that could live in this environment and draw a picture of the organism and label its structures showing how it would be adapted for life underground. Some students may wish to make a model instead of a drawing, or they may wish to write a story about the organism. Since students learn in different ways, these ideas provide a way to meet the needs of different students. The main criteria should be that the students provide information on structures and functions and how those structures help the organism survive in an aquifer or spring.

Are there internal structures that help your organism survive?

How does your organism respond to external stimuli?

How does the ecosystem support your organism?

If the environment changes and your organism adapts to the new changes, how might this affect subsequent populations?

What factors in the spring affect the population of your organism?

What chemical, organic, physical, and thermal changes caused by humans might affect your organism in its spring?

How would human population growth affect the aquifer or spring where your animal lives?

Do human recreational activities affect your organism in the spring?

What might change in the ecosystem if the adaptations for your organism help increase diversity? How might this affect the carrying capacity of the ecosystem?

Vocabulary

Adaptation

Aquifer

Artesian aquifers

Confined

Contaminants

External stimuli
Groundwater
Karst
Nonrenewable
Recharge
Runoff
Spring
Structures
Unconfined

Lesson 7.3: A Moving Experience

Essential Concept

Water moves into and through permeable rock in aquifers to recharge the system and keep springs flowing.

Objectives

1. Students will take part in a simulation demonstrating how water moves through various types of rocks and soil.
2. Students will compare movement of water through various types of rocks and soil.
3. Students will identify types of permeable rocks and soils.
4. Students will identify impermeable natural materials such as clay and granite.
5. Students will explain how water moves through aquifers.
6. Students will draw a diagram showing movement of water through at least three kinds of natural materials.

TEKS

6.3 A, B, C; 7.3 A, B, C; 7.8; 8.3 A, B, C

Aquatic Science: 2 H, J; 3 A; 7 B

Environmental Science: 2 I, K; 3 A

Estimated Time

1 class period

Materials

For each group of 4

Plastic jars or beakers

225 ml. gravel

225 ml. sand

225 ml. clay soil

225 ml. water for each soil and rock sample

Porous limestone

Note: Gravel and sand are easily obtained at local gardening/outdoor stores. Clay soil may have to be dug up from a nearby source such as road cuts or backyards.

Hint about clay: If you put clay soil in the container about 2 weeks prior to the activity, soak it with water for a few days, and then let it dry out, it will settle into a “cake” that will be almost impermeable, but will absorb water very slowly over time. If your clay soil

has other soils mixed in it, the clay will be more permeable than a sample that is all clay, but it will still be less permeable than the other samples.

For the Class

Science journals

Pencils/pens

2 rolls of blue crepe paper streamers (optional)

Safety Precautions

Remind students that while they will be close together in some of the activities, they should be careful to keep each other safe.

Procedure

1. Observation of Permeability of Soils and Rocks

Have 3 clear beakers or plastic jars: 1 with gravel, 1 with sand, and 1 with clay for each group. Ask each group to pour 225 ml. of water very slowly into each container one at a time. Students should observe the way water flows through the materials and write a description in their science journals of what happens in each container.

> **In which container did the water flow through fastest?**
>
> **In which container did the water move slowly or pool on top of the soil or rocks?**

If possible use porous limestone or marble, put a slab or chunk of the rock in a container and repeat the experiment.

- **What happens to the water in the limestone?** (Some of the water will run off and some will sink into the limestone filling pores and channels with water. You will see the limestone becomes a darker color as water is absorbed in tiny pores.)

Leave the limestone or marble sitting in water overnight and measure to see how much water is left in the beaker in the morning.

- **How much water did the limestone absorb?**

When water is able to make its way through a material, we say that the material is "permeable". Permeable materials have pores (small spaces) where water can collect.

2. Water Moves

In this simulation students will experience how water moves through various soils and rocks including gravel, sand, and clay. You will need an open space for the students to work. The simulation can be done outside or you can move the desks to the side of the room.

Note to the Teacher: Students who are playing the part of soil and rocks should not resist when the water molecules try to move past them.

If you would like to allow students to see the path of the water, you can have the water molecules unroll blue crepe paper streamers as they move through the soil and rocks. Have a student playing a particle of soil or rock hold the end of the crepe paper at the beginning of the water's journey.

Round 1

Appoint two students to be water molecules. The rest of the students will be gravel. Have the gravel students stand with their arms outstretched at shoulder level. They should be far apart so that they can turn completely around without touching another gravel particle. Have the water molecules flow through the gravel students to the other side of the group.

> **Was it easy or difficult to move through the gravel?** (Easy)

Round 2

Ask two more students to be water molecules. The rest of the students will represent sand. The sand students should stand with their elbows bent and sticking out from their sides with fingers touching their hips. Their elbows should be almost touching. Ask the water molecules to move through the sand to the other side of the group.

- **Was it easy or difficult to move through the sand? (**It was a little more difficult, but water was still able to move through the sand.)

When water can move through soil and rocks we say that the soil or rocks are permeable.

Round 3

Again, ask two students to be water molecules. The rest of the students will be clay particles in this round. The students who are clay particles should stand very close together with their arms at their sides. This will make it much more difficult or even impossible for the water molecules to move through the clay. Ask the water molecules to try to move to the other side of the group.

> **Was it easy or difficult to move through the clay?** (Very difficult or impossible–The water may pool up around the clay.)

We call soil and rocks that won't let water through "impermeable". Clay and granite are two impermeable natural materials that can help to contain confined aquifers.

If you have used a piece of porous limestone to test permeability, you may wish to model that interaction of rock and water also. Ask 2 more students to be water molecules. Have the rest of the students stand with arms to their side but in irregular clumps with pores and channels through the group. Ask the water molecules to move through the limestone to the other side of the group.

- **Was it easy or difficult to move through the limestone?** (It was harder than gravel or sand, but water can still move through pores and channels.)
- **Which soil or rock was the hardest to move through?** (Clay)
- **Which soil or rock was the easiest to move through?** (Gravel)

- **Which soil and rock might we find in an aquifer where water is stored and moves?** (Gravel, sand and limestone or marble)
- **Where might we find clay?** (Clay is impermeable and may form the boundaries of a confined aquifer, keeping water in a confined space within permeable rock and soils and producing pressure, which allows springs to form at the surface when the aquifer is exposed.)

3. Karst Aquifers

Karst aquifers are made of limestone or marble, and may be found in caves or porous limestone formations. Sometimes they have sinkholes, or underground streams.

We are going to see how karst forms. Give students a piece of limestone or marble, an eyedropper and some vinegar. Ask students to use a hand lens to see what happens to the limestone or marble when vinegar is dropped on it. (It will fizz as the vinegar dissolves the rock.) This is what happens when it rains on limestone, marble, and dolomite (rocks made up of calcium carbonate). Rainwater dissolves carbon dioxide from the air and forms a weak acid (carbonic acid). As this slightly acidic rain falls on limestone and other calcium carbonate rocks, the acid slowly dissolves the calcium carbonate leaving holes and channels. After a long period of time, pores, channels, caverns, sinkholes, and fissures form in the limestone making paths for water to flow through, and causing more weathering and dissolution.

- **How would this form a karst aquifer?** (Water slowly accumulates and moves through the various pores, channels, caverns, sinkholes, and fissures until a substantial amount of water is available underground.)
- **How does water move through a karst aquifer?** It may move slowly and in small amounts through pores in the limestone, or quickly and in large amounts through large caverns or even in underground rivers.

4. Using What We Learned

Ask students to use what they have observed and logical reasoning to analyze how water moves through an aquifer. Students should use their ideas to write a paragraph in their science journals (at least three sentences). They should include a diagram showing water movement through at least three kinds of natural materials.

5. Challenge Questions

Ask students to work in small group to discuss the following questions.

- **How are our lives connected to aquifers?**
- **Which aquifer provides groundwater where you live?**
- **How is your groundwater being used?**
- **Is your groundwater being conserved or is it being depleted?**

Research Question:

- **Are their any laws or regulations about what humans can do to the land above these underground water supplies? Why or why not?**

Vocabulary

Aquifer

Impermeable

Karst

Permeable

Spring

Lesson 7.4: Building a Model

Essential Concept

Springs are the places where groundwater in confined aquifers comes to the surface.

Objectives

1. Students will make a diagram of aquifers and a spring and label the parts.
2. Students will build a model of aquifers and a spring.
3. Students will identify the parts of different types of aquifers.
4. Students will explain how water gets from an underground aquifer to a spring.

TEKS

6.1 A, B; 6.2 A, C, D; 6.3 B, C; 6.4 A; 7.1 A, B; 7.2 C, D; 7.3 B, C; 7.4 A; 7.8 B; 8.1 A, B; 8.2 C, D; 8.3 B, C; 8.4 A

Aquatic Science: 1 A, B; 2 H, J; 7 A, B, C

Environmental Science: 1 A, B; 2 I, K

Estimated Time

1 class period for planning and building the model

1 class period for writing an explanation of the model and answering questions

Materials

For each Pair of Students

Oil based clay (not Playdough)

Sand

Gravel

Plastic rectangular lettuce keeper or other container

Water in a spray/squirt bottle

Plastic people, plants and animals (optional)

Special Instructions

Be sure there are no holes in the container for water to leak out.

Save the aquifer and spring models for use in the next activity.

Procedure

1. Planning a Model of Aquifers and a Spring

Distribute materials to pairs of students. Ask students to think about what they have read about how springs are formed.

Have each pair of students draw a diagram in their journals and label the parts showing how they think they could make a model of a spring. (Students should have layers of sand and gravel with a layer of clay both under and over a part of the sand and gravel layers to make both a confined and unconfined aquifer.) Walk around and look at the diagrams. Ask questions about their ideas to help clarify their thinking.

- **Where is the aquifer recharge zone?**
- **Would the recharge zone need to be higher or lower than the spring?**
- **What is confining the water in the aquifer?**
- **Is there an unconfined aquifer?**
- **What did we learn about permeable and impermeable materials?**
- **How can that information help you plan your model?**
- **Where will the spring emerge? Etc.**

Provide pictures when you can of aquifers from textbooks or the Internet to help struggling students.

2. Building the Model

When students are satisfied with their diagram, allow them to build their model.

Students should come up with a base of clay covered with sand and gravel. Sand and gravel should make a small hump at one end of the container. The sand and gravel should have another clay layer on top of it, but the clay layer should not go all the way across the container, but instead, it should leave an area of sand and gravel unconfined for recharge. The clay should be covered by a larger mound of sand covered with gravel making a big hill at one end of the container. At the bottom of the hill students may want to have mainly sand so that they can see when the water emerges from their spring.

When students are finished building their model, ask them to use the squirt bottle to make a rainstorm in their container. (Students should be sure to get their rain in the recharge zone, the area that was not covered by clay.) Watch the movement of the water**.**

Is it going to reach the spring?

If not, ask students to continue raining. Both the confined and unconfined aquifers should eventually have water. The spring should emerge on the opposite end of the container from the hill.

3. Explaining the Model

Ask students to explain in their journals how water gets to their spring and answer the following questions.

What are the parts of a confined aquifer? An unconfined aquifer?

What is the role of the recharge zone?

What is the role of the permeable soil and rocks?

What is the role of the impermeable material?

What type of aquifer is not represented by our model? (Karst aquifer)

What are the limitations of our model?

Can you think of a way to improve your design?

Vocabulary

Confined aquifer

Impermeable

Permeable

Recharge zone

Spring

Unconfined aquifer

Lesson 7.5: What Endangers Species?

Essential Concept

Species with very specific habitat needs often become endangered when their habitat changes or is lost.

Objectives

1. Students will use their aquifer model to see how species may be affected by changes in springs and aquifers caused by humans.
2. Students will take part in a simulation to see how habitat changes influence species viability.
3. Students will graph data on salamander populations from the simulation.
4. Students will explain what happened to the habitat to endanger the salamanders.

TEKS

6.2 D, E; 6.3 B; 6.12 E; 7.2 D, E; 7.3 B; 7.8 C; 7.13 A; 7.14 A, C; 8.2 D, E; 8.3 B; 8.11 B, C

Aquatic Science: 2 F, H, J; 4 A; 11 B; 12 A, B, C

Environmental Science: 2 F, I, K; 4 D, F, G; 7 A, C; 9 E, J

Estimated Time

1 class period

Materials

Science journals.

Pencils/pens

Aquifer and spring models built in the last lesson

Food coloring

20 dice per group of four students

Copies of the Rules for the Extinction Game

Data Sheets (optional–Students may make their own data tables in their journals.)

Graphs (optional–Students may make their own graphs in their science journals.)

Blue, green, and red pens for the graph

Special Instructions

You may wish to have more experienced students make their own data table and graphs in their journals.

Procedure

1. The Plight of Threatened and Endangered Species

Like most species that live in aquifers and springs, the Barton Springs salamander has a limited habitat occurring only at the spring outflows of Barton Springs. They are often found hiding among aquatic plants or under rocks and gravel or in water from a few inches up to 15 feet deep. They require the continuous flow of clear, clean spring water. While the Barton Springs salamander can live underground, it also inhabits the surface environment of the springs. They eat amphipods and other tiny crustaceans, and worms. Changes to the temperature, chemistry, sedimentation, bacteria, or flow rate of the springs can have devastating effects on these endangered species.

Biologists, ecologists, herpetologists, and other scientists study these and other endangered and threatened species to learn how to protect them and how to help them recover. They research the status of the organism (how rare the species is), the taxonomy or relationship between species, its life history (such as reproduction and food habits), and the ecology or habitat needs and interactions in order to find out what threatens the organism.

2. Where Does It Go?

Using the models of aquifers and springs built by the students in Activity 7.4, tell students that the people who live at the top of the hill used herbicides to kill off some weeds in their yard. Have each pair of students predict if they think human caused pollution on the hill in their model will make it all the way to the springs.

Then have students put 5 drops of food coloring at the top of the hill and use their squirt bottle to simulate rain. Watch for the color to appear in the aquifer and then in the spring. Students may need to simulate rain several times to get the water moving through their aquifer.

Have students answer the questions below in their journals.

- **Where is the color the strongest?** (Near the top of the hill)
- **Does the color reach the springs?** (If enough rain comes down, it should reach the springs.)
- **Even if only a little color reaches the springs, what would that mean for the sensitive organisms that live there?** (Depending on what the pollutant is, it could kill the animal outright, it could kill the plants used for shelter, it could kill the organisms used for food, and it could make the endangered species sick.)

3. Sensitive Species

Today we will take part in a simulation to look at the effects of changing conditions in the habitat of sensitive endangered species. We saw how pollution can make its way into an aquifer and spring, but there are also other changes that can occur and threaten sensitive plants and animals in an aquifer and spring. In this game we will look at the affects of changes in the aquifer or spring on the populations of sensitive organisms that live there.

Ask students to work in groups of 4 to play the game.

Round 1

In the first simulation we will change only one thing about the springs in which our endangered species lives. We will say that loss of water in the spring kills off some of the plants in the habitat.

Round 2

In the second simulation we will add an invasive species to the spring and find out what happens.

Round 3

In the third simulation we will add a chemical pollutant to the springs.

Read the rules and follow the directions. Record your results on the data table. Each line represents one month in the life of a salamander. **(See rules and data and graph sheets at the end of this activity.)**

4. Graphing Our Data

Graph your data. Use a blue pen for round one of the simulation, a green pen for round two of the simulation, and a red pen for round three of the simulation.

If students use the prepared graph, ask them to label the Y axis of the graph (population of salamanders in the spring) and record the results for each simulation with the colors suggested above.

5. Using What We Learned

Answer these questions in your science journal.

- **Did your salamanders become extinct?**
- **If so, in which round did this happen? How many months did it take in that round for extinction to occur?**
- **What can you say about the habitat in which the salamanders became extinct?** (The habitat was deteriorating, because of natural and human caused changes.)

- **Which changes to the habitat were due to natural causes and which were due to human activities?** (Spring flow decrease may be due to either natural or human causes. Invasive species and chemical pollution are due to human activities.)
- **How would the simulation represent what may happen to other endangered species?** (Sensitive species have difficulty surviving in a changing habitat.)
- **How is our model limited?** (It may underestimate the influence of changes such as invasive species in the spring or drought reducing spring flow. It does not take into account the carrying capacity of the spring.)
- **What does your data tell you about the interaction of endangered species and habitat changes?** (Endangered species often don't survive changes to their habitat, because they have a narrow range of tolerance. Their adaptations are keyed to the habitat making their habitat requirements very specific.)
- **If the number of salamander becomes very small, what happens to the gene pool? If these are the only remaining members of the species, what will happen when they die?** (The gene pool may be so small that reproduction and survival is not possible. The gene pool will be completely gone if the salamanders all die.)
- **How might this affect other organisms in the spring?** (It may change food chains, population dynamics, etc.)
- **How could humans living in the environment where the spring exists enact better environmentally friendly practices to help preserve the endangered salamander?** (Using more natural pest control and fertilizer, not releasing non-native species, being more aware of water use and conserving water in the aquifer)

Vocabulary

Ecologist

Ecology

Endangered

Extinction

Habitat

Herpetologist

Recovery

Status

Taxonomy

Threatened

Extinction Game

The rules for the simulation are:

1. Your group will have 20 dice. Divide them as equally as possible among your group.
2. The number on the dice will tell you what happens to the Barton Springs Salamander living in your spring.

These are the possible outcomes:

The salamander could continue to live well for another month.

The salamander could die.

The salamander could reproduce.

If a salamander is killed (rolls a number that changes the habitat), remove that die from the game.

If a salamander reproduces, add an extra die to the game.

If a salamander keeps living, just leave that die in the game for the next round.

Each of the dice represents one salamander. The numbers on the dice stand for different things that can happen in the habitat in different rounds.

In round one:

1=loss of water in the spring kills off plants in the habitat where the salamander hides and hunts for food and the salamander dies.

2=the salamander reproduces.

3=the salamander keeps living for another month.

4=the salamander keeps living for another month.

5=the salamander keeps living for another month.

6=the salamander keeps living for another month.

In round two:

1=loss of water in the spring kills off plants in the habitat where the salamander hides and hunts for food and the salamander dies.

2=the salamander reproduces.

3=an invasive species is introduced to the spring and the salamander dies.

4=the salamander keeps living for another month.

5=the salamander keeps living for another month.

6=the salamander keeps living for another month.

In round three:

1=loss of water in the spring kills off plants in the habitat where the salamander hides and hunts for food and the salamander dies.

2=the salamander reproduces.

3=an invasive species is introduced to the spring and the salamander dies.

4=chemical pollution makes its way to the spring and the salamander dies.

5=the salamander keeps living for another month.

6=the salamander keeps living for another month.

How to play

Everyone rolls all the dice at the same time.

1) Do what the numbers tell you to do (removing or adding dice "salamanders."
2) On the data table, keep track of how many salamanders are still in the springs after each roll of the dice. (the number of dice still in the game)
3) Play the game for three rounds each representing 20 months. (Roll the dice 20 times for each round.)

Graphing Data

Graph your data. Use a blue pen for round one of the simulation, a green pen for round two of the simulation, and a red pen for round three of the simulation.

Answer these questions in your science journal.

1. **Did your salamanders become extinct?**
2. **If so, in which round did this happen? How many months did it take in that round?**
3. **What can you say about the habitat in which the salamanders became extinct?**
4. **How would the simulation represent what may happen to other endangered species?**
5. **Which changes to the habitat were due to natural causes and which were due to human activities?**
6. **How would the simulation represent what may happen to other endangered species?**
7. **What does your data tell you about the interaction of endangered species and habitat changes? How does it tell us about the cumulative effect of multiple negative changes to an environment?**
8. **If the salamander becomes endangered, what happens to the gene pool? If these are the only remaining members of the species, what will happen when they die?**
9. **How might this affect other organisms in the spring?**

10. **How could humans living in the environment where the spring exists enact better environmentally friendly practices to help preserve the endangered salamander?**
11. **How is our model limited?**

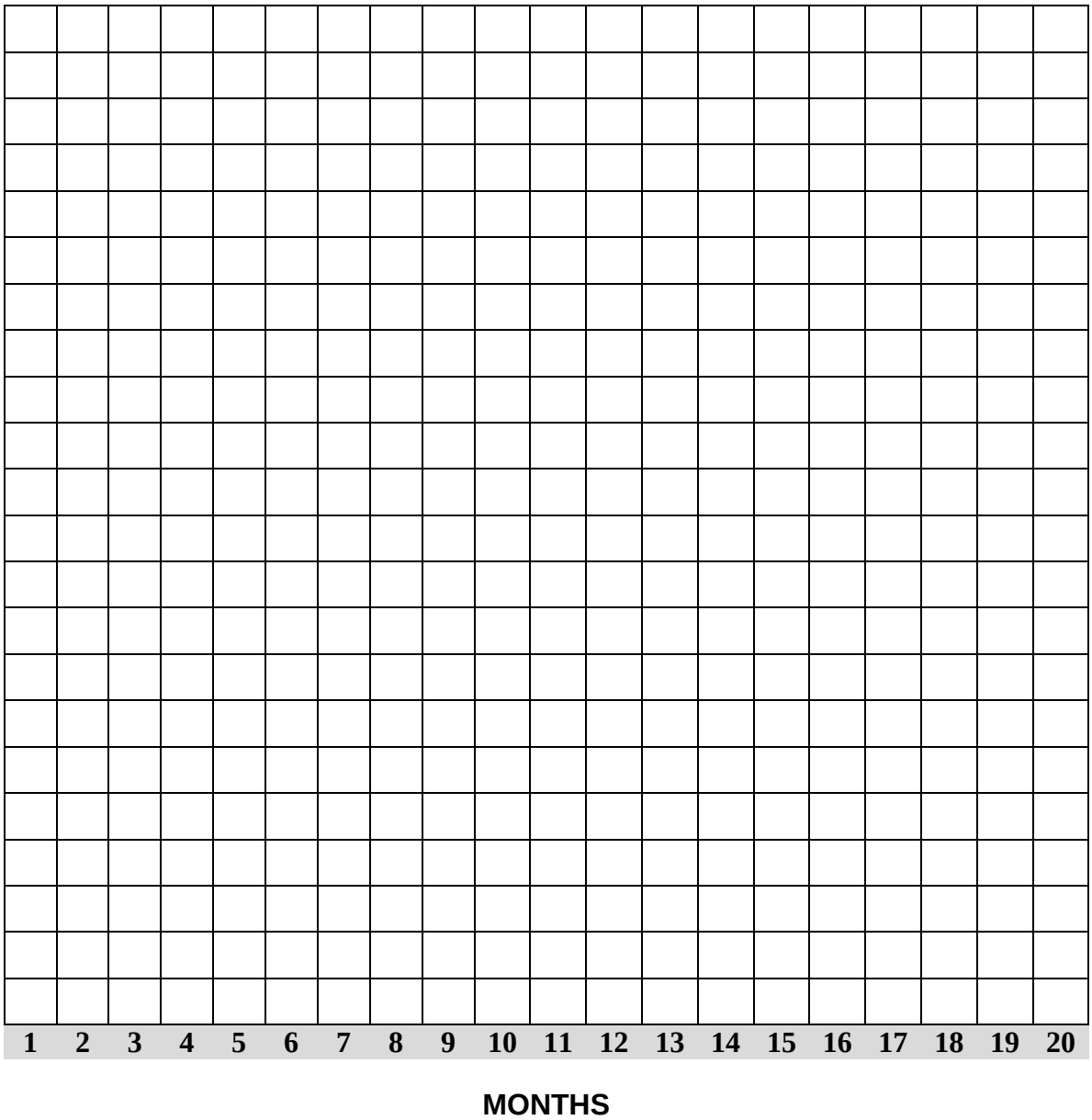
Student Page

Extinction Game Data Sheet

	Simulation 1		Simulation 2		Simulation 3
Month	Number of Salamanders	Month	Number of Salamanders	Month	Number of Salamanders
1		1		1	
2		2		2	
3		3		3	
4		4		4	
5		5		5	
6		6		6	
7		7		7	
8		8		8	
9		9		9	
10		10		10	
11		11		11	
12		12		12	
13		13		13	
14		14		14	
15		15		15	
16		16		16	
17		17		17	
18		18		18	
19		19		19	
20		20		20	

Student Page

Graph of Salamander Population



Label the Y axis of your graph and record your results for each simulation. Use a blue pen for the first simulation, a green pen for the second simulation, and a red pen for the third simulation.

What does your data tell you about the interaction of endangered species and habitat changes?

Lesson 7.6: Weird Creatures
Aquifers and Springs

Essential Concept

Unique organisms with very specialized habitat needs live in aquifers and springs.

Objectives

1. Students will use the library and Internet to research an endangered species that lives in aquifers and streams including status, life history, taxonomy, and habitat.
2. Students will evaluate the suitability of the habitat of the aquifer and spring for an alien invaders.
3. Students will write at least a six-paragraph report on their organism.
4. Students will include information on the specialized habitat needs of organisms that live in aquifers and springs.
5. Students will draw a picture of the alien invader species showing some of its characteristics.
6. Student will make a diagram of levels of organization within the spring ecosystem including organisms, populations, communities, and ecosystem.

TEKS

6.2 C; 6.12 D, E, F; 7.2 C; 7.12 A; 7.13 A; 8.2 C; 8.11 A, B, C

Aquatic Science: 2 J; 4 A; 10 B; 11 A; 12 A, B, C, D

Environmental Science: 2 K; 3 B; 4 A, B, F; 7 A, D; 9 A, E

Estimated Time

Varies. Two to three class periods if done in class, or it can be done as homework.

Materials

Library

Internet

Computer

Science journal

Pencils/pens

Endangered and Threatened Animals of Texas by Linda Campbell from Texas Parks and Wildlife Department

Procedure

1. Alien Invasion

Tell students that they will pretend to be aliens planning an invasion on the Earth. They will need to do careful observation of springs and aquifers, because that is where they will live. Their reconnaissance will need to include the kinds of organisms that already inhabit these ecosystems in Texas. They are each to choose one organism that is found in Texas aquifers and springs. They will write a report about their organism and its habitat and the suitability of that habitat as a new home for the aliens.

Students should site sources of their information about Texas organism. (books or websites)

Students should include information about the organism much like scientists use when researching endangered organisms.

They should research:

The status of the animal (threatened, endangered, not threatened)

Its life history

Its taxonomy

The habitat it requires

Any threats to its habitat

All of this should be written from the point of view of someone who wants to live in the same habitat. Be sure to state the characteristics and habitat requirements of the aliens that allow them to out compete the local species.

Students will draw a picture of their alien showing some of its adaptations.

What are the characteristics of the aliens that help them survive in an aquifer and springs?

What atmospheric geological, hydrological, or biological features make this aquatic environment a habitat suitable for the alien invaders?

Will the aliens be able to co-exist with the native organism?

Will the aliens compete with the native organism for survival needs?

Does the native organism present a threat of any kind?

What is the outlook for long-term maintenance and use of the habitat? What natural events might affect the habitat?

What impact will human populations have on the viability of the springs as a habitat for the aliens? Predict effects of chemical, organic, physical, and thermal changes from humans on the living and nonliving components of the spring.

Will human populations impact alien survival due to disease?

Will the alien invaders cause any changes to the habitat that might affect the native organisms? How might this affect the habitat that they wish to live in?

How will carrying capacity be affected by the reproductive rate of the aliens?

Have students make a diagram of the levels of organization within the spring ecosystem including organisms, populations, community, and ecosystem.

Give students the *Middle School* or *High School Rubric for Research Reports* before they start their project. There are also student instructions for middle school and for high school, as well as a list of endangered aquifer and spring organisms from which to choose a subject for research.

Students can choose from the following organisms for their research:

The Comal blind salamander

Rio Grande lesser siren

Pecos gambusia

Concho pupfish

Big Bend gambusia

Comanche Springs pupfish

Leon Springs pupfish

Texas wild rice

San Marcos salamander

Fountain darter

Texas blind salamander

Pecos gambusia

San Marcos gambusia

Clear Creek gambusia

Bone Cave harvestman

Tooth Cave pseudoscorpion

Bee Creek Cave harvestman

Tooth Cave spider

Tooth Cave ground beetle

Kretschmarr Cave mold beetle

Cave cricket

Vocabulary

Alien

Competition

Ecology

Habitat

Invasion

Taxonomy

Alien Invasion

You are an alien from Ach-Too-Oh-Mi, a watery planet. You are planning an invasion on the Earth and will need to do careful observation of springs and aquifers, because that is where you will live. Your reconnaissance will need to include the kinds of organisms that already inhabit these ecosystems.

You will also need to explain something about your alien characteristics that allow you to out compete the local species you have targeted, or fit into an unfilled niche, and what you will need in your habitat. You will write a report about a native organism and its habitat and the suitability of the habitat for your home.

You will choose one animal from an aquifer or spring habitat to research. (See attached list.) You should include information about the organism much like scientists use when researching endangered animals.

You should include in your research:

1. **The status of the organism (threatened, endangered, not threatened)**
2. **Its life history**
3. **Its taxonomy**
4. **The habitat it requires**
5. **Any threats to its habitat**

All of this should be written from the point of view of someone who wants to live in the same habitat. Keep in mind that these aliens evolved in similar habitat conditions. Be sure to state the characteristics that make it superior to native species, or how they fit a different niche and habitat requirements of the aliens.

Students will draw a picture of their alien showing some of its adaptations

1. **What are the characteristics of the aliens that allow it to survive in an aquifer and springs?**
2. **Will the aliens compete with the native organism for survival needs?**
3. **Does the native organism present a threat of any kind?**
4. **What is the outlook for long-term maintenance and use of the habitat? What natural events might affect the habitat?**
5. **What impact will human populations have on the viability of the springs as a habitat for the aliens?**
6. **Will the alien invaders cause any changes to the habitat that might affect the native organisms? How might this affect the habitat that they wish to live in?**

Make a diagram of the levels of organization within the spring ecosystem including organisms, populations, community, and ecosystem.

Student Page for High School

Alien Invasion

You are an alien from Ach-Too-Oh-Mi, a watery planet. You are planning an invasion on the Earth and will need to do careful observation of springs and aquifers, because that is where you will live. Your reconnaissance will need to include the kinds of organisms that already inhabit these ecosystems.

You will also need to explain something about your physical structures and physiological functions that allow you to out compete the local species you have targeted, or fit into an unfilled niche and what you will need in your habitat. You will write a report about a native organism and its habitat and the suitability of the habitat for your home.

You will choose one organism from an aquifer or spring habitat to research. (See attached list.) You should include information about the native organism much like scientists use when researching endangered animals.

You should include in your research:

1. **The status of the organism (threatened, endangered, not threatened)**
2. **Its life history**
3. **Its taxonomy (its relationship to other species)**
4. **The habitat it requires**
5. **Any threats to its habitat**

All of this should be written from the point of view of someone who wants to live in the same habitat. Keep in mind that these aliens evolved in similar habitat conditions. Be sure to state the characteristics that make them superior to native species, or how they fit a different niche and habitat requirements of the aliens. Draw a picture of your alien showing some of its characteristics.

1. **What are the characteristics of the aliens to survive in an aquifer and spring?**
2. **What atmospheric, geological, hydrological, or biological features make this aquatic environment a habitat suitable for the alien invaders?**
3. **Will the aliens compete with the native organism for survival needs? How?**
4. **Does the native organism present a threat of any kind?**
5. **What is the outlook for long-term maintenance and use of the habitat? What natural events might affect the habitat?**
6. **What impact will human populations have on the viability of the springs as a habitat for the aliens? Predict effects of chemical, organic, physical, and thermal changes from humans on the living and nonliving components of the spring.**
7. **Will human populations impact alien survival due to disease?**
8. **Will the alien invaders cause any changes to the habitat that might affect the native organisms? How might this affect the habitat in which the aliens wish to live?**
9. **How will carrying capacity be affected by the reproductive rate of the aliens?**

Student Page

Native Organisms in Texas' Springs and Aquifers

Choose one organism that is found in Texas aquifers and springs from the list below for your research.

The Comal blind salamander

Rio Grande lesser siren

Pecos gambusia

Concho pupfish

Big Bend gambusia

Comanche Springs pupfish

Leon Springs pupfish

Texas wild rice

San Marcos salamander

Fountain darter

Texas blind salamander

Pecos gambusia

San Marcos gambusia

Clear Creek gambusia

Bone Cave harvestman

Tooth Cave pseudoscorpion

Bee Creek Cave harvestman

Tooth Cave spider

Tooth Cave ground beetle

Kretschmarr Cave mold beetle

Cave cricket

Rubric for Alien Invasion Research

I. Organization **Total 10 points**

1. Title
2. Clear concise information
3. Organized in a logical way
4. Includes illustrations (drawing of alien)

II. Appearance **Total 20 points**

1. Neat, clean, attractive
2. Easy to read and colorful
3. Information easy to understand
4. Diagram of levels of organization is neat

III. Accuracy **Total 10 points**

1. Includes all information required
2. Uses web sites and at least 1 book
3. Information is correct and communicated appropriately.
4. Correct writing, grammar, and spelling.

IV. Critical Thinking **Total 20 points**

1. Conclusions based on logical inferences and generalizations related to data collected on websites and in books
2. Sources noted
3. Reasons for conclusions stated
4. Diagram of levels of organization of the ecosystem included

V. Includes the Following Information for the Texas Organism Total 15 points

1. The status of the animal
2. Its life history
3. Its taxonomy (its relationship to other species)
4. The habitat it requires
5. Any threats to its habitat

VI. The essay is written from the point of view of the alien who wants to live in the same habitat. Total 25 points

1. What are the characteristics of the aliens that help them survive in an aquifer and springs?
2. Will the aliens compete with the native organism for survival needs?
3. Does the native organism present a threat of any kind?
4. What is the outlook for long-term maintenance and use of the habitat? Will natural events affect the habitat?
5. What impact will human populations have on the viability of the springs as a habitat for the aliens?
6. Will the alien invaders cause any changes to the habitat that might affect the native organisms? How might this affect the habitat that they wish to live in?

Possible Grand Total 100 points

Rubric for Alien Invasion Research

I. Organization **Total 10 points**

1. Title
2. Clear concise information
3. Organized in a logical way
4. Includes illustrations (drawing of alien)

II. Appearance **Total 15 points**

1. Neat, clean, attractive
2. Easy to read and colorful
3. Information easy to understand

III. Accuracy **Total 10 points**

1. Includes all information required
2. Uses web sites and at least 1 book
3. Information is correct and communicated appropriately.
4. Correct writing, grammar, and spelling.

IV. Critical Thinking **Total 15 points**

1. Conclusions based on logical inferences and generalizations related to data collected on websites and in books
2. Sources noted
3. Reasons for conclusions stated

V. Includes the Following Information on Texas Organism **Total 15 points**

1. The status of the animal
2. Its life history
3. Its taxonomy
4. The habitat it requires
5. Any threats to its habitat

VI. The essay is written from the point of view of someone who wants to live in the same habitat. **Total 35 points**

1. What are the characteristics of the aliens to survive in an aquifer and springs?
2. What atmospheric, geological, hydrological, or biological features make this

aquatic environment a habitat suitable for the alien invaders?

3. Will the aliens compete with the native organism for survival needs? How?
4. Does the native organism present a threat of any kind to the alien species? If so, what is the threat?
5. What is the outlook for long-term maintenance and use of the habitat? What natural events might affect the habitat?
6. What impact will human populations have on the viability of the springs as a habitat for the aliens? Predict effects of chemical, organic, physical, and thermal changes from humans on the living and nonliving components of the spring.
7. Will human populations impact alien survival due to disease?
8. Will the alien invaders cause any changes to the habitat that might affect the native organisms? How might this affect the habitat that they wish to live in?
9. How will carrying capacity be affected by the reproductive rate of the aliens?

Possible Grand Total **100 points**

Chapter 7 Assessment

Multiple Choice Questions

Directions

Select the best answer for each of the following multiple-choice questions.

1. A confined aquifer has several parts including:

A Permeable material, karst, and springs

B Recharge zone, permeable material, and springs

C Impermeable material, recharge zone, and springs

D Permeable material, impermeable material, recharge zone, and springs

2. Animals in ecosystems in aquifers are adapted to which of the following conditions?

A Nutrient poor conditions

B Aerobic conditions

C No light

D A and C

3. The headwaters of a river is often found at–

A A spring

B An unconfined aquifer

C A recharge zone

D A low recharge aquifer

4. We can conserve groundwater by all of the below **EXCEPT–**

A Taking chemicals to hazardous waste disposal sites

B Using less fertilizer and herbicides

C Using impermeable materials for building

D Using less water from the aquifer

5. Aquifers are habitat for unique aquatic organisms that require clean, clear, free flowing water. These ecosystems are predictable environments with constant temperature. How would a drought affect these ecosystems?

A Increase temperature

B Decrease spring flow

C Increase carrying capacity

D Decrease aerobic conditions

Write In Questions

1. Draw a Venn Diagram comparing and contrasting ecosystems in aquifers and springs with those on land.

2. Draw a chart to compare the materials and surface interface of three kinds of aquifers.

3. Draw a diagram of how an aquifer can form a spring.

4. Explain how water moves through an aquifer.

5. Explain why both natural and human caused changes to habitat can affect species and cause them to become threatened or endangered.