Raising Your Water IQ: A Water Conservation Curriculum

Developed by the
Texas Water Development Board

Produced by
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INTRODUCTION

"When the well's dry, we know the worth of water."
- Benjamin Franklin

Water is our most precious natural resource. Without water, nothing else is possible. In this curriculum, water conservation messages and concepts derive from core academic standards detailed in the Texas Essential Knowledge and Skills (TEKS). These hands-on activities engage your students' interest in learning through our natural affinity for water.

The goals of the curriculum are to:

- Enhance students' abilities to make sound environmental decisions based on an understanding of science
- Foster students' awareness of the need for water conservation
- Help students discover and practice water conservation strategies
- Increase a sense of stewardship for local water resources, and
- Establish patterns of responsible water consumption.

This curriculum is designed to be flexible, scaffolded and interdisciplinary. Math, science, technology and social sciences combine to give students the knowledge, skills and dispositions to be more engaged, informed environmental decision-makers. The activities in this curriculum engage both hands and minds, are inquiry-based, and offer many community-based service learning opportunities. As students learn about water, they learn about themselves, and their communities.

The Texas Water Development Board has created a series of web-delivered, interactive visualizations that introduce concepts to students, and is an important component of this curriculum. Visit the site at:
http://www.twdb.state.tx.us/home/index.asp and click on TWDB For Kids.

Organization-

Online Visualizations-

- Introduce the Big Ideas of water conservation using visually engaging, interactive multimedia models.

Hands-on Activities-

- Offer investigations into the foundational concepts that build to the Big Ideas. Many of these activities explore concepts that focus groups of Texas teachers have identified as particularly difficult to teach and/or learn.
- Emerge from and are aligned with, TEKS.

- Include short, straightforward background articles for students, articulating the Big Ideas, and assessments to help teachers check for understanding.

The curriculum includes activities that explore very basic concepts of the water cycle, the relationship between surface water and groundwater, how human activity has shaped natural systems, and how the natural world has shaped human culture.

Once students have explored these concepts, investigations move them out into their communities, to discover how these concepts are applied in their neighborhoods. There are projects that engage students in in-depth analyses of their own environmental behaviors, and service learning opportunities that give students a voice in shaping their environment.

You can select only those activities that fit your specific needs, or take your classroom on a journey of discovery through the entire curriculum. Materials needed for hand-on activities are common, easy to obtain, and inexpensive. In all ways, we have tried to make this curriculum fit the needs and capacities of Texas classrooms.

WATER CONSERVATION GLOSSARY

Acid rain - Rain that has become more acidic than normal (a pH below 5.0) by combining with pollutants in the air, such as oxides of sulfur and nitrogen

Agriculture – the practice of cultivating the soil to produce crops and raise livestock

Aquifer – an underground layer of rock and sand that contains water

Bacteria – Very small, single-celled life-forms that can reproduce quickly

Chlorination – A method of water treatment where chlorine is added to disinfect the water

Commercial – related to business or business activity

Commercial customer – individual or group of people engaged in a business activity

Condensation – the process of a gas or vapor changing to a liquid form

Conservation – The care, preservation, protection, and wise use of natural resources

Contamination – The entry of undesirable organisms into some material or object reducing their quality

Delineation –the process of determining the boundary of a wetland in a specific location

Desalination - Removal of dissolved salts from seawater

Disinfection – elimination of bacteria in a water supply or distribution system

Drains – Pipes which carries away water

Drought - An extended period without rain

Dumping – Depositing garbage, sewage or environmentally harmful materials in unregulated or uncontrolled areas

Ecosystems – a community of interdependent organisms living together in an environment

Erosion – The wearing down or washing away of the soil and land surface

Evaporation – The change in state of water from a liquid to a gas

Fertilizers – A substance that improves the ability of soil to produce crops.

Filtration – A series of processes that physically removes particles from water

Flood –an excess of water that overflows the boundaries of a stream, river, or other body of water onto normally dry land

Groundwater - water naturally stored below the surface of the earth, supplying wells and springs

Groundwater contamination - The pollution of underground water

Hydrologic cycle – The movement of water from the atmosphere to the earth and back to the atmosphere through precipitation, runoff, infiltration, percolation, storage, evaporation, and transpiration

Industrial customer – an individual or group of businesses that are engaged in a particular kind of commercial enterprise

Industrial uses – the use or activity performed by industrial customer

Industrial wastes – Any wastes produced as a by-product of any industrial process or operation, other than domestic sewage.

Irrigating – Adding water to dry land to grow crops

Landfills – Land disposal sites for solid waste

Livestock– animals raised for commercial, human use

Manufacturing – The process of turning raw materials into finished products

Microorganisms – Animals and plants that are too small to be seen clearly with the naked eye

Municipal – anything related to the city, or domestic consumption.

Municipal uses – anything that is related to use by a city, or domestic consumption

Non-point Source Pollution - pollution that cannot be traced to a single, identifiable source

Nutrients - Substance that help plants and animals to grow

Organisms – A living thing: can be a human, plant, animal, bacterium or other life form

Permeability - the ability of a material to allow the passage of a liquid, such as water through rocks

Pesticides - poisons used to control undesirable organisms

Point Source Pollution – pollution from a, single identifiable source

Pollutant - Any substance introduced into the environment that causes problems for people or animals, or negatively changes the environment

Pollution -The introduction of substances to the environment which lead to undesirable effects on the natural environment.

Population - the collection of members of a single species living in a habitat

Porosity - Degree to which soil, gravel, sediment, or rock holds water

Precipitation - any kind of water that falls to the earth as part of weather events: can be rain, snow, sleet, fog, or hail

Purify – to remove all contaminants from a substance

Resource - A supply of something that can be used

Run off – Excess water that flows across the land picking up pollutants on its way to streams and rivers

Saturation - The point at which a liquid has taken into solution the maximum possible amount of a given substance at a given temperature and pressure

Sedimentation – The process by which suspended particles settle to the bottom

Septic tank – Tank used for domestic wastes when a sewer line is not available to carry them to a treatment plant

Sewage – Human-generated wastewater that flows from homes, businesses, and industries

Source - the place where something begins

Storm Drain – A pipeline that carries away excess rain, drainage or surface water

Surface water – water that is on the Earth's surface, such as in a stream, river, lake, or reservoir

Topographic maps – also called contour maps, are maps that show land shape, or elevation by means of contour lines

Toxic Contaminants - substance that can harm the health of living beings

Transpiration - The process by which plants loses water

Vapor - The gaseous form of any substance

Wastewater - Water that has been used and carries wastes from homes, businesses, and industries

Water Conservation – The care, preservation, protection, and wise use of water

Water cycle/ hydrologic cycle - The movement of water from the atmosphere to the earth and back to the atmosphere through precipitation, runoff, infiltration, percolation, storage, evaporation, and transpiration

Water treatment – A method of cleaning water for a specific purpose; such as drinking water, irrigation water or discharge to a stream.

Watershed - is the region of land whose water drains into a river, lake, sea, or ocean.

Waterways - path for water to travel across the land, such as a channel, lake, stream, river or sea

Wetlands - Areas that are covered with water during at least part of the year

WHAT IS A WATERSHED?

GRADE LEVEL 6th – 8th

Objectives

- Students will use a model to predict and observe the relationship between tributaries and the main stem of rivers as they drain to form watersheds.
- Students will investigate erosion in a watershed.
- Students will investigate point- and non-point source pollution in a watershed.

Background

In this activity students create and observe a simple model of a landform to learn about watershed systems and river flow, erosion and non-point source pollution. This activity can help students understand the concept of "systems." Critical concepts related to systems include:

- Most things are made of parts.
- Something may not work if some of its parts are missing.
- When parts are put together, they can do things that they couldn't do by themselves.
- In something that consists of many parts, the parts usually influence one another.
- Something may not work as well (or at all) if a part of it is missing, broken, worn out, mismatched, or misconnected.
- A system can include processes as well as things.
- Thinking about things as systems means looking for how every part relates to others. The output from one part of a system (which can include material, energy, or information) can become the input to other parts. Such feedback can serve to control what goes on in the system as a whole.
- Any system is usually connected to other systems, both internally and externally. Thus a system may be thought of as containing subsystems and as being a subsystem of a larger system.

(From *Benchmarks for Science Literacy*, by the American Association for the Advancement of Science, Project 2061)

All of these concepts can be explored as you work with students on this activity.

Time

Flexible, 30–45 minutes, with extensions

Materials

- Large flat pans (at least 11 x 17 — disposable roasting pans will work)
- Small cups of water with tight-fitting lids. Poke a large number of small holes in the lids to make "watering cups."
- Water supply
- Plastic sheet (can be made from a trash can liner)
- Newspapers
- 3–4 cups of soil
- 1–2 cups of colored drink mix
- Paper towels for spills
- Large watershed map — (You can locate your watershed on the Texas Water Development Board's mapping web site — http://www.twdb.state.tx.us/mapping/index.asp Select and download the map entitled, "Major River Basins in Texas.")

This activity will also help students investigate the associated concepts of *erosion* and *non-point source pollution*. The four major types of NPS pollution are:

- Sediments — Soil particles washed off the land
- Nutrients — fertilizers and animal waste
- Toxic Substances — pesticides, motor oil, etc.
- Pathogens — such as bacteria from septic systems.

Vocabulary

River — A large natural stream of water (larger than a creek)

Watershed — The specific land area that drains water into a river system or other body of water

Tributary — A stream that contributes its water to another stream or body of water

Height of land — The highest ridge-line or elevation around stream channels dividing watersheds

Landscape — An expanse of scenery that can be seen in a single view

Headwaters — The source and upper part of a stream

Mouth — The place where a stream enters another, larger stream

Floodplain — The land alongside a body of water that is subject to flooding

Erosion — The wearing down or washing away of the soil and land surface by the action of water, wind or ice. This process can be intensified by land-clearing practices related to farming, residential or industrial development, road building, or logging.

Pollutants — A waste material that contaminates air, soil, or water. Sediment, nutrients, and toxic chemicals are considered the major groups of pollutants.

Non-point Source Pollution — Pollution that cannot be traced to a single point, because it comes from many places or a widespread area. Examples include agricultural runoff or urban runoff from streets, yards and parking lots. Non point source pollution is the direct result of our everyday land use activities.

Point-Source Pollution — Pollution that can be traced to a single point, such as an industrial plant pumping waste into a surface water source, or an inefficient wastewater treatment plant discharging its waste into a surface water source.

Background

- Water flows downhill with the pull of gravity. We call a large channel of flowing water a river. A watershed is the area drained by one river. A high ridge of land (height of land) separates one watershed from another. On one side of the ridge, river water flows in one direction; on the other side, the water flows in the opposite direction.
- A large watershed may contain many smaller watersheds. A stream that flows into a larger stream or a river drains the smaller watershed. The smaller body of water that “contributes” to the larger river is called a *tributary*.
- There are 210 small watersheds in Texas, according to the EPA “Surf Your Watershed” web site (http://cfpub.epa.gov/surf/locate/index.cfm)

Method

Divide the class into small groups of 3–4 students. Give each group a large pan, several sheets of newspaper, a large sheet of plastic, a small amount of soil, a small amount of colored drink mix, and a watering cup full of water.

Have students crumple several sheets of newspaper into tight bundles, and stack them loosely in the large pan. Cover the newspaper with the plastic sheet.

Now you have a rugged *landscape* before you. Ask students to identify and/or predict the following:

- Where is the ridge with the highest elevation? (You may want to discuss *height of land.*)
- Mountains
- Where will the water go when it rains on the mountaintops?
- Where will small streams form?
- Where will streams join together?
- Where will larger rivers be located? Identify the *headwaters* and *mouth*.
- Where will ponds, lakes or oceans form?
- Can students find smaller watersheds within larger watersheds?
- Where is the largest watershed on this model?

You may wish to do the activity more than once for students to make increasingly detailed observations. Review new vocabulary words.

Ask students in each group to make it “rain” on their watershed, and check their predictions against what actually happens.

Erosion

Have students sprinkle a fine layer of soil onto their landscape. Ask them to predict where the soil will go when it "rains" on their landscape. When they have made their predictions, ask them to pour more water across the landscape to observe the "*erosion*."

Non-Point Source Pollution

When fertilizers and herbicides are overused, and when oil, antifreeze and other automotive liquids spill on the ground, they run off into waterways as *non-point source pollution.*

Have students sprinkle a fine layer of colored drink mix onto their landscape. This will act as a pollutant on the landscape. Ask them to predict where the *pollutant* will go when it "rains" on their landscape. When they have made their predictions, ask them to pour more water across the landscape to observe the *non-point source pollution*.

Assessment

Ask students to write a short paragraph answering one or more of these questions:

- What is a watershed?
- What are the parts of the watershed system?
- What is erosion, and what causes it?
- What is non-point source pollution, and what are some common pollutants?
- What natural features should we consider before we build houses and communities?
- What are the principal limitations of this watershed model?

Extensions

Looking at the land — Ask students to examine the surrounding landscape in the park or school grounds where you are located.

- Where is the highest elevation?
- Where will the water flow? (If there is time create a simple map of their table-top landscape using arrows to show the direction of water flow.)
- Where are there signs of erosion?
- Create structures to control or direct water flow across their landscape. (Gutters, drains, dams, etc.)
- If the river they created on their landscape were to flood, what land will be covered first?
- Discuss *floodplains*, the flat land along the river that is formed from sediments deposited by periodic flooding of the river. Has your community used the floodplain for a park, for housing, or for business development?

Student Name____ Date _______________________

What Is a Watershed?

A watershed is an area of land that drains to a body of water. Each watershed contains a set of streams and rivers that all drain to a single larger body of water, such as a larger river, a lake, a reservoir or an ocean. In Texas, rivers flow in a general southeastern direction, emptying into the Gulf of Mexico. Watersheds can be small, covering only a few acres, or very large, spanning thousands of miles.

A watershed includes more than just the water. Watersheds are complex systems with many smaller parts. All the surface water and groundwater, soils, plants, animals, and human activities are part of a watershed. Everything that happens in a watershed has an impact on the health of the whole system.

As the population in Texas grows, demand on available water supplies in Texas also grows. We all need to think about, and learn about, how to protect our water resources. Conservation is an especially important strategy to make sure Texas has enough water today, and into the future.

1. What are the important parts of a watershed?

2. Why is it important to protect the health of watersheds?

3. Write a question you have about this article.

TEKS/Grade Level	Learning Benchmarks
Grade 6	(2) Scientific processes. The student uses scientific inquiry methods during field and laboratory investigations. (3) Scientific processes. The student uses critical thinking and scientific problem solving to make informed decisions. (4) Scientific processes. The student knows how to use a variety of tools and methods to conduct science inquiry (5) Scientific concepts. The student knows that systems may combine with other systems to form a larger system. (14) Science concepts. The student knows the structures and functions of Earth systems.
Grade 7	(2) Scientific processes. The student uses scientific inquiry methods during field and laboratory investigations. (3) (3) Scientific processes. The student uses critical thinking and scientific problem solving to make informed decisions. (4) Scientific processes. The student knows how to use tools and methods to conduct science inquiry. (14) Science concepts. The student knows that natural events and human activity can alter Earth systems
Grade 8	(2) Scientific processes. The student uses scientific inquiry methods during field and laboratory investigations. (3) Scientific processes. The student uses critical thinking and scientific problem solving to make informed decisions. (4) Scientific processes. The student knows how to use a variety of tools and methods to conduct science inquiry. (12) Science concepts. The student knows that cycles exist in Earth systems. (14) Science concepts. The student knows that natural events and human activities can alter Earth systems.

Vocabulary

River — A large natural stream of water (larger than a creek).

Watershed — The specific land area that drains water into a river system or other body of water.

Tributary — A smaller stream that contributes its water to another larger stream or body of water.

Height of land — The highest ridge-line or elevation around stream channels dividing watersheds.

Landscape — An expanse of scenery that can be seen in a single view.

Headwaters — The source and upper part of a stream.

Mouth — The place where a stream enters another, larger stream.

Floodplain — The land alongside a body of water that is subject to flooding.

Erosion — The wearing down or washing away of the soil and land surface by the action of water, wind or ice. This process can be intensified by land-clearing practices related to farming, residential or industrial development, road building, or logging.

Pollutants — A waste material that contaminates air, soil, or water. Sediment, nutrients, and toxic chemicals are considered the major groups of pollutants.

Non-point Source Pollution — Pollution that cannot be traced to a single point, because it comes from many places or a widespread area. Examples include agricultural runoff or urban runoff from streets, yards and parking lots. Non point source pollution is the direct result of our everyday land use activities.

Point-Source Pollution — Pollution that can be traced to a single point, such as an industrial plant pumping waste into a surface water source, or an inefficient wastewater treatment plant discharging its waste into a surface water source.

SOAK IT UP: A NON-POINT SOURCE POLLUTION PREVENTION PROJECT

Overview

Solutions to water quality issues begin at home. In this service-learning project, students will map the immediate neighborhood around their school, identify features that contribute to non-point source pollution, single out a site for making improvements in the landscape and present the plan to an authentic audience of planners or community members.

Service-learning is an effective strategy for engaging students in solving real problems as they learn core academic content and practice the essential skills of learning. The more local the service project, the more meaningful it can be to students.

A critical element of effective service-learning is student voice-the degree to which students make decisions and direct their own learning. Seldom do we invite young people to re-imagine their environment. Giving students permission to take a lead in neighborhood improvements empowers them to become a more active, positive force in their community.

In this project, students have the opportunity to identify the site they want to "re-imagine" and create a new vision for the site they have chosen.

Background

Non-point source (NPS) pollution comes from many sources in urban and rural areas. Unlike point source pollution from industrial and wastewater treatment plants, NPS is caused by all of us. We all share in the causes of this type of water pollution, and we can all be part of the solution to pollution.

The primary cause of NPS pollution is runoff from rainfall or snowmelt that picks up natural and human-made pollutants from land surfaces and carries them into ground water, streams, rivers, lakes, and wetlands. Impervious surfaces and construction sites in urban areas, and farmland and barnyards in rural areas, also contribute to NPS.

The four major types of NPS pollution are:

- Sediments — Soil particles washed off the land
- Nutrients — Fertilizers and animal waste
- Toxic Substances — Pesticides, motor oil, etc.
- Pathogens — Such as bacteria from septic systems.

Time

This project can vary in length of time, depending on your schedule, size of the class, and scope of your project. Figure on at least five class periods (these can be non-consecutive) with students doing homework and research between class periods.

Note: This activity requires a field investigation in your neighborhood.

Materials

You will need:

- Neighborhood maps for each student
- Topographical maps for each team of 3–5 students
- Map Symbols Guide for each team of students

Neighborhood maps of adequate quality are available through several free online mapping sites, including Yahoo Maps, MapQuest and others. Type in your school's address, enlarge or shrink the map to meet your needs, and select the printer-friendly version to print.

Topographical maps can be purchased locally through any one of several agencies, including the Texas Natural Resources Information Systems http://www.tnris.org and nationally, through the U.S. Geological Survey http://store.usgs.gov/

Consider giving a student or a group of students the responsibility for obtaining the necessary maps.

In general, NPS comes from:

- Roads and streets (stormwater runoff)
- Agriculture
- Logging
- Mining
- Construction and land development sites
- Eroding streambanks and other habitat modifications
- Septic tanks
- Animal feeding operations
- Lawns, parks and golf courses
- Boating and marine activities.

1. Getting Started: Preparation

Divide your class into study groups of 3–5 students. Students will work in these groups throughout the project.

Reflecting

Reflection is a critical element of service-learning. Ask students to keep a daily journal of their service-learning experience. Give them daily questions to which they can respond. Collect journals periodically to check in on students' progress and thinking.

Formative reflection questions might include:

- What is working well, and what needs to be improved?
- What surprised me in my work today?
- What is the biggest challenge I faced today?
- What is hard for me to understand about the work I did today?
- What do I need to do next?
- Why is this work important to me and my community?
- What am I learning about myself through this project?

Summative reflection questions might include:

- What will I do differently next time?
- Why should my community care about non-point source pollution?
- Tell a story about your service-learning experience that is meaningful to you.
- What did you learn about your community during this project?
- How did my service project affect my community?
- What did you learn about yourself during this project?

2. Outline the Study, Identify the area

Download, or find, a map of the neighborhood around your school, and outline the boundaries of the area students will explore. Limiting the area of study gives you an important measure of control over how big the project will be. Constrain the area to make your project something you, and students, can reasonably manage. Make sure the printed map is large enough for students to mark local features on it.

3. Day One: Introducing the Project

If your students have no experience with service learning, begin by discussing the idea with them. You may want to have them talk in small groups about their neighborhood and the concerns they have.

- What works in their neighborhoods, and what do they see that could be improved? Is there litter on the streets?
- Is there a lot of automobile traffic?
- Are there enough trees to shade the buildings?
- Are there enough natural areas?
- Are there oil spots on the pavement where cars park?
- Do people sweep their yard clippings into a storm drain?

Distribute copies of the neighborhood map, the *Map Symbols Guide*, and the *Student Overview* to small groups of students. Every student in each group should read the Student Overview. Ask students to discuss the following questions in their groups:

- Why is non-point source pollution an important issue in their neighborhood?
- What kinds of non-point pollution sources do they predict they will find in their study area?
- What are their goals for the project? These might include cleaning up their neighborhood, making a difference in their community, working to solve a real problem, etc.
- Who else in the community might be interested in hearing about this service project and what students have discovered?

Share the results of students' discussions in the large group. Gather students' ideas onto one comprehensive list.

Discuss the audience to whom your students will present their findings: neighbors, planners or other policy makers. Remind students: They will need to take their study seriously if they want their audience to take their findings and recommendations seriously.

Discuss the students' goals for the project. Narrow the list of goals to a reasonable number. Don't try to do too much.

Consider how you and your students will assess how well they did on the project. How will they know if they succeeded? Ask them to think about how to evaluate their project. There are assessment ideas included with this activity.

See:

- Improvement Plan Rubric
- Oral Presentation Rubric.

4. Day Two: Survey the Area

Each team will walk the boundaries of the study area, marking likely sources of non-point source pollution, and the types of pollution generated. These include:

Types of NPS pollution:

- Sediments — Soil particles washed off the land
- Nutrients — fertilizers and animal waste
- Toxic Substances — pesticides, motor oil, etc.
- Pathogens — such as bacteria from septic systems.

Sources of NPS pollution:

- Parking lots, driveways, roads and streets (stormwater runoff)
- Agriculture
- Logging
- Mining
- Construction and land development sites
- Eroding streambanks and other habitat modifications
- Septic tanks
- Animal feeding operations
- Lawns, parks and golf courses
- Boating and marine activities.

For each likely source that teams mark on their maps, they should also include:

- Measurements of the site, where appropriate (for paved areas, lawns, etc.)
- Observations and descriptions of the source — a gas station might have spilled oil or solvents on the ground, streets may have litter, etc.
- Any appropriate information about the ownership of the site, including contact information.

Student teams should also make note of the natural areas, habitats, gardens and other places that make their community a "greener" place to live.

Students may not have a second chance to survey the neighborhood in their group, so make the most of this survey. Each student in the group should take notes, make observations, offer ideas and record information.

5. Day Three–Five: Identify Your Site, Identify Your Strategy

After students have surveyed the neighborhood, ask students to make two pie charts showing:

- The different categories of contributing sources of pollution, and
- The number of examples of each of the major categories of pollution they found.

Once you have your maps marked with contributors to non-point source pollution in your neighborhood, the next step is to choose the contributing feature your team will focus on, and a strategy for the improvement you will recommend.

Analysis of Survey Maps

Look at the street surveys and look for two trends:

- The source of the most damaging pollution
- The source of the most easily remedied pollution.

Your Strategy: Developing a Plan

Develop an action plan to remove the most easily remedied pollution. The action plan should:

- Identify the exact source of the pollution.
- Identify the impact the source is having on the stream. (Use a topographical map to determine where the pollutant might enter a waterway.)
- Decide what can reasonably be done to remove or reduce the source.
- Create all the steps necessary to remove or reduce the pollution.
- Decide who will do each step.
- Create a poster to display this information.
- Develop an oral presentation to communicate this information.

Authentic Audience

Real work deserves a real audience. Who in your community would be interested in hearing about your students' work? Is there a neighborhood group that might be interested? Who might implement your students' plans? Make contact with local groups that share your interest in neighborhood improvement and ask for time at an upcoming meeting. Have students present their findings.

Many positive changes happen when a group of interested, well-prepared students commit to making positive changes.

To Learn More

Service-learning is a promising strategy for engaging students' interest and increasing community involvement while meeting rigorous academic standards. To learn more about service-learning, including research, resources, grants and regional support, go to:

- The Texas Center for Service Learning, http://www.txcsl.org/txsl/index.html

Soak It Up Improvement Plan Rubric

	Exceptional 4	Admirable 3	Acceptable 2	Amateur 1	Score
Identifying a site for improvement	Students have accurately identified a site, and how the improvement plan or service will address the need, including expected outcomes	Students have identified a site, and how the improvement plan will address the need, but outcomes are not clearly defined	Students have not identified an appropriate site. Improvement plan doesn't clearly address issue. Outcomes are not clearly defined.	Students have not identified an appropriate site. Improvement plan doesn't clearly address issue. Outcomes are not defined, or unlikely.	
Articulating the improvement plan	Improvement plan is clearly defined, practical and effective. Student capacities are clearly considered, and the plan is realistic and practical.	Improvement plan is clearly defined, reasonably practical and effective. Student capacities may have been over- or under-estimated. The plan is reasonable and practical.	Improvement plan is vague or unfocused. Student capacities have been over- or under-estimated. The plan is somewhat practical.	Plan is unfocused or ineffective. Student capacities have been over- or under-estimated. The plan is not practical.	
Resources of the team	The resources of the team have been accurately identified. Student team members have creatively offered skills and interest areas as contributions to the team effort.	The resources of the team have been identified. Student team members have offered skills and interest areas as contributions to the team effort.	The resources of the team have been identified, but not clearly or comprehensively. Team members have offered some skills and interests to the team.	The resources of the team have not been identified. Team members have been reticent to offer skills as a contribution to the group effort.	
Student participation	All students enthusiastically participate	At least 3/4 of students actively participate	At least half the students confer or present ideas	Only one or two persons actively participate	

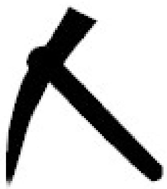
Soak It Up Improvement Plan Rubric

	Exceptional 4	Admirable 3	Acceptable 2	Amateur 1	Score
Responsibility	Responsibility for task is shared evenly	Responsibility is shared by most group members	Responsibility is shared by 1/2 the group members	Exclusive reliance on one person	
Listening and leadership	Excellent listening and leadership skills exhibited; students reflect awareness of others' views and opinions in their discussions	Students show adeptness in interacting; lively discussion centers on the task	Some ability to interact; attentive listening; some evidence of discussion or alternatives	Little interaction; very brief conversations; some students were disinterested or distracted	
Student roles	Each student assigned a clearly defined role; group members perform roles effectively	Each student assigned a role but roles not clearly defined or consistently adhered to	Students assigned roles but roles were not consistently adhered to	No effort made to assign roles to group members	
Identifying resources	Other resources have been thoroughly and accurately identified, including information, materials, community members and partnerships, and necessary funding.	Most, but not all, of the other resources have been identified, including information, materials, community members and partnerships, and necessary funding.	Some, but not most, of the other resources have been identified, including information, materials, community members and partnerships, and necessary funding.	Few of the necessary resources available have been identified. Efforts seem perfunctory.	

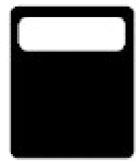
Soak It Up Improvement Plan Rubric

	Exceptional 4	Admirable 3	Acceptable 2	Amateur 1	Score
Comparing resources to project needs	Students have thoughtfully compared resources with needs. The results show an exceptional level of understanding of the issues and processes involved.	Students have compared resources with needs. The results show a thorough understanding of the issues and processes involved.	Students have compared resources with needs, but the results show an incomplete understanding of either the issues or processes.	Students have not mastered the concepts needed to compare resources with needs. Results show a lack of understanding of either the issues, or the processes.	
Getting resources	Students have precisely identified how to get needed resources. Results demonstrate a thorough familiarity with both their community, and their needs.	Students have determined how to get needed resources. Results demonstrate a familiarity with both community and needs.	Students have determined how to get needed resources, but the results show a lack of familiarity with either their community, or their needs.	Students have not determined how to get needed resources. Results show a lack of familiarity with both community and needs.	
Flow chart	Flow chart precisely maps the task. Great care and thought is evident in both design and execution.	Flow chart accurately maps the tasks. Care and thought are evident in both design and execution.	Flow chart maps the task, but is unclear, or confusing. Some care and thought are evident in either design or execution.	Flow chart does not accurately chart task. Flow is confusing. Little care or thought is evident in either design or execution.	
Plan Implementation	Plan was fully implemented. Work was shared equally. All members of the team were fully engaged and responsible.	Plan was fully implemented. Work was shared, not always equally. Most team members were fully engaged and responsible.	Plan was mostly implemented. Work was not equally shared. Some team members were engaged and responsible.	Plan was not fully implemented. Work was not fully shared. Most team members were not engaged or responsible.	

Soak It Up Map Icons

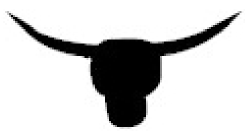

Mining


Roads & Streets

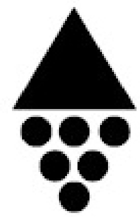

Septic Tanks

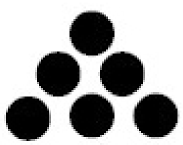

Natural Areas


Agriculture


Animal Feeding Operations

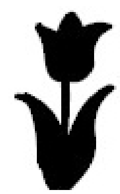

Boating and Marine Activities Modifications

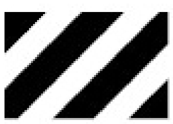

Eroding Stream Banks & Other Habitat


Logging


Habitats


Lawns, Parks & Golf Courses


Gardens


Construction & Land Development Sites

Soak It Up Oral Presentation Rubric

Name: ______________________________

	Superior	Adequate	Minimal	Inadequate
Content	The speaker provides a variety of types of content appropriate for the task, such as generalizations, details, examples and various forms of evidence. The speaker adapts the content in a specific way to the listener and situation. Solutions proposed are creative, reasonable, and are well supported by research.	The speaker focuses primarily on relevant content. The speaker sticks to the topic. The speaker adapts the content in a general way to the listener and the situation. Solutions proposed are reasonable, and are supported by research.	The speaker includes some irrelevant content. The speaker wanders off the topic. The speaker uses words and concepts which are inappropriate for the knowledge and experiences of the listener (e.g., slang, jargon, technical language). Solutions proposed are not reasonable, or are not supported by research.	The speaker says practically nothing. The speaker focuses primarily on irrelevant content. The speaker appears to ignore the listener and the situation. Solutions proposed are not reasonable, and are supported by research.
Delivery	The speaker delivers the message in a confident, poised, enthusiastic fashion. The volume and rate varies to add emphasis and interest. Pronunciation and enunciation are very clear. The speaker pauses very infrequently and has no interruptions, such as 'ahs,' 'uhms,' or 'you knows.'	The volume is not too low or too loud and the rate is not too fast or too slow. The pronunciation and enunciation are clear. The speaker pauses infrequently and has few interruptions, such as 'ahs,' 'uhms,' or 'you knows.	The volume is too low or too loud and the rate is too fast or too slow. The pronunciation and enunciation are unclear. The speaker pauses frequently and has some interruptions, such as 'ahs,' 'uhms,' or 'you knows.' The listener is distracted by problems in the delivery of the message and has difficulty understanding the words in the message.	The volume is so low and the rate is so fast that you cannot understand most of the message. The pronunciation and enunciation are very unclear. The speaker appears uninterested.
Organization	The message is clearly well organized. The speaker helps the listener understand the sequence and relationships of ideas by using organizational aids such as announcing the topic, previewing the organization, using transitions, and summarizing.	The message is organized. The listener has no difficulty understanding the sequence and relationships among the ideas in the message. The ideas in the message can outlined easily.	The organization of the message is confusing. The listener must make some assumptions about the sequence and relationship of ideas.	The message is so disorganized you cannot understand most of the message.
Creativity	Very original presentation of material; captures the audience's attention.	Some originality apparent; good variety and blending of materials / media.	Little or no variation; material presented with little originality or interpretation.	Repetitive with little or no variety; insufficient use of materials / media.
Length of Presentation	Within two minutes of allotted time .	Within four minutes of allotted time.	Within six minutes of allotted time.	Too long or too short; ten or more minutes above or below the allotted time.

Soak It Up TEKS Alignment Chart

Grade level/ Content area	TEKS Benchmarks
6th Grade — Social Science	(6) Geography. The student understands the impact of physical processes on patterns in the environment.
	(7) Geography. The student understands the impact of interactions between people and the physical environment on the development of places and regions.
	(20) Science, technology, and society. The student understands the relationships among science and technology and political, economic, and social issues and events.
	(21) Social studies skills. The student applies critical-thinking skills to organize and use information acquired from a variety of sources including electronic technology
	(22) Social studies skills. The student communicates in written, oral, and visual forms.
	(23) Social studies skills. The student uses problem-solving and decision-making skills, working independently and with others, in a variety of settings.
7th Grade — Social Science	(9) Geography. The student understands the location and characteristics of places and regions of Texas.
	(10) Geography. The student understands the effects of the interaction between humans and the environment in Texas during the 19th and 20th centuries.
	(17) Citizenship. The student understands the importance of the expression of different points of view in a democratic society.
	(20) Science, technology, and society. The student understands the impact of scientific discoveries and technological innovations on the political, economic, and social development of Texas.
	(21) Social studies skills. The student applies critical-thinking skills to organize and use information acquired from a variety of sources including electronic technology.
	(22) Social studies skills. The student communicates in written, oral, and visual forms.
	(23) Social studies skills. The student uses problem-solving and decision-making skills, working independently and with others, in a variety of settings.
8th Grade — Social Science	(10) Geography. The student uses geographic tools to collect, analyze, and interpret data.
	(12) Geography. The student understands the physical characteristics of the United States during the 18th and 19th centuries and how humans adapted to and modified the environment.
	(20) Citizenship. The student understands the rights and responsibilities of citizens of the United States.
	(22) Citizenship. The student understands the importance of the expression of different points of view in a democratic society.
	(30) Social studies skills. The student applies critical-thinking skills to organize and use information acquired from a variety of sources including electronic technology.
	(31) Social studies skills. The student communicates in written, oral, and visual forms.
	(32) Social studies skills. The student uses problem-solving and decision-making skills, working independently and with others, in a variety of settings.

TRANSPIRATION

TARGET AUDIENCE: 6th–8th grade

Time

Two class periods, with a 24-hour waiting period between

Materials

See section headings for:

- Outdoor Investigation
- Indoor Investigation.

Background Information

Transpiration, part of the water cycle, is a very difficult concept for many students to understand.

In this activity, students will conduct an experiment that demonstrates how water can be obtained and purified by taking advantage of:

- Transpiration and condensation aspects of the water cycle, and;
- Radiant energy from the sun or other light/heat source.

Transpiration is the process by which water in plants is transferred as water vapor to the atmosphere. To capture water from transpiration, students will make a solar still. A still is a tool used to distill liquids by heating and then cooling.

Prior Knowledge

Students should understand that plants hold moisture in their cells. Transpiration occurs when that moisture is transferred to the atmosphere. Transpiration requires an input of energy, in this case, energy from the sun.

Porosity — If possible, do the *Porosity Activity* with students before doing this one. Students should understand that soil holds moisture in the spaces between particles.

Water Use Inventory — Students may use data from the *Water Use Inventory* in the extension to this activity.

This activity is described in two ways. The preferred method is to use an outdoor learning area. A second option is described that will work in a classroom if you do not have an outdoor area available to you.

The Problem

You are lost in the wilderness. Pure water, free of contaminants like chemicals and other pollutants, is essential for human survival. In fact, all life on earth depends on water to some extent. Could you make a system to obtain and purify water that would save your life?

- What time of day or night would be the best time to purify water?
- What materials would you need?
- How much water could you produce in a 24-hour period?

Vocabulary

Transpiration — The process by which water in plants is transferred as water vapor to the atmosphere.

Condensation — The process of changing from a gas to a liquid or a solid.

Radiant energy — Energy that is derived by heat. Energy that comes to earth from the sun.

Teacher Notes

Divide class into small groups of 2–4 students.

Materials for Outdoor Investigation

Each group of students should have:

- Clean black plastic garbage bag, cut open fully so it will lay flat
- Small plastic or glass container, able to hold up to a liter of water. Beakers work best, if you have them.
- A variety of local plant materials- several pounds of leaves, grasses, etc. *Have each group of students weigh out and take one pound of plant materials.*
- Shovel or other implement to dig a hole
- Thermometer
- Scale.

Outside investigation — Though this outdoor still produces day and night, it will produce about 50% more water in the cooler hours between 8p.m. and 8 a.m. than it does during warmer daylight hours. The still will take up to 24 hours before collecting 1 liter of water.

Teacher Directions: Outdoor Investigation

A simple still for water condensation can be made from a clean garbage bag, plant materials, and a small collection container.

Dig a hole in the ground in a sunny place. The hole should be about 1 meter across and 1/2 meter deep or deeper if possible. The site should be preferably in moist ground.

When the hole has been dug, line it with a variety of plant materials, and pack them down. Weight the plant materials down with small flat stones. Place the collection container in the center of the hole on top of the plant materials to catch the moisture from the condensation. Put the thermometer on the plant materials, to measure the air temperature under the black plastic.

Cover the hole with the clean garbage bag. (Make sure to cut the bag open so it lies flat in a single layer.) Use some of the soil scooped from the hole to seal the edges and hold them to the ground.

Place a stone on top, and in the center of, the plastic garbage bag, over the center of the water container to weigh it down. Make sure the plastic garbage bag doesn't touch the collection container. The rock will push the black plastic down in a point aiming at the water collection container.

Moisture in the soil and in the plant materials packed in the hole will transpire as they are heated by the sun and condense on the underside of the plastic.

The condensed moisture will collect into droplets, and trickle down the underside of the plastic to the lowest point where they will drop off into the container.

To make the droplets run off more cleanly, roughen the underside of the plastic with a fine abrasive. You can use fine particles of sand, or a fine-grained stone to roughen the surface. Be extremely careful not to puncture the plastic while you do this.

Leave the still in place for 24 hours.

Teacher Directions: Indoor Investigation

Divide class into small groups of 2–4 students.

Materials

Each group of students should receive:

- A variety of local plant materials — several pounds of leaves, grasses, etc. *Have each group of students weigh out and take one-half pound of plant materials.*
- Large bucket of moist sand
- Large flat pan
- Small plastic container, able to hold up to a liter of water. A beaker is best if you have access to one.
- Small rocks
- Clean black plastic garbage bag, fully cut open so it will lay flat
- Masking tape
- Thermometer
- Sunny, warm location, or a warm light source, such as a lamp.

Fill the large flat pan with the moist sand, and dig a deep depression in it. Line the deep depression with a variety of plant materials, and pack them down. Weight the plant materials down with small flat stones. Place the collection container in the center of the hole on top of the plant materials to catch the moisture from the condensation. Put the thermometer on the plant materials, to measure the air temperature under the black plastic.

Cover the depression with the clean garbage bag. (Make sure to cut the bag open so lies flat in a single layer.) Use the masking tape to seal around the edges of the plastic bag, so the condensed liquid will not leak out.

Place a small stone on top of the plastic garbage bag over the center of the water container to weigh it down. Make sure the plastic garbage bag does not touch the collection container.

Place a light source directly above the solar still, so the light shines on the black plastic.

Moisture in the sand and in the plant materials packed in the hole will transpire as they are heated by the sun (or other heat/light source) and condense on the underside of the plastic.

To make the droplets run off more cleanly, roughen the underside of the plastic with a fine abrasive. You can use fine particles of sand, or a fine-grained stone to roughen the surface. Be extremely careful not to puncture the plastic while you do this.
Leave the still in place for 24 hours.

Data Collection

- Remove the stone from the top of the plastic then remove the plastic. Immediately note and record the temperature.
- Measure and record the amount of water that has collected in the collection container.
- Make note of the length of time that has elapsed since you began the experiment.

Discussion

- What happened?
- Which part of this activity demonstrated *transpiration*?
- Which part of this activity demonstrated *condensation?*
- Where did the water in the collection container come from?
- What caused the transfer of energy that created the water sample in the collection container?
- What part of the day produced the most water? If you don't know, how could you find out?
- What variables could you change to make more water?

Extension

Refer to the data you generated in the *Water Use Inventory*.

- Calculate the percentage of your daily water use that you generated using this still. Create a graph that shows your calculations.
- How big a still would you need in order to generate enough water for your family?

TEKS	
Grade 6 — Science	6.2(B) collect data by observing and measuring, 6.2(C) analyze and interpret information to construct reasonable explanations from direct and indirect evidence. (3) Scientific processes. The student uses critical thinking and scientific problem solving to make informed decisions. The student is expected to: (C) represent the natural world using models and identify their limitations; 8(B) explain and illustrate the interactions between matter and energy in the water cycle 9(B) compare methods used for transforming energy in devices such as water heaters.
Grade *7* — Science	(3) Scientific processes. The student uses critical thinking and scientific problem solving to make informed decisions. The student is expected to: (C) represent the natural world using models and identify their limitations;
Grade 8 — Science	(14) Science concepts. The student knows that natural events and human activities can alter Earth systems. The student is expected to: (C) describe how human activities have modified soil, water, and air quality.

Student Name____ Date _______________________

Background Information

Pure water is essential. In fact, all life on Earth depends on water. More than half of all plants and animals live in water. The human body is 2/3 water. Water is even more important than food. People can survive for many days without food, but will survive only a few days without water.

Plants hold water in their cells. Transpiration is a continuous process in which water evaporates from leaves of plants, while the roots take in water from the soil. Transpiration cools plants down (just as evaporation cools our bodies) and enables the plant to take in minerals and nutrients. This process, part of the water cycle, requires an input of energy from the sun to keep water moving through plants, into the atmosphere, where it falls to Earth again as rain, and is again taken up by plants.

How do plants move water from the soil to the atmosphere?

Where does the energy come from to make transpiration happen?

Background

Pure water is essential. In fact, all life on earth depends on water. More than half of all plants and animals live in water. The human body is 2/3 water. Water is even more important than food. People can survive for many days without food, but will survive only a few days without water.

Plants hold water in their cells. Transpiration is a continuous process in which water evaporates from leaves of plants, while the roots take in water from the soil. Transpiration cools plants down (just as evaporation cools our bodies) and enables the plant to take in minerals and nutrients. This process, part of the water cycle, requires an input of energy from the sun to keep water moving through plants, into the atmosphere, where it falls to earth again as rain, and is again taken up by plants.

Vocabulary

Transpiration — The process by which water in plants is transferred as water vapor to the atmosphere.

***Condensation* —** The process of changing from a gas to a liquid or a solid.

Radiant energy — Energy that is derived by heat. Energy that comes to earth from the sun.

Student Directions: Outdoor Investigation

1. Dig a hole in the ground in a sunny place. The hole should be about 1 meter across and 1/2 meter deep or deeper if possible. The site should be preferably in moist ground.

2. When the hole has been dug, line it with one pound of plant materials. Weight the plant materials down with small flat stones.

3. Place the collection container in the center of the hole on top of the plant materials to catch the moisture from the condensation. Put the thermometer on the plant materials, to measure the air temperature under the black plastic.

4. Cover the hole with the clean garbage bag. (Make sure to cut the bag open so it lies flat in a single layer.) Use some of the soil scooped from the hole to seal the edges and hold them to the ground.

5. Place a small stone on top of the plastic garbage bag, over the center of the water container to weigh it down. Make sure the plastic garbage bag doesn't touch the collection container. The rock will push the black plastic down in a point aiming at the water collection container.

6. Make note of the time.

7. Leave your solar still in place for 24 hours.

Data Collection

- Remove the stone from the top of the plastic then remove the plastic. Immediately note and record the temperature.
- Measure and record the amount of water that has collected in the collection container.
- Make note of the length of time that has elapsed since you began the experiment.

Think about, and be prepared to discuss these questions:

- What happened?
- Which part of this activity demonstrated *transpiration*?
- Which part of this activity demonstrated *condensation?*
- Where did the water in the collection container come from?
- What caused the transfer of energy that created the water sample in the collection container?
- What part of the day produced the most water? If you don't know, how could you find out?
- What variables could you change to make more water?

Student Directions: Indoor Investigation

1. Fill the large flat pan with the moist sand, and dig a deep depression in it. Line the deep depression with one pound of plant materials, and pack them down.

2. Weight the plant materials down with small flat stones.

3. Place the collection container in the center of the hole on top of the plant materials to catch the moisture from the condensation. Put the thermometer on the plant materials, to measure the air temperature under the black plastic.

4. Cover the depression with the clean garbage bag. (Make sure to cut the bag open so it lies flat in a single layer.) Use the masking tape to seal around the edges of the plastic bag, so the condensed liquid will not leak out.

5. Place a small stone on top of the plastic garbage bag in the over the center of the water container to weigh it down. Make sure the plastic garbage bag does not touch the collection container.

6. Place a light source directly above the solar still, so the light shines on the black plastic. You can use a lamp, or place the still in a sunny location.

7. Make note of the time.

8. Leave the still in place for 24 hours.

Data Collection

- Remove the stone from the top of the plastic then remove the plastic. Immediately note and record the temperature.
- Measure and record the amount of water that has collected in the collection container.
- Make note of the length of time that has elapsed since you began the experiment.

Think about and be prepared to discuss the following questions:

- What happened?
- Which part of this activity demonstrated *transpiration*?
- Which part of this activity demonstrated *condensation?*
- Where did the water in the collection container come from?
- What caused the transfer of energy that created the water sample in the collection container?
- What part of the day produced the most water? If you don't know, how could you find out?
- What variables could you change to make more water?

EVAPORATION

Overview

(This investigation is made up of two activities on evaporation and the role evaporation plays in water planning in Texas.)

Evaporation (part of the water cycle) occurs when water molecules absorb energy, and move fast enough to escape their liquid state to become a gas. This transformation is one of the easiest examples of the concept of energy transfer.

Applying this concept to the local environment is a powerful way to learn why the transfer of energy is an important concept. Evaporation plays a critical role in water planning in Texas. Every year, a great deal of water held in Texas reservoirs evaporates into the atmosphere. Water planners must be able to account for water lost to evaporation. The more water that evaporates, the less is available to draw upon for various uses.

In the first activity, students will investigate evaporation, and the factors that influence evaporation rates.

Background

Reservoirs are an essential part of Texas' water supply. Reservoirs stabilize the flow of water in a watershed, slow down and hold back floodwaters, provide a source of water for drinking and other uses, keep streams flowing during dry periods, help generate power and provide recreational opportunities.

Just like Texans, reservoirs come in all shapes and sizes. Some are wide and shallow, while others are narrow and deep. Texas has approximately 5,700 reservoirs with a surface area of 10 acres or larger. Overall, reservoirs in Texas cover approximately 3,065,600 acres of surface area. When reservoirs are wide and shallow, they are less efficient, losing more water to evaporation for their volume than deeper reservoirs. In the hot, dry Texas summer, evaporation rates can be very high. Refer to the enclosed map, Average Annual Evaporation, to give students an idea of how much water evaporates in your area.

Wide, shallow reservoirs also require more land to be flooded to hold the same amount of water that a narrow, deep reservoir might hold.

Materials

- Large shallow pans (three per team)
- Tall narrow containers (three per team)
- Black plastic sheeting, cut to fit into the bottom of the large flat pan
- 100 ml graduated cylinders
- Thermometers (one per group)
- Rulers (one per group)
- Light sources — either a sunny window or lights you can focus on the containers

(**Materials note:** Select the shape of the containers based on the ability of your students to calculate the area of a shape. If your students are ready to calculate the area of a circle, use round containers. If they can calculate the area of a rectangle, use square or rectangular containers.)

Extension Materials

- Copies of Reservoir Information Sheets

  OR

- Access to the Texas Water Development Board's site, "Comprehensive Surface Water Information — Statewide surface water database, links and map tool." http://wiid.twdb.state.tx.us/ims/resinfo/viewer.htm

The surface area of a reservoir is one of three major factors affecting the rate of evaporation. The three major factors that affect the rate of evaporation are:

- Water temperature
- Surface area, and
- Wind

In this investigation, students will manipulate two of these three variables to see how they affect evaporation rates. The resulting evaporation rates will be expressed in an equation, (mm/unit of surface area/hour) that includes surface area as a factor.

Please note: Measuring the evaporation from a reservoir in real field conditions is an extremely complex process. Wind, relative humidity, temperature, atmospheric pressure, surface area, water depth, water clarity and other factors make it difficult to accurately measure evaporation rates of lakes and other water bodies.

Procedure

Divide students into groups of four. Each team will set up and track an investigation into two of the factors that influence evaporation rates.

Day One

Each team will:

1. Make two sets of containers with one of each type of container. Number each of the containers to correspond to the descriptions on the Data Sheet.
2. Measure out exactly 100ml of water into a graduated cylinder. Record the temperature of the water, and pour it into the large, shallow container.
3. Calculate the surface area of the water in the container. To do that, students will need to measure the length and width of the container at the surface of the water.
4. Measure out a second 100 ml of water, record the temperature, and pour it into the tall, narrow container.
5. Calculate the surface area of the water in the container. As with the first container, students will need to measure the length and width of the container at the surface of the water.
6. Measure out a third 100 ml of water, record the temperature, and pour it into the large, shallow pan with the black plastic covering the bottom of the container.
7. Calculate the surface area of the water in the container. As with the first container, students will need to measure the length and width of the container at the surface of the water. The surface area of this pan should be exactly the same as the other large, shallow pan.
8. Put all three containers in a sunny location, or under a light source. Leave overnight.
9. Repeat these steps, filling a second large, shallow container, a second large shallow pan lined with black plastic, and a second tall, narrow container. Place this second set of three containers in a cool, dark location. Leave overnight.

Day Two

1. Record the number of hours that have passed since students began the experiment.
2. Record the temperature of the water in all six containers.
3. Re-measure the amount of water left in the containers by pouring it back into the graduated cylinder.
4. Calculate the rate of evaporation by subtracting the amount of water left from the original 100ml in the containers, then dividing it by the number of hours that have passed since they began the experiment. This gives them the rate of water loss in ml/hr.
5. Express the rate of evaporation as an equation.
6. Ask each team of students to answer the questions on the Evaporation Assessment.

Discussion

Discuss students' findings:

1. Was the water in each set of containers warmer or cooler than when they began the investigation? Which set of containers had the biggest change in temperature?

2. In which set of containers did students observe the biggest change in volume of water?

3. What was the source of energy that caused the water to evaporate?

Activity Two — Application

In this investigation, students will use their evaporation rates and apply them to real reservoirs in Texas. This extension can take two forms:

1. Included with this activity are six sample information sheets from the Texas Water Development Board's site, "Comprehensive Surface Water Information — Statewide surface water database, links and map tool." http://wiid.twdb.state.tx.us/ims/resinfo/viewer.htm

   Students can use evaporation rates from their investigations to calculate the volume of water lost from one of the sample reservoirs. Distribute copies of the Information Sheets, and ask students to apply their formula for evaporation rates to the reservoir's surface area to find the amount of water lost per day.

2. Ask students to go to http://wiid.twdb.state.tx.us/ims/resinfo/viewer.htm

   Using the mapping tool, ask students to select a reservoir in your area, or the nearest reservoir to your area, and find the surface area on the information sheet.

   Students will apply their formula for evaporation rate to the surface area of the reservoir to calculate the amount of water lost per day.

Name____ Date ____________________

Container Number	Water Temperature	Water Volume	Location	Evaporation Rate (Expressed as an equation — mm/unit of surface area/hour)
Container 1 — Large, shallow container			Set A — Sunny location	
Container 2 — Large shallow container, with black plastic			Set A — Sunny location	
Container 3 — Tall, narrow container			Set A — Sunny location	
Container 4 — Large, shallow container			Set B — Cool, dark location	
Container 5 — Large shallow container, with black plastic			Set B — Cool, dark location	
Container 6 — Tall, narrow container			Set B — Cool, dark location	

Grade Level/Content Area	TEKS
6th Grade — Science	1) Scientific processes. The student conducts field and laboratory investigations using safe, environmentally appropriate, and ethical practices.
	(2) Scientific processes. The student uses scientific inquiry methods during field and laboratory investigations.
	(4) Scientific processes. The student knows how to use a variety of tools and methods to conduct science inquiry.
	(8) Science concepts. The student knows that complex interactions occur between matter and energy.
7th Grade — Science	(1) Scientific processes. The student conducts field and laboratory investigations using safe, environmentally appropriate, and ethical practices.
	(2) Scientific processes. The student uses scientific inquiry methods during field and laboratory investigations.
	(4) Scientific processes. The student knows how to use tools and methods to conduct science inquiry.
8th Grade — Science	(1) Scientific processes. The student conducts field and laboratory investigations using safe, environmentally appropriate, and ethical practices.
	(2) Scientific processes. The student uses scientific inquiry methods during field and laboratory investigations.
	(4) Scientific processes. The student knows how to use a variety of tools and methods to conduct science inquiry.
	(10) Science concepts. The student knows that complex interactions occur between matter and energy.

Evaporation Activity Assessment

Day One			
Set A — Sunny location	Temperature	Set B — Cool, dark location	Temperature
Container 1 — Large, shallow container		Large, shallow container	
Container 2 — Large shallow container, with black plastic		Large shallow container, with black plastic	
Container 3 — Tall, narrow container		Tall, narrow container	
Day Two			
Set A — Sunny location	Temperature	Set B — Cool, dark location	Temperature
Container 4 — Large, shallow container		Large, shallow container	
Container 5 — Large shallow container, with black plastic		Large shallow container, with black plastic	
Container 6 — Tall, narrow container		Tall, narrow container	

1. Write down the equation you used to calculate the rate of evaporation.

2. Which set of containers had the biggest change in temperature?

3. In which set of containers did you observe the biggest change in volume of water?

4. Which **two** of these statements are best supported by the data?

   a. Cooler temperature = more evaporation
   b. Higher surface area = more evaporation
   c. Higher surface area = higher temperature
   d. Taller container = higher temperature
   e. Higher temperature = more evaporation

5. This activity demonstrated a transfer of energy. Explain what happened in this energy transfer. In your explanation, please include:

   a. The source of energy,
   b. The substance that absorbed the energy,
   c. How water evaporates (what happens to the molecules that make up water)
   d. The variable that increased the rate of energy absorption, and
   e. The result of the exchange of energy.

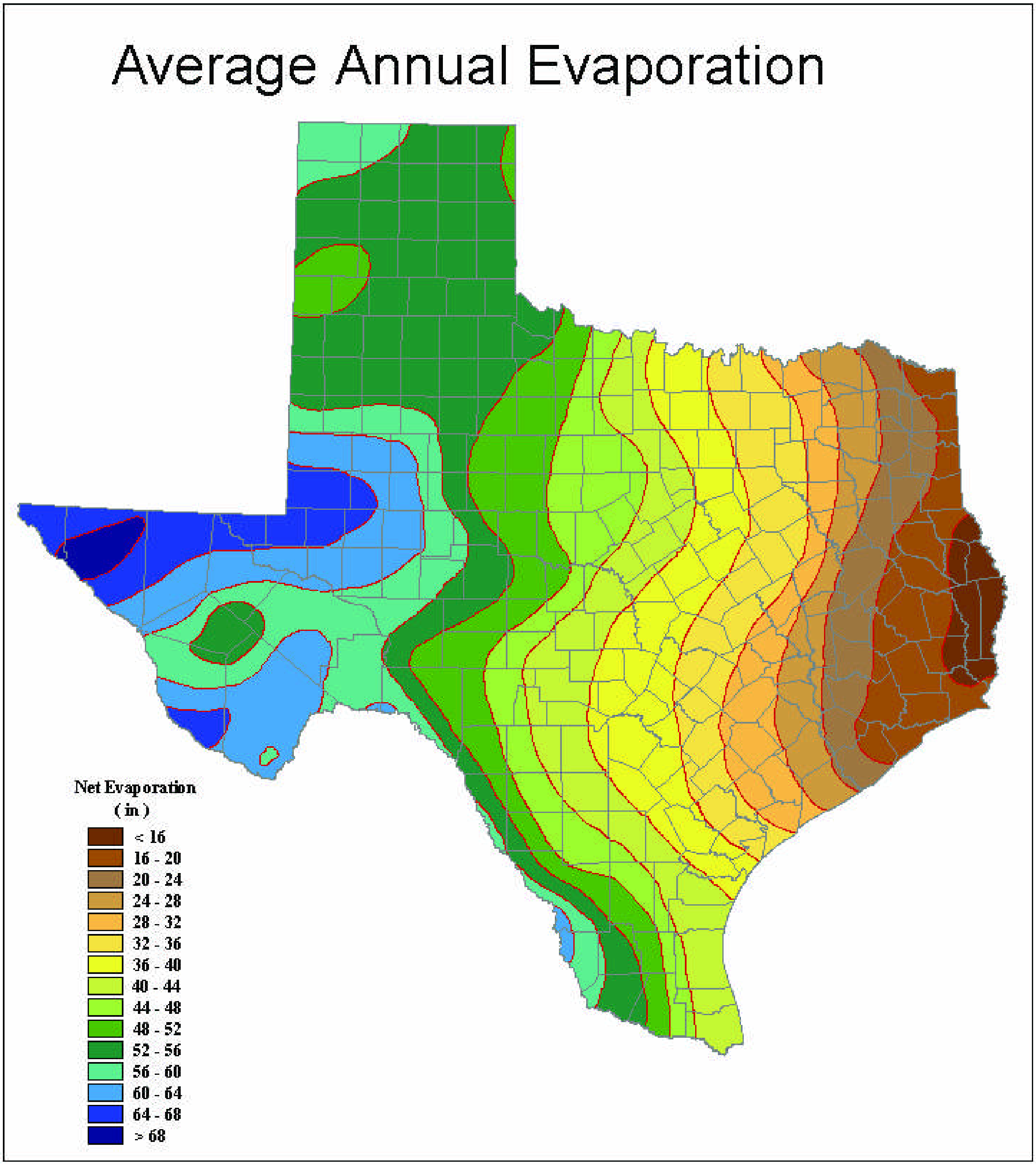
Background Information

Pure water is essential. In fact, all life on earth depends on water. More than half of all plants and animals live in water. The human body is 2/3 water. Water is even more important than food. People can survive for many days without food, but will survive only a few days without water.

Plants hold water in their cells. Transpiration is a continuous process in which water evaporates from leaves of plants, while the roots take in water from the soil. Transpiration cools plants down (just as evaporation cools our bodies) and enables the plant to take in minerals and nutrients. This process, part of the water cycle, requires an input of energy from the sun to keep water moving through plants, into the atmosphere, where it falls to earth again as rain, and is again taken up by plants.

How do plants move water from the soil to the atmosphere?

Where does the energy come from to make transpiration happen?


Average Annual Evaporation
Net Evaporation
(in)
< 16
16 - 20
20 - 24
24 - 28
28 - 32
32 - 36
36 - 40
40 - 44
44 - 48
48 - 52
52 - 56
56 - 60
60 - 64
64 - 68
> 68

TWDB Reservoir Information Sheet: Natural Dam Lake

Texas Reservoir Number		14033
Reservoir Name		Natural Dam Lake
Also Known As		
Impoundment Name		
Dam Name		
Owner		Colorado River Municipal Water District
Dam Length (Feet)		
Elevation at Top of (Feet MSL)	Dam	
	Flood Pool	
	Conservation Pool	2457
	Dead Zone	
Storage at Top of (Acre-Feet)	Flood Pool	
	Conservation Pool (Original)	54560
	Conservation Pool (Surveyed)	
	Dead Zone	
Surface Area at Top of (Acre)	Conservation Pool (Original)	3605
	Conservation Pool (Surveyed)	
Date of Last Survey		
Drainage Area (Square Miles)		
Main Purposes		water quality
Year of Completion		1989
Basin ID		14
River Basin		Colorado
Stream		Sulphur Springs Draw
County		Howard
Nearest Town		Big Spring
Direction to Nearest Town		8 miles W
Water Planning Region		F
Dam Central Latitude		32.2183
Dam Central Longitude		-101.625
Reservoir Gage		8123640
Upstream USGS Streamflow Gage		
Downstream USGS Streamflow Gage		
Major Water Rights		P5480
Elevation-Area-Capacity		Table, Graph
Lake Photos		Link
Real-Time Reservoir Status		Link
Engineering Plate		Link

TWDB Reservoir Information Sheet: Richland-Chambers Reservoir

Texas Reservoir Number		08240
Reservoir Name		Richland-Chambers Reservoir
Also Known As		
Impoundment Name		
Dam Name		Richland-Chambers Dam
Owner		Tarrant Regional Water District
Dam Length (Feet)		31000
Elevation at Top of (Feet MSL)	Dam	330
	Flood Pool	
	Conservation Pool	315
	Dead Zone	
Storage at Top of (Acre-Feet)	Flood Pool	
	Conservation Pool (Original)	1181866
	Conservation Pool (Surveyed)	1136600
	Dead Zone	
Surface Area at Top of (Acre)	Conservation Pool (Original)	44252
	Conservation Pool (Surveyed)	41356
Date of Last Survey		Oct 1994
Drainage Area (Square Miles)		1957
Main Purposes		water supply, recreation
Year of Completion		1987
Basin ID		8
River Basin		Trinity
Stream		Richland Creek
County		Navarro
Nearest Town		Kerens
Direction to Nearest Town		14.4 mi. N
Water Planning Region		C
Dam Central Latitude		31.95
Dam Central Longitude		-96.1417
Reservoir Gage		8064550
Upstream USGS Streamflow Gage		8064100
Downstream USGS Streamflow Gage		8065000
Major Water Rights		C5030, C5035, C5035A
Elevation-Area-Capacity		Table, Graph
Lake Photos		Link
Real-Time Reservoir Status		Link
Engineering Plate		Link

TWDB Reservoir Information Sheet: Smithers Lake

Texas Reservoir Number		12450
Reservoir Name		Smithers Lake
Also Known As		
Impoundment Name		
Dam Name		Smithers Lake Dam
Owner		Reliant Energy
Dam Length (Feet)		3000
Elevation at Top of (Feet MSL)	Dam	71
	Flood Pool	
	Conservation Pool	66
	Dead Zone	
Storage at Top of (Acre-Feet)	Flood Pool	
	Conservation Pool (Original)	18700
	Conservation Pool (Surveyed)	
	Dead Zone	
Surface Area at Top of (Acre)	Conservation Pool (Original)	2480
	Conservation Pool (Surveyed)	
Date of Last Survey		
Drainage Area (Square Miles)		24.2
Main Purposes		industrial, flood control
Year of Completion		1957
Basin ID		12
River Basin		Brazos
Stream		Dry Creek
County		Fort Bend
Nearest Town		Richmond
Direction to Nearest Town		10 miles SE
Water Planning Region		H
Dam Central Latitude		29.48
Dam Central Longitude		-95.63
Reservoir Gage		
Upstream USGS Streamflow Gage		
Downstream USGS Streamflow Gage		
Major Water Rights		C5325
Elevation-Area-Capacity		Table, Graph
Lake Photos		Link
Real-Time Reservoir Status		Link
Engineering Plate		Link

TWDB Reservoir Information Sheet: B A Steinhagen Lake

Texas Reservoir Number		06130
Reservoir Name		B A Steinhagen Lake
Also Known As		
Impoundment Name		
Dam Name		Town Bluff Dam
Owner		Corps of Engineers-SWF
Dam Length (Feet)		6698
Elevation at Top of (Feet MSL)	Dam	95
	Flood Pool	85
	Conservation Pool	83
	Dead Zone	
Storage at Top of (Acre-Feet)	Flood Pool	124786
	Conservation Pool (Original)	94200
	Conservation Pool (Surveyed)	66972
	Dead Zone	16600
Surface Area at Top of (Acre)	Conservation Pool (Original)	13700
	Conservation Pool (Surveyed)	10687
Date of Last Survey		May 2003
Drainage Area (Square Miles)		7573
Main Purposes		water supply, hydropower
Year of Completion		1951
Basin ID		6
River Basin		Neches
Stream		Neches River
County		Tyler, Jasper
Nearest Town		Town Bluff
Direction to Nearest Town		0.5 mile N
Water Planning Region		I
Dam Central Latitude		30.7667
Dam Central Longitude		-94.15
Reservoir Gage		8040000
Upstream USGS Streamflow Gage		8033500
Downstream USGS Streamflow Gage		8040600
Major Water Rights		C4411, C4411A, C4411B, C4411C excluding the backups for other diversion
Elevation-Area-Capacity		Table, Graph
Lake Photos		Link
Real-Time Reservoir Status		Link
Engineering Plate		Link

TWDB Reservoir Information Sheet: Lake Corpus Christi

Texas Reservoir Number		21070
Reservoir Name		Lake Corpus Christi
Also Known As		
Impoundment Name		
Dam Name		Wesley E. Seale Dam
Owner		City of Corpus Christi
Dam Length (Feet)		5980
Elevation at Top of (Feet MSL)	Dam	106
	Flood Pool	
	Conservation Pool	94.3
	Dead Zone	55.5
Storage at Top of (Acre-Feet)	Flood Pool	
	Conservation Pool (Original)	308700
	Conservation Pool (Surveyed)	257260
	Dead Zone	140
Surface Area at Top of (Acre)	Conservation Pool (Original)	
	Conservation Pool (Surveyed)	18256
Date of Last Survey		January 2002
Drainage Area (Square Miles)		16656
Main Purposes		water supply, recreation
Year of Completion		1958
Basin ID		21
River Basin		Nueces
Stream		Nueces River
County		San Patricio, Jim Wells
Nearest Town		Mathis
Direction to Nearest Town		4 miles SW
Water Planning Region		N
Dam Central Latitude		28.0417
Dam Central Longitude		-97.865
Reservoir Gage		8210500
Upstream USGS Streamflow Gage		8210100
Downstream USGS Streamflow Gage		8211000
Major Water Rights		C2464
Elevation-Area-Capacity		Table, Graph
Lake Photos		Link
Real-Time Reservoir Status		Link
Engineering Plate		Link

TWDB Reservoir Information Sheet: Lake Texoma

Texas Reservoir Number		02230
Reservoir Name		Lake Texoma
Also Known As		
Impoundment Name		Lake Texoma
Dam Name		Denison Dam
Owner		Corps of Engineers-SWT
Dam Length (Feet)		15200
Elevation at Top of (Feet MSL)	Dam	670
	Flood Pool	640
	Conservation Pool	617
	Dead Zone	
Storage at Top of (Acre-Feet)	Flood Pool	5393000
	Conservation Pool (Original)	2733000
	Conservation Pool (Surveyed)	2516232
	Dead Zone	11000
Surface Area at Top of (Acre)	Conservation Pool (Original)	89000
	Conservation Pool (Surveyed)	74686
Date of Last Survey		June 2002
Drainage Area (Square Miles)		39719
Main Purposes		water supply, hydroelec, flood protection, recreation
Year of Completion		1944
Basin ID		2
River Basin		Red
Stream		Red River
County		Grayson
Nearest Town		Denison
Direction to Nearest Town		5 miles nw
Water Planning Region		C
Dam Central Latitude		33.8183
Dam Central Longitude		-96.57
Reservoir Gage		7331500
Upstream USGS Streamflow Gage		
Downstream USGS Streamflow Gage		7331600
Major Water Rights		P2006, P5003, C4898, C4899, C4900, C4901
Elevation-Area-Capacity		Table, Graph
Lake Photos		Link
Real-Time Reservoir Status		Link
Engineering Plate		Link

WATER TREATMENT

Overview

In this inquiry activity, students will design, construct and test a model wastewater treatment plant.

Background

Everything that goes down the drain becomes part of our water systems. The remains of dinner when you wash the dishes, detergent from the laundry, everything you flush down the toilet (unless you have a septic tank), whatever is ground up in your garbage disposal, it all cycles through — first to the wastewater treatment facility, and then back into the water cycle. Water treatment is a critical part of ensuring that Texas has enough clean water to meet the growing demand.

In most wastewater treatment plants, there are two stages of treatment. In the primary stage, solids are removed through sedimentation. Water is held in large tanks, the solids settle to the bottom and are pumped out for disposal.

Grease and oil are skimmed off the top of these tanks and removed for disposal or incineration.

Secondary treatment involves aerating the water, or mixing it to increase the volume of oxygen, then adding different types of microorganisms. The microorganisms "eat" the remaining foreign substances in the water. When the microorganisms die, they fall to the bottom of the tank and the resulting sludge is pumped out for disposal.

Water is treated with chlorine to kill any remaining bacteria, then filtered through carbon filters to reduce the toxicity. In the final step before it is pumped back into the waterways, water is treated with sulfur dioxide to reduce the concentration of chlorine. Chlorine helps clean the water of harmful microorganisms, but it could be harmful to the river ecosystem.

Wetlands are a naturally occurring part of wastewater treatment. Wetlands act as sponges, absorbing and processing many of the nutrients in water. Wetland plants trap sediments in their root systems and slow the flow of non-point source pollution to surface and groundwater sources.

In this inquiry-based activity, students will watch a demonstration, and investigate methods of treating and cleaning water using a variety of tools and materials.

Time

This activity will take two or three 45–55 minute periods, depending on how you structure the investigation. Begin with a demonstration of how wetland plants absorb pollutants, a discussion of what is in wastewater, and a planning session for teams to investigate materials, and begin to design their models. Days two and three offer an opportunity for students to design, test and refine their model, adding layers of inquiry, discovery, and student engagement.

Materials

Demonstration

- Celery — 2–3 stalks per group
- Food coloring
- Glass jar
- Water

Wastewater Treatment

This materials list is extensive, but the variety of materials is intended to give students lots of ideas and tools to experiment with as they create their treatment plant. If you don't have every one of these items, use what you can reasonably gather.

- Large flat pans — one per group (Note: disposable roasting pans will work.)
- Fine sand — at least 2 cups per group
- Fine gravel — at least 2 cups per group
- Gravel — at least 2 cups per group
- Alum (potassium aluminum sulfate, can be found in the spice aisle at grocery stores)
- Filter papers (Cone-shaped coffee filters will work.)
- Rubber bands

(continued next page)

Method

As you plan for this investigation, you will need to decide in advance if students' work will span two days, or three.

Day One

- Read background article
- Wetlands demonstration
- Discuss what is in the water
- Investigate materials
- Plan model

Day Two

- Build and test model
- Demonstrate model

  OR
- (Plan modifications)

Day Three

- (Revise and demonstrate model)

Materials

Wastewater Treatment *(continued)*

- Empty 2-liter soda bottles — several per group
- Glass jars with lids — one per group (Note: 1-quart canning jars or empty mayonnaise jars work well.)
- Small plastic cups
- Scissors
- Graduated cylinders
- Granulated activated charcoal
- Paper towels
- Duct tape
- Water quality test kits (optional)

Pollutants in the Water

- Soil — (Sediments) at least 1 cup per group
- Food coloring (Nutrients)
- Vinegar (alters pH)
- Salad oil — (Toxics) about a cup
- Liquid detergent
- Grass clippings

Day One — Introduction

Ask students to read the background article before the inquiry begins.

Begin the inquiry with a demonstration and a discussion.

Explain to students that they will be building a model wastewater treatment plant. They can use any of the materials provided. They can bring additional materials from home if they want.

Each model must meet the following criteria:

- Each model must use only the materials provided, or those brought by students from home
- Each model must fit into the roasting pan
- Each model treatment plant has at least two stages
- Each treatment plant must remove all of the pollutants listed above.

Demonstration

Wetland plants are a vital part of the water system. They clean the water as they absorb pollutants. We can see how that happens in a simple demonstration.

1. Measure out 50 ml of water, and pour it into a glass jar.

2. Add 3–4 drops of food coloring (representing a pollutant) to the water.

3. Cut across the large ends of 2–3 stalks of celery. Put the cut ends of the celery stalks into the colored water.

4. Leave the celery and the water undisturbed for 24 hours.

While the celery demonstration is working, begin a discussion with students about substances that might be found in water. In the wetlands demonstration, the food coloring represents a pollutant, but what exactly is it representing?

In small discussion groups, ask them to list substances that they send down the drain.

- Which rooms in the house have sinks, or water faucets?
- In each of these rooms, make a list of things that go down the drain.
- How is water used outside their homes?
- Where does that water go, and what does it carry with it?
- In the school, how many rooms have drains? Make a list of what goes down these drains.
- Where is the closest wastewater treatment plant?

Gather students' lists onto a large chart or whiteboard. Ask students to create categories of substances, and organize the lists into categories.

Introduce the materials available to them for constructing their wastewater treatment plant. Discuss the methods of water treatment used by municipal wastewater treatment plants. Talk about which materials they have that will replicate commercial treatment methods.

Discuss how they will determine the quality of the water they have treated. If you have water quality testing kits, consider conducting tests on the water students treat with their model treatment plants. If you do not have water-testing kits, what other methods could students use? Visual comparisons, "smell" tests, how clear is the water {this can be measured with a secchi disk} does it have an oil sheen, can you test the pH, etc.

Category	Method	Materials
Physical	**Aeration** — Mixing air and water to increase the amount of oxygen in the water.	Glass jars
	Sedimentation — Letting solids settle out of wastewater.	Soda bottles, glass jars
	Filtration — A process for removing solids from water by passing them through a filter, or filtering materials like sand or gravel.	Filter paper
Chemical	**Coagulation** — Using chemicals to make suspended solids gather or group together into small clots called "flocs."	Alum
	Disinfection — A chemical process that kills microorganisms.	N/A
Biological	**Bioremediation** — Using bacteria and enzymes to "eat" the pollutants in wastewater.	N/A

As a final discussion, give students time in their small groups to begin talking about the **design** of their model. Let them look through the materials and begin thinking about how to construct their wastewater treatment plant.

Day Two — The Model

Begin by checking on the celery stalk experiment. The celery will have pulled water (and food coloring) up into the veins in the stalk. This is a powerful visualization of how effective plants can be in removing and sequestering pollutants from water.

Give each group of students a large roasting pan. Each group of students may select the materials they need for their wastewater treatment model, based on their discussion and design from the previous day.

Give students as much time as possible to design and test their models. Each group will complete a Water Treatment Reporting Sheet, detailing their model, and explaining their treatment methods.

If you are planning on doing the inquiry extension, wait until the end of the third day to have students fill out their reports. Instead, ask students to discuss how their groups could refine their model.

- Which parts of their model work well?
- Which parts of their treatment process need refining?
- How will they change their models?
- What additional materials do they need? (Students will need to bring any materials not provided from home.)

Important — Ask students to save a sample of the water they treated using the first version of their wastewater treatment plant. They will compare this sample to water they treat after refining their model.

Day Three — Refining the Model

If you plan this investigation to happen over three days, the third day has students refining their models to improve the effectiveness of their wastewater treatment plant model.

Using their assessment of the first model, give students time to change and refine their model, and retest water samples.

Ask each group to report their findings, and compare treatment methods. Each individual student should fill out a report on their investigation. Use these reports to assess students' understanding of the investigation.

Water Treatment Background

According to the U.S. Environmental Protection Agency, water pollution comes from three major sources: industrialization, human population growth and natural resource development. Once water is polluted, it is very difficult to clean up.

There are many different kinds of pollutants in wastewater, so wastewater treatment plants need to use many processes to clean it up. These processes can be grouped into three categories:

Physical	**Aeration** — Mixing air and water to increase the amount of oxygen in the water. **Sedimentation** — Letting solids settle out of wastewater. **Filtration** — A process for removing solids from water by passing them through a filter, or filtering materials like sand or gravel.
Chemical	**Coagulation** — Using chemicals to make suspended solids gather or group together into small clots called "flocs." **Disinfection** — A chemical process that kills microorganisms.
Biological	**Bioremediation** — Using bacteria and enzymes to "eat" the pollutants in wastewater.

In many areas, wetlands are part of the water treatment process. Wetlands act as sponges, absorbing and processing many of the nutrients in water. Wetland plants trap sediments in their root systems. They also slow the flow of non-point source pollution to surface and groundwater sources.

In municipal wastewater treatment plants, there are generally two stages of treatment. In the primary stage, solids are removed through sedimentation. In this process, water is held in large tanks; the solids settle to the bottom and are then pumped out for disposal.

Grease and oil is skimmed off the top of these tanks and removed for disposal or incineration.

Secondary treatment involves aerating the water, or mixing it to increase the volume of oxygen, then microorganisms are added. The microorganisms "eat" the remaining foreign substances in the water. When the microorganisms die, they fall to the bottom of the tank and are pumped out for disposal.

The water is treated with chlorine to kill any remaining bacteria, then filtered through carbon filters to reduce the toxicity. In the final step before it is pumped back into the waterways, water is treated with sulfur dioxide to reduce the concentration of chlorine. Chlorine helps clean the water of harmful microorganisms, but it could be harmful to the river ecosystem.

Even after going through all these processes, wastewater might still be polluted. Some chemicals, drugs, and heavy metals like mercury cannot be removed in the wastewater treatment process. For these, prevention is the best option. Keeping these things out of the water in the first place is the best way to keep water clean.

Name___________________________________ Date_______________

Water Treatment Reporting Sheet

(Please use complete sentences in your report.)

1. Draw a sketch of your Wastewater Treatment plant, labeling all parts.

2. Explain how your Wastewater Treatment plant works. Make sure to include an explanation of both Stage One and Stage Two treatments.

3. What are the most effective parts of your design? What parts could be more effective?

4. What will you do differently next time?

Water Treatment TEKS Alignment

Grade level/ Content Area	TEKS
6th Grade — Science	(1) Scientific processes. The student conducts field and laboratory investigations using safe, environmentally appropriate, and ethical practices.
	(2) Scientific processes. The student uses scientific inquiry methods during field and laboratory investigations.
	(3) Scientific processes. The student uses critical thinking and scientific problem solving to make informed decisions.
	(4) Scientific processes. The student knows how to use a variety of tools and methods to conduct science inquiry.
	(7) Science concepts. The student knows that substances have physical and chemical properties.
7th Grade — Science	(1) Scientific processes. The student conducts field and laboratory investigations using safe, environmentally appropriate, and ethical practices.
	(2) Scientific processes. The student uses scientific inquiry methods during field and laboratory investigations.
	(3) Scientific processes. The student uses critical thinking and scientific problem solving to make informed decisions
	(4) Scientific processes. The student knows how to use tools and methods to conduct science inquiry.
	7) Science concepts. The student knows that substances have physical and chemical properties.
	(14) Science concepts. The student knows that natural events and human activity can alter Earth systems.
8th Grade — Science	(1) Scientific processes. The student conducts field and laboratory investigations using safe, environmentally appropriate, and ethical practices.
	(2) Scientific processes. The student uses scientific inquiry methods during field and laboratory investigations.
	(3) Scientific processes. The student uses critical thinking and scientific problem solving to make informed decisions.
	(4) Scientific processes. The student knows how to use a variety of tools and methods to conduct science inquiry.
	(5) Scientific processes. The student knows that relationships exist between science and technology.
	(9) Science concepts. The student knows that substances have chemical and physical properties.
	(14) Science concepts. The student knows that natural events and human activities can alter Earth systems.

POROSITY

GRADE LEVEL — 6th–8th

Purpose

- To understand the principle of porosity as it relates to soils
- To measure the amount of water stored in the pore space of a soil sample.
- To express porosity in different forms: as a fraction, a percentage and in a graph.

Teacher Background

Soils are made of particles of different types and sizes. The space between particles is called pore space. Pore space determines the amount of water that a given volume of soil can hold. Porosity is the percentage of the total volume of soil that consists of pore space. This is an important measurement in areas where drinking water is provided by groundwater reserves.

Each soil type has a different porosity. If you have access to different soil types, bring in several kinds and have students compare their porosity. As students pour water into their soil samples, the soil will become saturated. In an aquifer, the top surface of saturated soil is called the *water table.*

(Note: If you are interested in knowing more about the primary soil types in Texas, follow the links below.

For a table showing the major soil types in Texas, go to: Comparative Summary of the Regions http://www.csdl.tamu.edu/FLORA/taes/tracy/chkltab2NF.html

For definitions and distributions of the different kinds of soil types, go to this site from the University of Idaho College of Agriculture and Life Sciences http://soils.ag.uidaho.edu/soilorders/orders.htm

TEKS	Learning Benchmarks
Science Experiments Grade 6	(2) Scientific processes. The student uses scientific inquiry methods during field and laboratory investigations. (4) Scientific processes. The student knows how to use a variety of tools and methods to conduct science inquiry. (7) Science concepts. The student knows that substances have physical and chemical properties. (14) Science concepts. The student knows the structures and functions of Earth systems.
Mathematics Grade 6	(1) Number, operation, and quantitative reasoning. The student represents and uses rational numbers in a variety of equivalent forms (2) Number, operation, and quantitative reasoning. The student adds, subtracts, multiplies, and divides to solve problems and justify solutions (3) Patterns, relationships, and algebraic thinking. The student solves problems involving proportional relationships
Science Experiments Grade 7	Scientific processes. The student uses scientific inquiry methods during field and laboratory investigations. (4) Scientific processes. The student knows how to use tools and methods to conduct science inquiry. (14) Science concepts. The student knows that natural events and human activity can alter Earth systems
Mathematics Grade 7	(1) Number, operation, and quantitative reasoning. The student represents and uses numbers in a variety of equivalent forms. (2) Number, operation, and quantitative reasoning. The student adds, subtracts, multiplies, or divides to solve problems and justify solutions. (3) Patterns, relationships, and algebraic thinking. The student solves problems involving proportional relationships.
Science Experiments Grade 8	Scientific processes. The student uses scientific inquiry methods during field and laboratory investigations. (3) Scientific processes. The student knows how to use a variety of tools and methods to conduct science inquiry. (9) Science concepts. The student knows that substances have chemical and physical properties. (14) Science concepts. The student knows that natural events and human activities can alter Earth systems.
Mathematics Grade 8	(2) Number, operation, and quantitative reasoning. The student selects and uses appropriate operations to solve problems and justify solutions (3) Patterns, relationships, and algebraic thinking. The student identifies proportional relationships in problem situations and solves problems. (4) Patterns, relationships, and algebraic thinking. The student makes connections among various representations of a numerical relationship. The student is expected to generate a different representation given one representation of data such as a table, graph, equation, or verbal description.

Vocabulary

Soil — Soil is the layer of minerals and organic matter on the land surface. Its main components are mineral matter, organic matter, moisture, and air.

Particle — A very small piece of something bigger.

Pore space — The space found between particles of soil, sand or gravel. In aquifers, pore space is filled with water.

Porosity — The amount of water that soil can hold in its pores.

Saturation — In soils, the point at which soil or an aquifer will no longer absorb any water without losing an equal amount.

Water table — The surface of groundwater in the soil.

Groundwater — Water beneath the surface of the Earth that saturates the pores of sand, gravel, and rock.

Materials

- Dry soil samples, representative of what can be found in the local area. Include several kinds to allow students to investigate the porosity of soils with different particle sizes. These should include clays, loams, gravel, sand or other types
- Two 500 ml beakers **per pair** of students — If you do not have beakers, substitute graduated cylinders
- Water
- Paper towels to clean up spills

Procedure

This activity can be done either as a guided lab or an inquiry investigation, depending on the teacher's time and comfort level with inquiry-based learning. For a guided lab, give students the following instructions:

1. All students should read the Porosity Background information sheet. If you want to use this as a pre-assessment, ask students to read the information, then fill in the answer to the question on the sheet. You can also ask them to wait until after this investigation to answer the questions.

2. Divide class into pairs of students. Distribute the materials.

3. Fill one beaker, up to the 500 ml mark, with dry soil or sand. Place it on a table or flat workspace.

4. Fill the other beaker, up to the 500 ml mark, with water.

5. Slowly pour the water from the second beaker into the soil sample. Stop pouring when the water level reaches the top of the soil. The soil has reached saturation and cannot hold any more water.

6. How much water is left in the second beaker?

7. Subtract this amount from the original 500 ml of water you began with. How much water is now held in the pore spaces of the soil sample?

8. Use your answer from question 5 to compute the porosity (the percentage of pore space) of the soil sample. Express that percentage as a number, a fraction of the original 500ml and as a percentage of the original 500 ml..

9. When they have finished, ask them to answer the questions on the Porosity Background information sheet, either in class (if you have time) or as homework.

To make this procedure more inquiry-based, try the following:

1. Ask students to read the Porosity Background information sheet. Do not have them fill out the questions until after the investigation.

2. Split class into pairs of students. Distribute materials to each pair.

3. Ask student to answer the following questions,

   - How can you measure the porosity of different soils?
   - What is the porosity of each soil type, expressed as a percentage of volume, a fraction of volume and on a graph?

4. Give students a set amount of time to plan and conduct their investigation. On the back of the Porosity background information sheet, ask them to record their plan, their predictions, their observations and their conclusions.

5. When they have completed their investigations, ask students to answer the questions on the Porosity Background information sheets., either in class (if you have time) or as homework.

Student Name____ Date _______________________

Thinking About Porosity

Soils are made of particles of different types and sizes. The space between particles is called pore space. Pore space determines the amount of water that a given volume of soil can hold. Porosity is the percentage of the total volume of soil that consists of pore space, and gives us information on how much water can be pumped out of the ground. This is an important measurement in areas where groundwater is used for drinking water.

Texas has many types of soils. Each soil type has a different porosity. In an aquifer, the top surface of saturated soil is called the water table.

Knowing where your water comes from can help you make decisions about how much water you use. For example, if your water comes from an aquifer, you may want to reduce the amount of water you use so that your water supply will last longer.

List the important vocabulary words in these paragraphs.

Summarize the main idea in each of the paragraphs.

Why is porosity important to people in Texas who use groundwater for drinking water?

Name____ Date_____________________________

Soil Type	**Volume of water held**		
	Volume	Fraction of 500 ml	Percentage of 500 ml

Porosity Background

Soils are made of particles of different types and sizes. The space between particles is called pore space. Pore space determines the amount of water that a given volume of soil can hold. Porosity is the percentage of the total volume of soil that consists of pore space, and gives us information on how much water can be pumped out of the ground. This is an important measurement in areas where groundwater is used for drinking water.

Texas has many types of soils. Each soil type has a different porosity. In an aquifer, the top surface of saturated soil is called the water table.

Knowing where your water comes from can help you make decisions about how much water you use. For example, if your water comes from an aquifer, you may want to reduce the amount of water you use so that your water supply will last longer.

Vocabulary

Soil — Soil is the layer of minerals and organic matter on the land surface. Its main components are mineral matter, organic matter, moisture, and air.

Particle — A very small piece of something bigger

Pore space — The space found between particles of soil, sand or gravel. In aquifers, pore space is filled with water.

Porosity — The amount of water that soil can hold in its pores.

Saturation — In soils, the point at which soil or an aquifer will no longer absorb any water without losing an equal amount

Water table — The surface of groundwater in the soil.

Groundwater — Water beneath the surface of the Earth that saturates the pores of sand, gravel, and rock.

PERMEABILITY —TEACHER BACKGROUND AND INSTRUCTIONS

Background

This activity works well when combined with the Porosity Investigation.

Permeability is the ability of a material to allow the passage of a liquid, such as water through rocks. Permeable materials, such as gravel and sand, allow water to move quickly through them, whereas impermeable materials, such as clay, don't allow water to flow freely. Permeability also refers to the degree to which soils and rock are interconnected, depending upon size and shape of pores and the size and shape of their interconnections.

The coarser (containing more larger particles like sand and gravel) the soil, the more permeable it is. Water will run though more permeable soils at a faster rate than through soils with small particles. This concept (along with porosity) is important in understanding how water soaks through the ground (infiltrates) into an aquifer, a key component of the complex relationship between surface water and groundwater.

Description

Students will determine the relative permeability of several soil samples (sand, soil, and gravel).

This investigation is designed to take students approximately one 50-minute period to complete.

General Instructions to the Teacher

Students will be working in groups of 2 or 3 during this investigation. See **Permeability Investigation — Student Directions** for detailed instructions on how to conduct this investigation.

Time

One 50-minute period

Materials

- Permeability Activity Student Data Chart — one per person
- Soil samples
- Sand samples
- Gravel samples
- Small plastic bags — nine per group, to hold soil samples
- Spoons (Tbsp.)
- Stop watches or clock with second hand
- 10 ml graduated cylinders — one per group
- Funnels (small)
- Hand lenses
- Plastic bottles or small-mouthed containers
- Filter paper (nine pieces for every group of student. You can use round, flat coffee filters.)
- Paper towels
- 50–100 ml water containers — one per group

Each team of students will need to weigh out a predetermined amount of each sample, depending on how much you have available. (The teacher can also do this before class if time is particularly short. Students, however, will benefit from the experience of using scales.) Once the soil, sand and gravel have been weighed out, they should be stored in a small plastic bag until needed. A central supply area, if needed, should be easily accessible.

TEKS	Learning Benchmarks
Science Experiments Grade 6	(2) Scientific processes. The student uses scientific inquiry methods during field and laboratory investigations. (4) Scientific processes. The student knows how to use a variety of tools and methods to conduct science inquiry. (7) Science concepts. The student knows that substances have physical and chemical properties. (14) Science concepts. The student knows the structures and functions of Earth systems.
Mathematics Grade 6	(1) Number, operation, and quantitative reasoning. The student represents and uses rational numbers in a variety of equivalent forms (2) Number, operation, and quantitative reasoning. The student adds, subtracts, multiplies, and divides to solve problems and justify solutions (3) Patterns, relationships, and algebraic thinking. The student solves problems involving proportional relationships
Science Experiments Grade 7	(2) Scientific processes. The student uses scientific inquiry methods during field and laboratory investigations. (4) Scientific processes. The student knows how to use tools and methods to conduct science inquiry. (14) Science concepts. The student knows that natural events and human activity can alter Earth systems
Mathematics Grade 7	(1) Number, operation, and quantitative reasoning. The student represents and uses numbers in a variety of equivalent forms. (2) Number, operation, and quantitative reasoning. The student adds, subtracts, multiplies, or divides to solve problems and justify solutions. (3) Patterns, relationships, and algebraic thinking. The student solves problems involving proportional relationships.
Science Experiments Grade 8	(2) Scientific processes. The student uses scientific inquiry methods during field and laboratory investigations. (3) Scientific processes. The student knows how to use a variety of tools and methods to conduct science inquiry. (9) Science concepts. The student knows that substances have chemical and physical properties. (14) Science concepts. The student knows that natural events and human activities can alter Earth systems.
Mathematics Grade 8	(2)Number, operation, and quantitative reasoning. The student selects and uses appropriate operations to solve problems and justify solutions (3) Patterns, relationships, and algebraic thinking. The student identifies proportional relationships in problem situations and solves problems. (4) Patterns, relationships, and algebraic thinking. The student makes connections among various representations of a numerical relationship. The student is expected to generate a different representation given one representation of data such as a table, graph, equation, or verbal description.

Vocabulary

Permeable — A substance (such as sand, some types of rock) that allows water to pass through cracks and between particles.

Impermeable — A substance that does not allow water to pass through it.

Permeability — The rate at which water will flow through soil or rocks.

Particle — A very small piece of something bigger.

Pores — The spaces found between particles of soil, sand or gravel.

Porosity — The amount of space that is available to hold water in the soil.

Infiltrates — When a material like water passes into or through another material.

Assessments

Students will graph the data collected from their investigations on the Permeability Activity Student Data Chart.

See also: Permeability Assessment

Permeability Investigation — Student Directions

Task

In this investigation, you will be working in groups to determine the relative porosity of different soil samples.

Materials

- Permeability Activity Student Data Chart — one per group
- Soil samples — 3
- Sand samples — 3
- Silt samples — 3
- Small plastic bags — nine per group
- Hand lens
- 10 ml graduated cylinder
- Funnel
- Plastic bottle or small-mouthed container
- Filter paper — nine pieces for each group
- Spoon
- Paper towels
- Stop watch
- Water container

Directions

1. Members of your group will measure out three samples of each soil type and put them in small plastic bags.
2. Observe each sample with the hand lens and record your observations.
3. Which sample has the largest particles?

   ____

4. Which sample has the smallest particles?

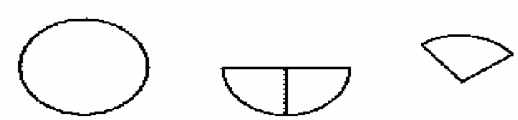
   ____

5. Predict which type of soil is the most permeable.

   ____

6. Place the funnel into the plastic bottle or small-mouthed container.
7. Fold a piece of filter paper and place a filter in the funnel.

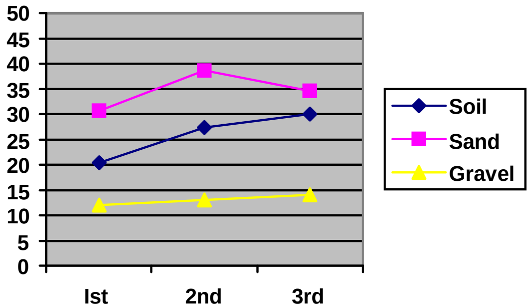
   Directions for folding: Fold paper in half, then in half again. Open to form a cone with 3 quarters on one side and one on the other (see diagram).



8. Fill the filter paper with water to wet the filter paper. As soon as the water flows out of the funnel, dump the water back into the water container. The filter paper should stick to the sides of the funnel without any air bubbles. Be sure to let all the water drip through the filter before placing the soil sample in it.
9. Measure out 10 ml of water in the graduated cylinder.
10. Put one of your pre-measured soil samples into the wet filter paper and gently pack down the sample with the back of the spoon. Pour 10 ml of water on top of the soil in the funnel.

11. Time how long it takes for the 10 ml of water to disappear into the soil.
12. Record your time on the data chart.
13. Repeat steps #8-12 with each of the remaining samples of this same soil type.
14. Repeat steps #8-12 with each of the other soil types. (All together, you should collect data three times for each of the three soil types.)

Student Name____ Date _______________________



Your chart will end up looking something like this.

1. Use a different color for each soil type.
2. Measure the time it takes for the water to run through the soil sample three times for each soil type.
3. Record your times on the chart below.

Time	50			
	45			
	40			
	35			
	30			
	25			
	20			
	15			
	10			
	5			
	0			
		1st attempt	2nd attempt	3rd attempt

Student name ______________________________ Date _________________________

Thinking About Permeability

Permeability is the rate at which water will flow through soil or rocks. Permeable materials, such as gravel and sand, allow water to move quickly through them. Impermeable materials, such as clay, don't allow water to flow freely. Permeable soils and rocks are interconnected by the water that flows between them.

The bigger the particles are in the soil, the more permeable it is. Water will run though soils that have large particles (like gravel) faster than it will run through soils with small particles (like sand.) This concept (along with porosity) is important in understanding how water soaks through the ground (infiltrates) into an aquifer. This is a key component of the complex relationship between surface water and groundwater.

What are the important vocabulary words in these paragraphs?

What are the main ideas in these paragraphs?

Why is *permeability* important in the relationship between surface water and groundwater?

Background on Permeability

Permeability is the rate at which water will flow through soil or rocks. Permeable materials, such as gravel, sand and silt allow water to move quickly through them. Impermeable materials, such as clay, don't allow water to flow freely. Permeable soils and rocks are interconnected by the water that flows between them.

The bigger the particles are in the soil, the more permeable it is. Water will run though soils that have large particles (like gravel) faster than it will run through soils with small particles (like sand and silt.) This concept (along with porosity) is important in understanding how water soaks through the ground (infiltrates) into an aquifer. This is a key component of the complex relationship between surface water and groundwater.

Vocabulary

Permeabl*e* — A substance (such as sand, some types of rock) which allows water to pass through cracks and between particles.

Impermeable — A substance which does not allow water to pass through it.

Permeability — The rate at which water will flow through soil or rocks.

Particle — A very small piece of something bigger.

Pores — The spaces found between particles of soil, sand or gravel.

Porosity — The amount of space that is available to hold water in the soil.

Infiltrates — When a material like water passes into or through another material.

GROUNDWATER CONTAMINATION: POINT- AND NON-POINT SOURCES

Lesson Introduction: For the Teacher

A serious threat to both human and wildlife safety is groundwater contamination. Though the figure will vary from year to year, approximately 63% of the water used in Texas comes from underground. Polluted groundwater is more difficult to detect than polluted rivers or lakes because the pollutants generally cannot be seen or smelled and serious contamination problems can occur before they are detected. In this lesson, the students will build and experiment with a model aquifer in order to investigate how pollutants get into groundwater. Sources of pollution come from both point- and non-point sources.

Half of your small groups of students will investigate point-source pollution and half will investigate non-point source pollution. Plan enough time to allow groups to share and discuss their findings.

This activity is intended to give you a great deal of flexibility. As you go through the activity, you will see opportunities to make the activity more of an inquiry investigation, if you have time and inclination. There is also a synthesis and writing extension that helps students practice literacy skills by asking them to write about their investigations.

You can do one, two or all three of these activities, as time and interest allow. Doing all three of the activities will give students an opportunity for an in-depth investigation into meaningful and important content areas. Doing all three activities will give you the following assessment data points:

Formative assessments:

- Discussions
- Observations of student investigations
- Data sheets — predictions, observations and conclusions
- Lists of student-generated questions
- Inquiry Investigation Planning Sheets

Summative assessments:

- Groundwater Assessment — Literacy Through Science

Time

Day One
Science experiments — one 50-minute session
Day Two
Inquiry extension — one 50-minute session
Homework — Assessment Extension Synthesis and Writing

Materials

For the teacher:

- Whiteboard and markers
  OR
- Large chart paper and markers

Science experiments

- Data Sheets
- Clear plastic tray (at least 4" deep)
- Dry sand
- Gravel
- Powdered red drink mix
- Small cups
- Paper towels
- 12 inch rulers or similar sized flat pieces of wood.

Inquiry extensions

- Inquiry Planning Sheets
- Clear plastic tray (at least 4" deep)
- Dry sand
- Gravel
- powdered red drink mix
- Small cups
- Paper towels
- Aluminum foil
- Clay
- Plastic wrap
- Plant materials (grasses, leaves, twigs, etc.)

Advance Preparation

- Divide students into groups of 4.
- Copy data sheets. Distribute one data sheet to each student.

Background Information

Pollutants are considered hazardous based on four characteristics:

- Ignitability (or how flammable the substance is). Example: oil and other petroleum products
- Corrosivity (a function of the pH of a substance, measuring the acidity or alkalinity of the pollutant). Example: Leaking batteries, solvents like toluene.
- Reactivity (a measure of how easily the substance reacts with water or air to produce heat or explosion). Example: Hydrogen and chlorine
- Toxicity (a measure of how dangerous the substance is to living things). Example: Ammonia, benzene.

Once groundwater has become polluted, it is very difficult and expensive to clean.

In this activity, students will investigate two types of groundwater contamination: point source and non-point source. Point source contamination is that originating from directly identifiable sources of contamination including leaking chemicals from storage tanks, septic systems, landfills, etc. Non-point source contamination is that originating from pollution such as pesticides, fertilizers or acid precipitation that does not enter the ground water at any one specific point.

TEKS	Learning Benchmarks
Science Experiments Grade 6	(2) Scientific processes. The student uses scientific inquiry methods during field and laboratory investigations. (3) Scientific processes. The student uses critical thinking and scientific problem solving to make informed decisions. (4) Scientific processes. The student knows how to use a variety of tools and methods to conduct science inquiry. (7) Science concepts. The student knows that substances have physical and chemical properties. (14) Science concepts. The student knows the structures and functions of Earth systems.
Synthesis and Writing Grade 6	(13) Writing/purposes. The student writes for a variety of audiences and purposes and in a variety of forms. (20) Writing/inquiry/research. The student uses writing as a tool for learning and research.
Science Experiments Grade 7	(3) Scientific processes. The student uses scientific inquiry methods during field and laboratory investigations. (4) (3) Scientific processes. The student uses critical thinking and scientific problem solving to make informed decisions. (5) Scientific processes. The student knows how to use tools and methods to conduct science inquiry. (14) Science concepts. The student knows that natural events and human activity can alter Earth systems
Synthesis and Writing Grade 7	(15) Writing/purposes. The student writes for a variety of audiences and purposes and in a variety of forms. (20) Writing/inquiry/research. The student uses writing as a tool for learning and research.
Science Experiments Grade 8	(3) Scientific processes. The student uses scientific inquiry methods during field and laboratory investigations. (4) Scientific processes. The student uses critical thinking and scientific problem solving to make informed decisions. (5) Scientific processes. The student knows how to use a variety of tools and methods to conduct science inquiry. (6) Scientific processes. The student knows that relationships exist between science and technology. (9) Science concepts. The student knows that substances have chemical and physical properties. (12) Science concepts. The student knows that cycles exist in Earth systems. (14) Science concepts. The student knows that natural events and human activities can alter Earth systems.
Synthesis and Writing Grade 8	(15) Writing/purposes. The student writes for a variety of audiences and purposes and in a variety of forms. (20) Writing/inquiry/research. The student uses writing as a tool for learning and research.

Procedure: Day One

Tap Prior Knowledge

1. Ask students to think about where things "go" when they go "away."

   - Where does litter go?
   - When cars leak oil, where does the oil go?
   - When you put fertilizer on your lawn, and it rains, where does the fertilizer go?
   - When leaves fall off the trees, where do they go?
   - When you flush the toilet, or run water through your washing machine, where does it go?

Share with Neighbor

2. Ask students to work in their small groups to brainstorm where each of these things go. Have them draw a simple map showing how each of these substances gets to where it is going.

3. Give students time to share their maps and ideas about where things go with the whole class.

Introduce Vocabulary

(Everything that ends up in our water systems is either point- or non-point source pollution. As you discuss the following concepts with students, ask them to categorize the substances on their maps as either point or non-point source pollution.)

Groundwater contamination — The pollution of springs and wells from their sources underground. Some sources of groundwater contamination include:

- Used oils, paint thinners, gasoline and other petroleum-based products
- Leaking storage tanks (e.g. underground storage tanks, aboveground storage tanks, home heating fuel tanks, kerosene tanks)
- Overuse of pesticides, herbicides and fertilizers that may be used on lawns, golf courses and agricultural fields
- Chemical spills at businesses, farms and along highways *(e.g.,* solvents, petroleum products)
- Illegal dumps and poorly managed landfills
- Failing septic tanks

Pollutants — A material that contaminates air, soil, or water. Toxic chemicals and nutrients are considered the major groups of groundwater pollutants.

Aquifer — An underground layer of rock, sand and silt that contains water.

Non-point source pollution — Pollution that occurs when rainfall, snowmelt, or irrigation runs over land or through the ground, picks up pollutants, and deposits them into rivers, lakes, and coastal waters or introduces them into ground water.

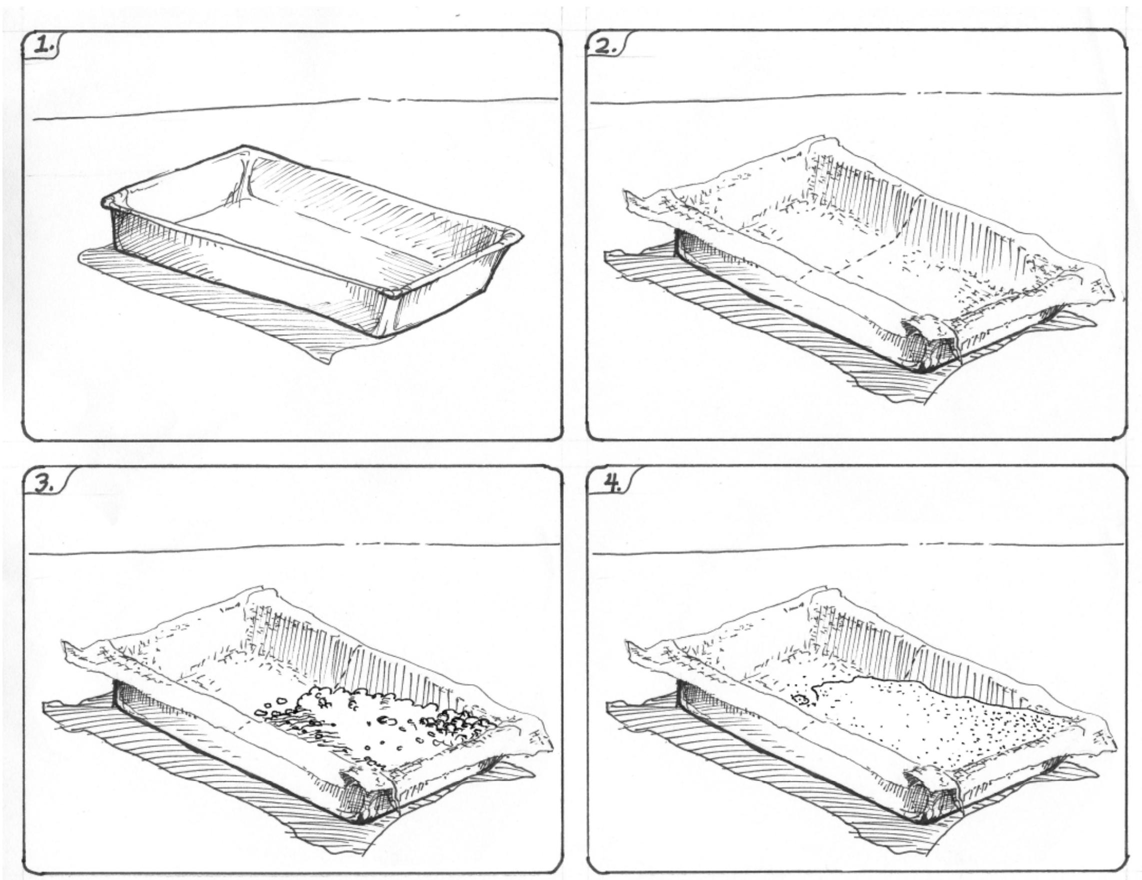
Point source pollution — Pollution originating from a single point such as pipes, ditches, wells, vessels, and containers

Engage Students in a Hands-On Activity

4. Explain to students that they are going to create a model to investigate pollution. Split small groups of students into two categories — half of the small groups will investigate **point sources** of pollution and half will investigate **non-point** sources.

5. Distribute materials. Begin building the model by putting a paper towel on the bottom of the container. Make sure that several centimeters of the towel is draped over the edge of the container. Place 3 cm layer of gravel on the bottom of the tray (on the paper towel). Create a slope across the top surface of the gravel so that there is an empty space at one edge of the tray that will represent a lake.

6. Place a loose, thin layer of sand over the gravel.



(Instructions for non-point source pollution groups)

1. **Non-point source pollution groups** will spread 20 grams of powdered drink mix over the sand. The drink mix represents a pollutant such as pesticides or fertilizers. Ask them to think about what will happen to the pollutant when rain falls on the ground. Have them write their predictions on their data sheets.

2. Sprinkle warm water on top. Have students observe and record their observations on their data sheets. Compare the results to their predictions. As the water moves through the sand, it dissolves the drink mix and the color will mix with the water.

3. Observe the paper towel that was placed under the gravel. What has happened to it? How and why do the students think this occurred? Ask students to record all their observations on their data sheets. Does the teacher know the right answer?

4. As a group, draw conclusions about what they have observed.

5. As a group, write down a list of 3–5 questions they have about what they observed.

(Instructions for point source pollution groups)

6. **Point source pollution groups** will put the powdered drink mix in a small cup and dissolve it with water. Ask them to think about what will happen to the pollutant when it is "discharged" or spilled onto the ground. Students should record their predictions of what will happen when they pour the pollutant on the sand.

7. Place a 12-inch ruler or similar sized piece of wood across the pan, over the sand layer of your landscape. Poke a hole in the bottom of the cup then balance the cup on the ruler. The dissolved "pollutant" will spill onto the layer of sand through the hole in the cup. Have students record their observations.

8. As a group, draw conclusions about what they have observed.

9. As a group, write down a list of 3-5 questions they have about what they observed.

Discuss the Scientific Principle

10. Ask students from each set of groups (point and non-point sources) to report the predictions, observations and conclusions from their investigations. Collect their predictions, observations and conclusions on a whiteboard or large pieces of chart paper.

11. Ask students to share the questions they had related to what they observed. Collect their questions on a whiteboard or large piece of chart paper,

12. An underground layer of rock, sand and silt that contains water is called an aquifer. An illustration of an aquifer can be found on the following web site: http://www.groundwater.org/kc/whatis.html. Though the figure varies from year to year, approximately 63% of the water used in Texas comes from aquifers.

13. Refer students to their experiments, and the information they recorded on their data sheets. Polluted surface water contaminated their aquifer in two ways, through point and non-point sources. The first was non-point source pollution, also called run-off. When they made it "rain" on their landscapes, pollutants (colored drink mix) washed across the surface and carried the pollutants into rivers, lakes and eventually into the groundwater (aquifer).

14. The second experiment demonstrated groundwater contamination by a point source. The student saw this when they poked a hole in their cup full of "pollutants" and it spilled onto their landscape. In each case, they should have observed that the colored drink mix "pollutant" stained the paper towels as it traveled through the ground and into the ground water. Water drawn from underneath a contaminated source is itself contaminated when the geologic materials are porous and permeable. This can contaminate wells used by humans for drinking, sometimes even miles away from the source of the pollution.

Relate Activity and Concept

15. Ask the students how what they have just observed in this model is related to their lists of things that “go away” made at the beginning of the experiment. Discuss the effects of litter, septic tanks, etc. on water sources.

16. In preparation for the next day’s Inquiry Extension, ask students to work in their small groups to identify from their list of questions the one question they are most interested in investigating further. Distribute an **Inquiry Planning Sheet** to each student. Give them a few minutes to sum up with a plan for the next day’s investigation. If their plan involves materials beyond what you will provide, tell them they will need to bring them from home.

Day Two: Inquiry Extension

1. Begin by asking each group to identify the one question they will investigate. Have each group build a second model.

2. Distribute fresh data sheets to each student. Students should record their predictions. As they investigate their questions, students record their observations.

3. Ask students to record their conclusions on their data sheets.

4. Ask students to share their findings. Gather their questions, observations and conclusions on a whiteboard or large sheets of chart paper.

Groundwater Assessment: Literacy Through Science

Synthesis and Writing

Distribute the **Background on Groundwater Sheet** to students. Ask them to read the following three paragraphs, and respond to the three questions below.

> Groundwater comes from moisture that soaks into the ground. Moisture can come from rain, snow, sleet, or hail. Gravity moves the water down into the ground, passing between particles of soil, sand, gravel, or rock. Groundwater can move through the ground and into a lake or stream. Water in a lake or stream can soak down into the ground and become groundwater. This is all part of the water cycle.
>
> Groundwater is stored in the ground in the tiny spaces, or pores, between particles of gravel, sand or silt. Water can also move through some rock formations or through cracks in rocks. An area that holds a lot of water is called an aquifer. Wells drilled into the ground pump groundwater from the aquifer. Pipes deliver the water to cities, houses in the country, or to crops.
>
> Much of the groundwater in Texas is clean, but groundwater can become polluted, or contaminated. When pollutants leak, spill, or are carelessly dumped on the ground they can move through the soil, and as you saw in your investigations, pollute the groundwater.

1. List the important vocabulary words in these three paragraphs.
2. Summarize the main idea in each of the three paragraphs.
3. What is one thing you can do to prevent groundwater contamination?

Use this assessment to check students' understanding of groundwater concepts and as an opportunity to practice literacy skills as they learn science.

Background on Groundwater

Groundwater comes from moisture that soaks into the ground. Moisture can come from rain, snow, sleet, or hail. Gravity moves the water down into the ground, passing between particles of soil, sand, gravel, or rock. Groundwater can move through the ground and into a lake or stream. Water in a lake can soak down into the ground and become groundwater. This is all part of the water cycle.

Groundwater is stored in the ground in the tiny spaces, or pores, between particles of gravel or sand. Water can also move through some rock formations or through cracks in rocks. An area that holds a lot of water is called an aquifer. Wells drilled deep into the ground pump groundwater from the aquifer. Pipes deliver the water to cities, houses in the country, or to crops.

Much of the groundwater in Texas is clean, but groundwater can become polluted, or contaminated. When pollutants leak, spill, or are carelessly dumped on the ground they can move through the soil, and as you saw in your investigations, pollute the groundwater.

Vocabulary

Groundwater contamination — The pollution of springs and wells from their sources underground.

Pollutants — A waste material that contaminates air, soil, or water. Sediment, nutrients, and toxic chemicals are considered the major groups of pollutants.

Aquifer — An underground layer of rock, sand and silt that contains water.

Non-point source pollution — Pollution that occurs when rainfall, snowmelt, or irrigation runs over land or through the ground, picks up pollutants, and deposits them into rivers, lakes, and coastal waters or introduces them into ground water.

Point source pollution — Pollution originating from a single point such as pipes, ditches, wells, vessels, and containers.

Student Name______________________________________ Date ______________________

Groundwater Contamination

Groundwater comes from moisture that soaks into the ground. Moisture can come from rain, snow, sleet, or hail. Gravity moves the water down into the ground, passing between particles of soil, sand, gravel, or rock. Groundwater can move through the ground and into a lake or stream. Water in a lake can soak down into the ground and become groundwater. This is all part of the water cycle.

Groundwater is stored in the ground in the tiny spaces, or pores, between particles of gravel or sand. Water can also move through some rock formations or through cracks in rocks. An area that holds a lot of water is called an aquifer. Wells drilled deep into the ground pump groundwater from the aquifer. Pipes deliver the water to cities, houses in the country, or to crops.

Much of the groundwater in Texas is clean, but groundwater can become polluted, or contaminated. When pollutants leak, spill, or are carelessly dumped on the ground they can move through the soil, and as you saw in your investigations, pollute the groundwater. Once polluted, groundwater is very difficult to clean up.

List the important vocabulary words in these three paragraphs.

How are surface waters and groundwater connected?

What is meant when we say, "Pollutants do not go away. There is no away"?

What is one thing you can do to prevent groundwater contaminations?

Student Name____ Date _______________________

Student Data Sheet
Groundwater Contamination

For this experiment, you will use the aquifer model you created. Read the directions for your experiment, and record your predictions, descriptions, observations and conclusions in the spaces provided.

Prediction — What do you think will happen when you pour water (rain) over your landscape and your pollutant?

Description — Describe the physical properties of each of the soils in your landscape.

Observation — Record what happens when you pour water (rain) over your landscape and your pollutant. (Record ONLY what you see happening, but try and record EVERYTHING you see happening.)

Conclusion — Why do you think this happened? Why are pollutants harmful to groundwater?

Student name ______________________________ Date ____________________

Investigation Question:

Materials needed for my investigation:

My first step will be to …

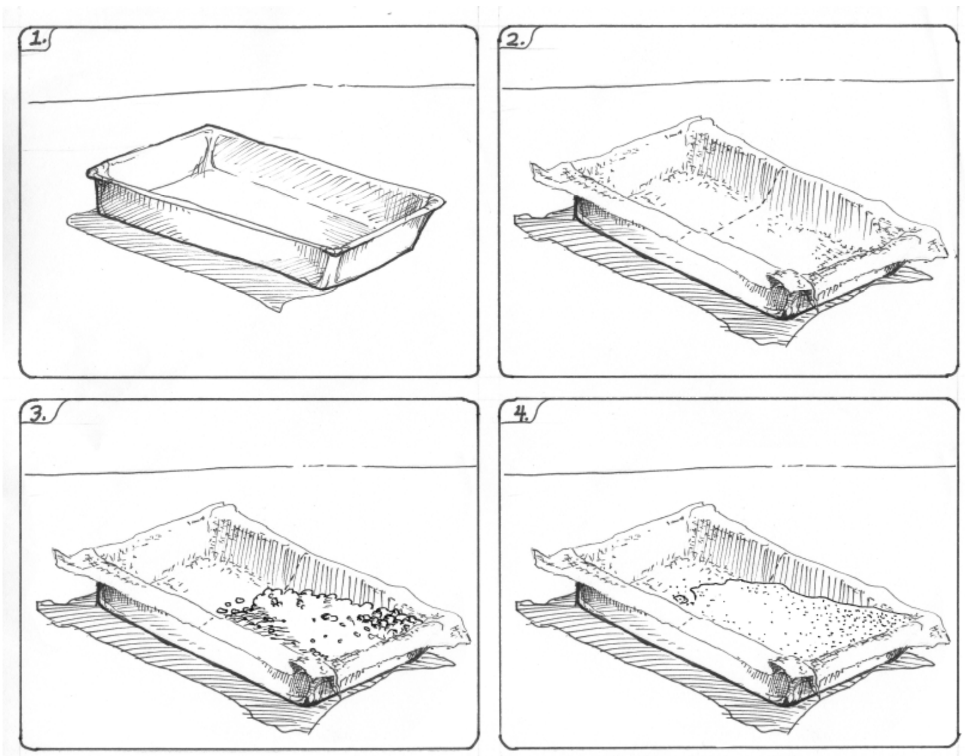
My next step will be to …

Instructions for Non-Point Source Pollution Groups

1. Begin building the model by putting a paper towel on the bottom of the container. Make sure to drape several centimeters of the towel over the edge of the container.

2. Place 3 cm layer of gravel on the bottom of the tray (on the paper towel). Create a slope across the top surface of the gravel so that there is an empty space at one edge of the tray that will represent a lake.

3. Place a loose, thin layer of sand over the gravel.



4. Spread 20 grams of powdered drink mix over the sand. The drink mix represents a pollutant such as pesticides or fertilizers.

5. On your data sheets, predict what will happen when rain falls on your landscape.

6. Sprinkle warm water on top of your landscape.

   - On your data sheets, observe and record what happens to the pollutant as the water spreads across and through your landscape. Compare the results to your predictions.

7. Observe the paper towel you placed under the gravel. What happened to it? How and why do you think this occurred?

   - Record your observations and conclusions on your data sheets.

8. As a group, write down a list of 3-5 questions you have about what you observed

Groundwater Contamination

Instructions for Point-Source Pollution Groups

1. Begin building the model by putting a paper towel on the bottom of the container. Make sure to drape several centimeters of the towel over the edge of the container.

2. Place 3 cm layer of gravel on the bottom of the tray (on the paper towel). Create a slope across the top surface of the gravel so that there is an empty space at one edge of the tray that will represent a lake.

3. Place a loose, thin layer of sand over the gravel.

4. Put the powdered drink mix in a small cup and dissolve it with water. Predict what will happen to the pollutant when it is “discharged” or spilled onto the ground.

    - Record your predictions of what will happen when you spill the pollutant on the sand.

5. Place a 12-inch ruler or similar sized piece of wood across the pan, over the sand layer of your landscape. Poke a hole in the bottom of the cup then balance the cup on the ruler. The dissolved “pollutant” will spill onto the layer of sand through the hole in the cup.

    - Record your observations of what happens on your data sheets.

6. As a group, write down a list of 3-5 questions you have about what you observed.

WEBQUEST: WATER IN TEXAS

Overview

Did you use water today? If you brushed your teeth, used a toilet, took a shower, ate a meal, or even breathed the air, chances are very good that water was involved. We use water in almost everything we do, and for most of the things we do that involve water, there is nothing we could use as a substitute.

In this activity, you will investigate who uses water in Texas, and how much they use. Water is a limited, precious resource, essential to almost everything we do. Will we have adequate water resources in the future? Many people in Texas don't realize who uses the most water, and how they use it. If we don't have an accurate picture of how water is used, we can't make a successful plan to conserve water.

You will investigate water use in Texas, and make recommendations on how to use water efficiently and wisely.

For information on the TEKS in this activity, see "Water In Texas WebQuest TEKS" included in this activity.

Introduction

You are part of a team hired by the state of Texas to make a water plan. It takes thoughtful planning to make sure that when you turn on the faucet, water comes out. (and that water will continue to flow for future generations of Texas) Texas relies on both groundwater from aquifers and surface water from rivers and reservoirs to provide enough water for everyone.

Your team will need to look at a lot of competing interests and different points of view, in order to come up with a plan that gives everyone enough water now and in the future. You will share your research with others on your team to develop a plan, but you will need data to support your plan. The solution does not have to be one that is currently used. Think creatively; original ideas are encouraged.

Quest(ions) and the Task

You are a member of a team assembled to determine how Texas will ensure citizens continue to have adequate water resources. You will be assigned to represent a region of Texas, and your task is to recommend measures that will help reduce water consumption by 10%.

Process

Making a plan to assure Texas has enough water is a complex process. In 1997, Senate Bill 1 created a regional water planning process in Texas. Texas is broken into 16 regional water planning groups, and each group develops a water plan for their region. The Texas Water Development Board coordinates the regional water planning process and incorporates the regional plans into a State Water Plan, which is updated every five years. As citizens, you have an important role in providing feedback to water planners. You will work in teams to come up with a plan that assures Texans will have enough water today, and into the future.

Water planning groups use many models in the water planning process. One model helps groups understand how much groundwater and surface water is available, called "groundwater availability models" or GAMs. Another is called a "Water Availability Model" or WAM. Models that include crop water use efficiency, weather conditions and soil moisture are used to estimate agricultural water use. Models also help planners figure out how much water people should NOT use, leaving enough water in rivers and estuaries to balance the needs of people and wildlife (called environmental flows).

Your whole team will need to answer this question:

Why do we use models to think about water planning and how do we use these models?

Teams will consist of four members. Each team member will select one of the following roles to play. Choose the four roles that figure most prominently into the economy of your region.

Team Member	Representing (Customer Category)	Guiding Interest
Farmer	Irrigation	Adequate water to irrigate crops
Mayor	Municipal	Adequate water for residential (homes) and commercial (restaurants, schools, hospitals) uses
Manufacturer	Industrial	Enough water to run factories, manufacturing facilities, and other businesses
Power plant engineer	Electric Utility Generating Facility	Enough water to generate electricity for the town
Rancher	Livestock	Adequate water to raise livestock such as cattle, poultry, sheep, and hogs.
Mining Operator	Mining	Adequate water to extract and process oil and various minerals
Biologist	Environmental	Enough water in the rivers and estuaries to provide habitat for aquatic ecosystems

Your team will represent a specific regional water planning group in Texas, assigned by either your teacher, or by your own choice. (To see a map of the different regional water planning groups, go to http://www.twdb.state.tx.us/mapping/maps/pdf/sb1_groups_8x11.pdf)

Some regions will have plenty of water; others will be quite dry. Some regions have lots of agriculture, others will have more mining, or power plants, or ranching.

Each category of water user will have a different capacity to conserve water without inhibiting their ability to make a living. For instance, in order for a farmer to conserve water they might switch to more efficient irrigation methods. That way, they could use less water without affecting their yields. A rancher, on the other hand, might have to raise fewer animals in order to use less water. That could have a negative impact on the rancher's livelihood.

Each team member will explore resources to collect information and record their data. A summary of your individual research and a list of resources will be collected from each team member on the day of the presentation. The goal is to reduce water consumption.

The information each team member collects will be compiled to create one final group presentation. Your team must present your findings in an oral presentation, and it must be supported by one of the following products:

- A PowerPoint or other multimedia presentation
- A poster
- Summary Tables
- A report
- A web page
- Every presentation must include graphs that represent your findings.

Individual team members must answer the following questions:

Farmer

- How much water per year is used for irrigating crops in your region?
- In what ways would a water shortage affect your business?
- Why would you be interested in reducing water use?
- What factors discourage you from reducing water use?
- What are your recommendations for conserving water used for irrigated agriculture?

Mayor

- How much water per year do municipalities use in your region today?
- How will water use change as the population of your city grows?
- In what ways would a water shortage affect your city?
- What are your recommendations for conserving water used for municipal use?

Manufacturer

- How much water per year does industry use in your region?
- In what ways would a water shortage affect your business?
- What are your recommendations for conserving water used for industry?
- What would motivate you to conserve water?

Engineer

- How much water per year do steam-electric power plants need to operate in your region?
- In what ways would a water shortage affect your business?
- What are your recommendations for conserving water used for power generation?

Rancher

- How much water per year does livestock use in your region?
- In what ways would a water shortage affect your business?
- What are your recommendations for conserving water used for agriculture?
- Is water conservation as important from your perspective as from the farmer's perspective? Why or why not?

Mining Operator

- How much water per year does mining use in your region?
- In what ways would a water shortage affect your business?
- What are your recommendations for conserving water used for mining?

Wildlife or Aquatic Biologist

- In what ways does a healthy aquatic ecosystem benefit the health of people?
- In what ways are healthy aquatic ecosystems important to the Texas economy?
- In what ways would a water shortage affect local aquatic ecosystems?
- What are your recommendations for conserving water so there is enough for healthy ecosystems?

To answer your questions, use the resources listed in the Resources section of this WebQuest. Use only the resources listed.

Remember, water is a difficult issue, and team members won't always agree on things. You will have to compromise, negotiate, and create a plan that treats each water user fairly, while ensuring that all Texans have enough water. Your goal is a 10% reduction in water usage in your region.

Resources

Information on how much water can be saved by employing different conservation strategies- http://www.twdb.state.tx.us/assistance/conservation/gdsstudy.asp

A summary of water usage in Texas
http://www.twdb.state.tx.us/data/popwaterdemand/2003Projections/HistoricalWaterUse/2002WaterUseSurvey.asp

Historical Texas water usage data
http://www.twdb.state.tx.us/data/popwaterdemand/2003Projections/HistoricalWaterUse.asp

Population of Texas by region
http://www.twdb.state.tx.us/data/popwaterdemand/2003Projections/PopulationProjections.asp

This Texas Parks and Wildlife Department (TPWD) page shows the ecologically unique stream segments in Texas, the endangered and threatened wildlife species and the criteria used to designate stream segments as unique.
http://www.tpwd.state.tx.us/texaswater/sb1/rivers/unique/sigseg.phtml

This Texas Parks and Wildlife Department (TPWD) web page gives you some good information on the water needs of Texas wildlife.
http://www.tpwd.state.tx.us/texaswater/sb1/index.phtml

This page has the most recent State Water Plan, "Water For Texas-2002". Pay special attention to the individual graphic files on this page. There are many useful graphs listed here.
http://www.twdb.state.tx.us/publications/reports/State_Water_Plan/2002/FinalWaterPlan2002.asp

This next resource is a chapter from the State Water Plan that shows the projected water supplies and user demands across regions in graphic form.
http://www.twdb.state.tx.us/publications/reports/State_Water_Plan/2002/WP%20Ch%2011.pdf

This next resource is another chapter from the State Water Plan that shows the projected impact of not having enough water.
http://www.twdb.state.tx.us/publications/reports/State_Water_Plan/2002/WP%20Ch%2012.pdf

Water Planning Information Tool: look up the population projections, water demands, and water management strategies for individual water user groups in Texas.
http://www.twdb.state.tx.us/assistance/rwpg/DB02/index.asp

This next resource is a very good web site on the Ogallala Aquifer.
http://www.hpwd.com/ogallala/ogallala.asp

An electronic version of TWDB's agricultural water conservation brochure explains water conservation strategies for irrigated agriculture
http://www.twdb.state.tx.us/assistance/conservation/ConservationPublications/AgBrochure.pdf

TWDB's Water Conservation Best Management Practices Guide
http://www.twdb.state.tx.us/assistance/conservation/TaskForceDocs/WCITFBMPGuide.pdf

Texas Parks and Wildlife
www.tpwd.state.tx.us/landwater/

Evaluation

Your water plan will be graded using the Water In Texas WebQuest Rubric, included with this activity.

Conclusion

You have researched some information about water needs in Texas, identified strategies to conserve water and made a recommendation with your ideas and suggestions.

- Do you think that we know all there is to know about water conservation?
- Are there other ideas currently being researched to help people think about water conservation?
- Do you think that any of your ideas could be used in your community?
- Why do you think some people don't practice water conservation strategies?
- Why is it so hard to predict how much water can be saved by using different conservation strategies?
- As a citizen, why would you be interested in learning about water planning?

Every region in Texas has a regional water planning group. If you are interested in finding out more about how water planning is handled in your area, go to this web page, and search for your region: http://www.twdb.state.tx.us/rwpg/main-docs/mbr-main.asp

Get involved in water where you live, and help us plan for YOUR future.

TEKS Alignment	Beginning 1	Developing 2	Accomplished 3	Exemplary 4	Score
Individual Research	Information gathered has little or nothing to do with the questions posed.	Information gathered provides answers to main questions, but no details and/or examples are given.	Information gathered provides answers to main questions along with 1-2 supporting details and/or examples.	Information gathered provides answers to the main questions along with several supporting details and/or examples for each.	
Individual Recommendations	Fewer than 2 recommendations suggested have little or nothing to do with the questions posed. Recommendations not based in fact or possibility.	At least 2 recommendations suggested provide some connection to the questions and have some basis in fact and possibility. Supporting details and/or examples are weak.	At least 3 recommendations suggested connect to the questions posed and are based in fact and possibility. Supporting details and/or examples are strong.	More than 3 recommendations suggested connect clearly to question posed, and are based in fact and possibility. Supporting details and/or examples are creative and powerful.	
Group explanation — Use of Models	Students are not able to explain why and how models are used in the water planning process. Explanations are not supported by facts. Fewer than 2 examples are included.	Students explain why and how models are used in the water planning process, but explanations do not demonstrate clear understanding, or are not supported by facts. Fewer than 2 examples are included.	Students clearly explain why and how models are used in the water planning process. Explanations are supported by facts and include at least 2 examples.	Students clearly explain why and how models are used in the water planning process. Explanations are insightful, supported by facts and include at least 3 examples drawn from their own case studies.	
Group Recommendation — Conservation Strategies	Students identify fewer than 2 reasonable, insightful possible strategies per team member.	Students identify at least 2 reasonable, insightful possible strategies per team member.	Students identify at least 3 reasonable, insightful possible strategies per team member	Students identify more than 3 reasonable, insightful possible strategies per team member	
Group Recommendation Support	Students include fewer than 2 high-quality examples or pieces of data per team member to support their ideas	Students include at least 2 high-quality examples or pieces of data per team member to support their ideas.	Students include at least 3 high-quality examples or pieces of data per team member to support their ideas.	Students include 4 or more high-quality examples or pieces of data per team member to support their ideas.	
Group Sources of Information	Students include fewer than 2 sources per team member.	Students include 2-3 sources per team member but some of are questionable quality.	Students include 2-3 high quality sources per team member.	Students include 4 or more high quality sources per team member.	

Social Studies TEKS — Grade 6	(7) Geography. The student understands the impact of interactions between people and the physical environment on the development of places and regions.
	(21) Social studies skills. The student applies critical-thinking skills to organize and use information acquired from a variety of sources including electronic technology.
	(22) Social studies skills. The student communicates in written, oral, and visual forms.
	(23) Social studies skills. The student uses problem-solving and decision-making skills, working independently and with others, in a variety of settings.
Social Studies TEKS — Grade 7	9)Geography. The student understands the location and characteristics of places and regions of Texas.
	(21)Social studies skills. The student applies critical-thinking skills to organize and use information acquired from a variety of sources including electronic technology.
	(22)Social studies skills. The student communicates in written, oral, and visual forms.
	(23) Social studies skills. The student uses problem-solving and decision-making skills, working independently and with others, in a variety of settings.
Social Studies TEKS — Grade 8	(30) Social studies skills. The student applies critical-thinking skills to organize and use information acquired from a variety of sources including electronic technology.
	(31) Social studies skills. The student communicates in written, oral, and visual forms.
	(32) Social studies skills. The student uses problem-solving and decision-making skills, working independently and with others, in a variety of settings.
TEKS Technology Applications for Middle School (6-8)	(5)Information acquisition- The student acquires electronic information in a variety of formats, with appropriate supervision.
	(6)Information acquisition- The student evaluates the acquired electronic information.
	(7)Solving problems- The student uses appropriate computer-based productivity tools to create and modify solutions to problems.
	(8)Solving problems- The student uses research skills and electronic communication, with appropriate supervision, to create new knowledge.
	(10)Communication- The student formats digital information for appropriate and effective communication.

WHERE ARE WE?

GRADE LEVEL — 6th and 7th

Overview

(This activity is the second of two activities on who uses water in Texas.)

In this activity, students will use maps to analyze average rainfall, evaporation, and distribution of water resources, and discuss how those factors have influenced the distribution of population in regions across Texas.

Background

People simply cannot live without water. The availability of water is one of the forces that have an impact on where people settle, where people move, where cities develop and where business thrives.

Maps make this fact of life very apparent. By analyzing maps that represent different data sets, students will see the correlations between the availability of water — an irreplaceable resource — and the development of human settlements.

Preparation

Make sure you have access to, and copies of, all the documents listed in Materials. Each team of students will need one full set of images. The images are available online, but a full set of image and information files is included with this curriculum.

Materials

- "Evaporation in Texas" Handout — one per team
- "Rainfall in Texas" Handout — one per team
- Three maps from the Texas Water Development Board's online mapping site — http://www.twdb.state.tx.us/mapping/index.asp
  - Regional Water Planning Groups (Displays the boundaries for all TWDB Regional Water Planning Group jurisdictions.)
  - Major Texas Water Resources
  - Major Surface Water Features

(Note — These maps are included with this curriculum as PDF files, and can be downloaded and printed before working with students, if access to computers is limited.)

Procedure

1. Divide the class into small discussion groups of 3–4 students.
2. Distribute maps, images and information sheets to each group.
3. Go through each of the maps and give a brief description of the data it displays.
4. Ask students to discuss and answer each of the discussion questions.

(**Note:** To make the activity more engaging for different learning styles, and to keep the activity moving, consider the following brain-friendly strategy:

- Write each of the discussion questions on a half-sheet of paper.
- Fold each piece of paper in half, and number each piece of paper.
- Set the questions on a table or desk at the front of the room.
- On your signal, one representative from each group goes to the table, selects a sheet of paper, and runs back to the group. The group will work together to answer the question, and record the answer.

When that question has been answered, a second representative from the group takes the paper back up to the table, drops it off, gets a second question, and returns to the group. Continue until every group has answered every question.

(The "race" element of this strategy makes the activity engaging, fast-paced and light-hearted.)

Materials

Map images from the "Texas State Data Center and Office of the State Demographer," http://txsdc.utsa.edu/ :

- Total Population Size in Texas Counties, 2000 http://txsdc.utsa.edu/maps/thematic/cnty_totpop.php
- Persons per Square Mile in Counties in the State of Texas, 2000 http://txsdc.utsa.edu/maps/thematic/sf1-2k/popdens.php
- Percent Population Change in Texas Counties, 1990-2000 http://txsdc.utsa.edu/maps/thematic/cnty_pct90-00.php
- Percent Net Migration in Texas Counties, 1990-2000 http://txsdc.utsa.edu/maps/thematic/cnty_net90-00.php

(Note — These four images included with this curriculum as PDF documents, courtesy of the Texas State Data Center and Office of the State Demographer.)

Discussion Questions

1. Which regions of Texas experience the greatest rainfall?
2. Which regions of Texas have the most surface water features?
3. Which regions of Texas experience the greatest rates of evaporation?
4. Which regions of Texas have experienced the most people leaving?
5. Which regions of Texas have experienced the most people arriving?
6. Which regions of Texas have the highest population?
7. Which regions of Texas have the highest population density?

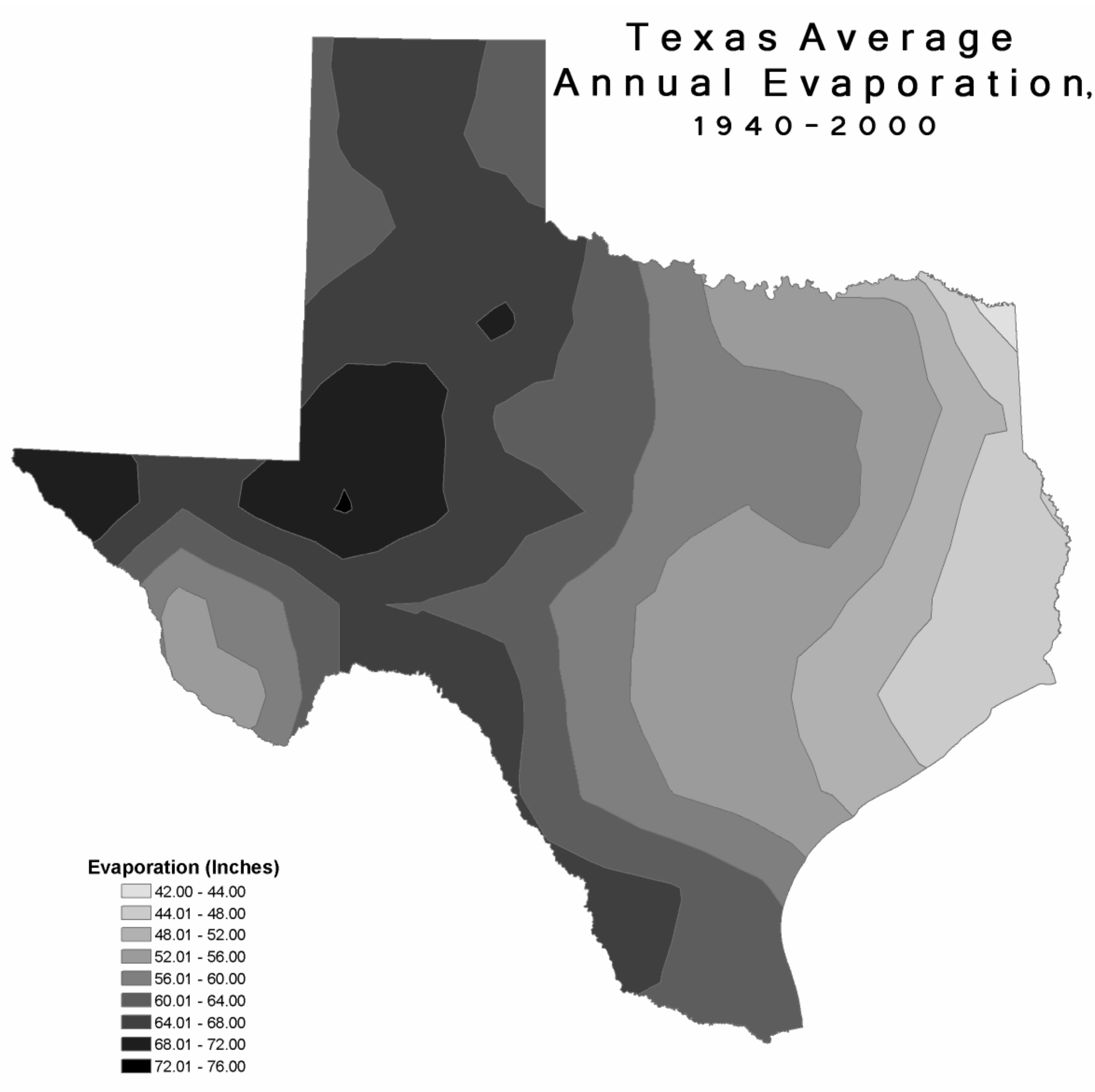
Individual Reflection Questions

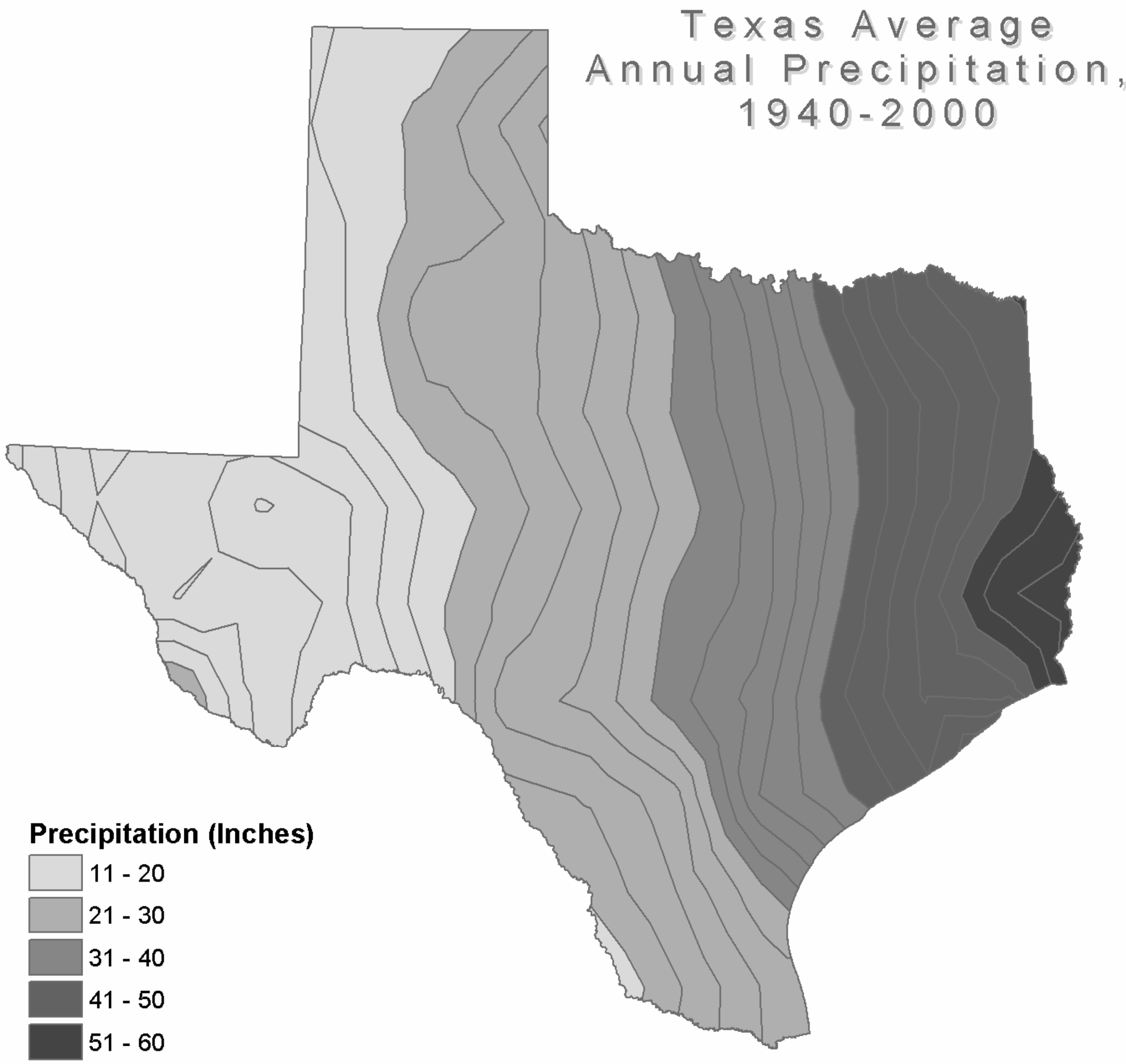
1. In what ways has water influenced WHERE people live in Texas?
2. In what ways has water influenced HOW people live in Texas?

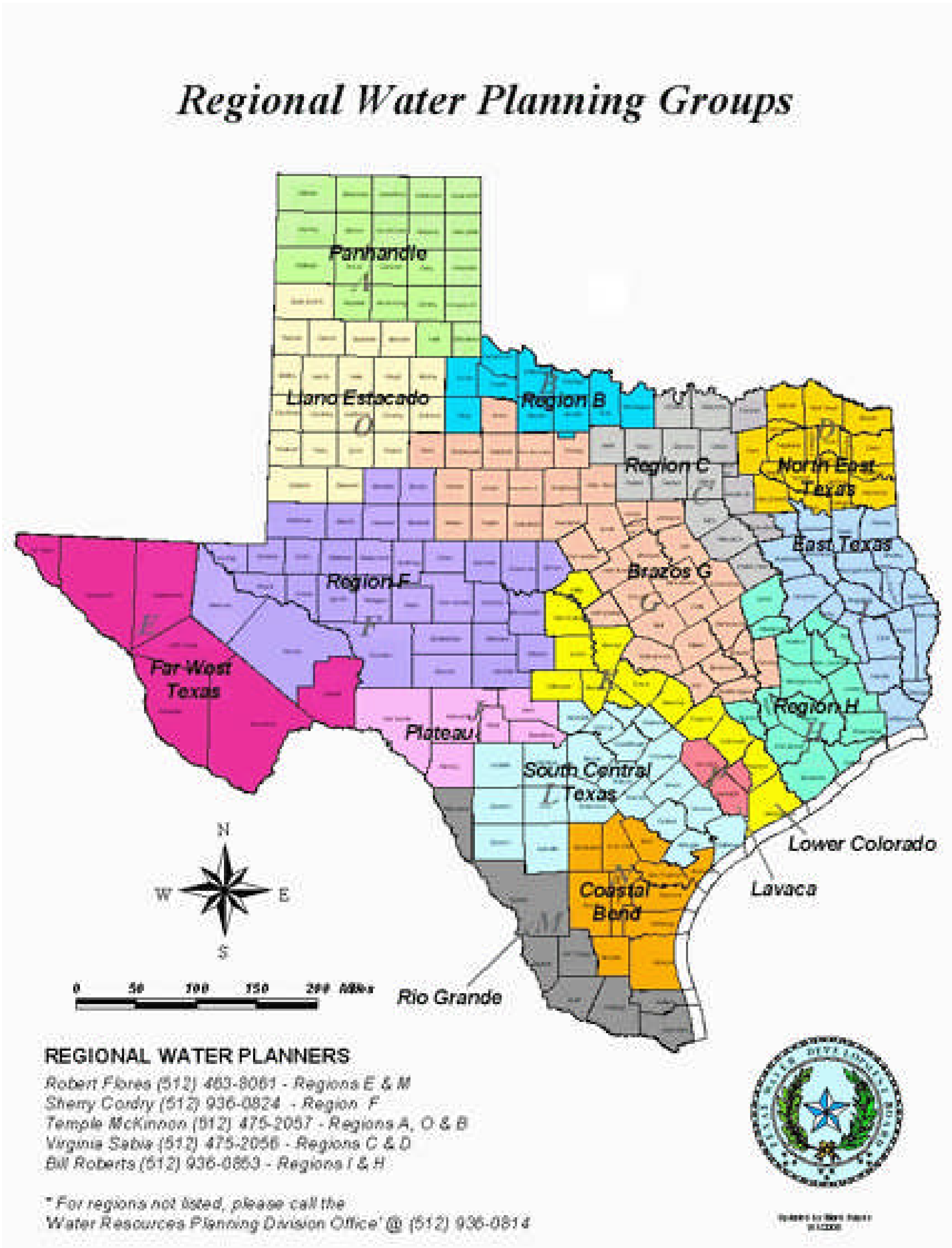
Assessing Understanding

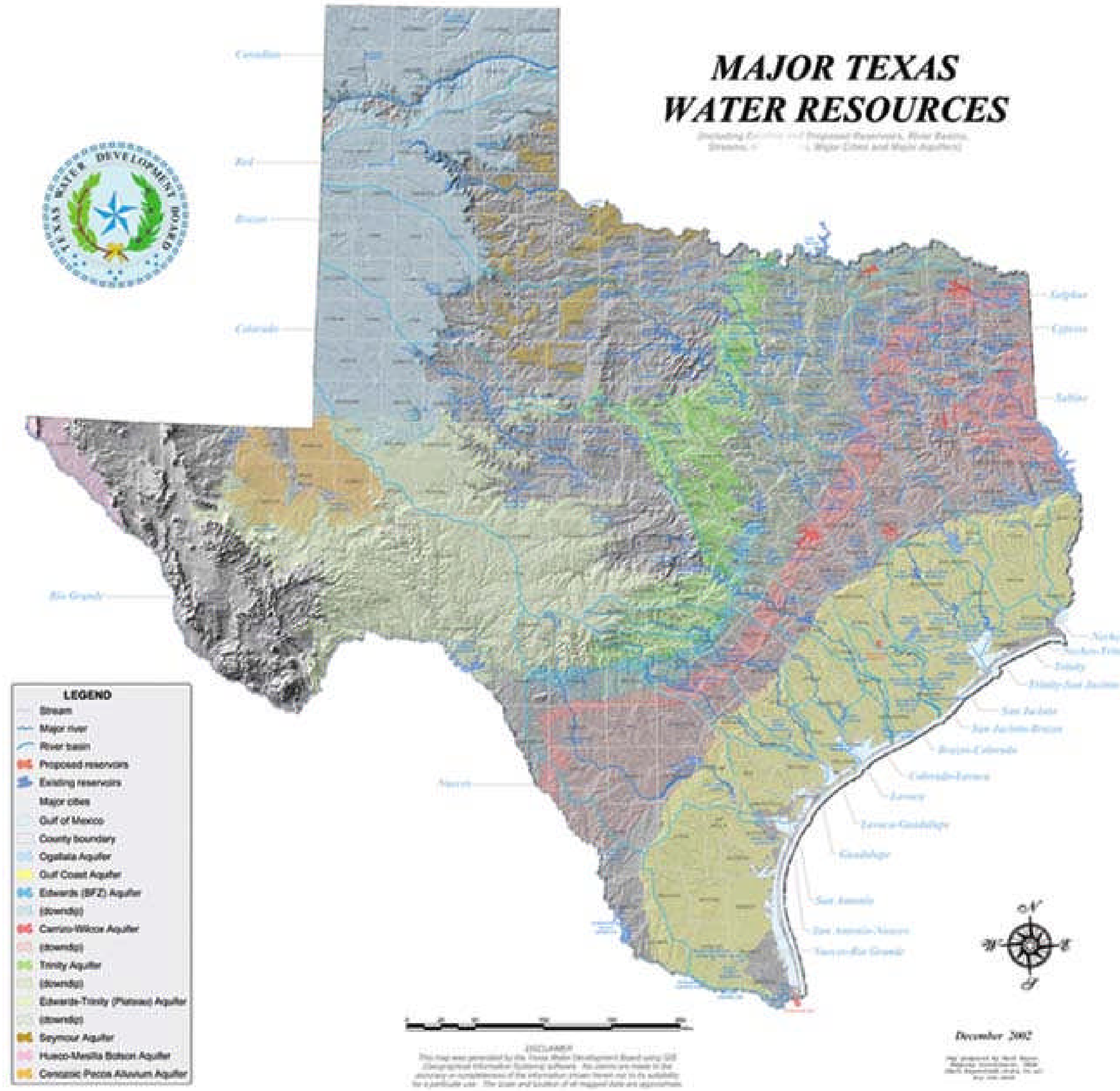
When student groups have answered all the questions, go through them and ask each group to report their findings. If groups arrive at different interpretations, ask the groups to defend their reasoning.

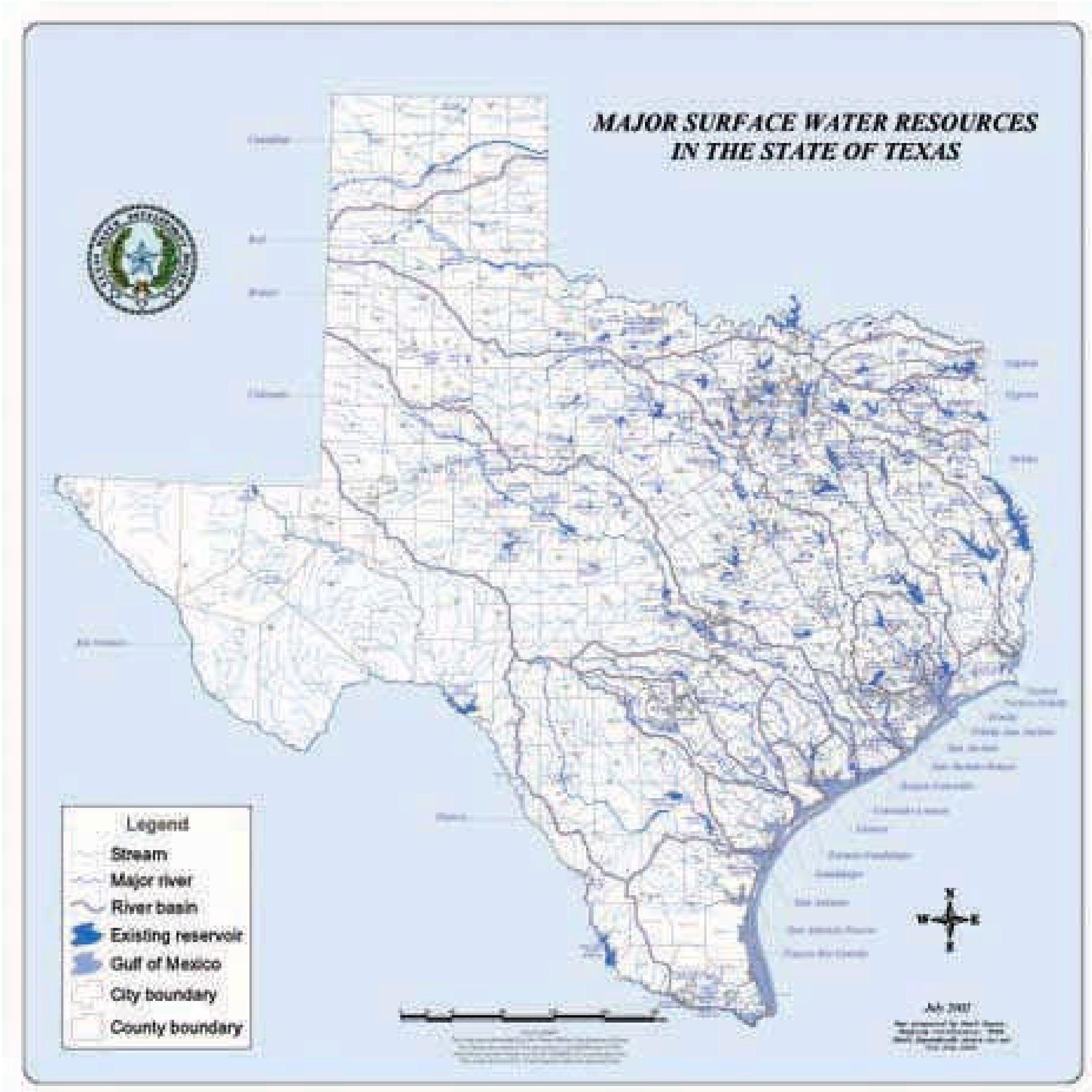
Use the final two questions as an individual assessment. Ask students to answer these questions with a short essay that synthesizes the information displayed on the maps, images information sheets, and discussions.

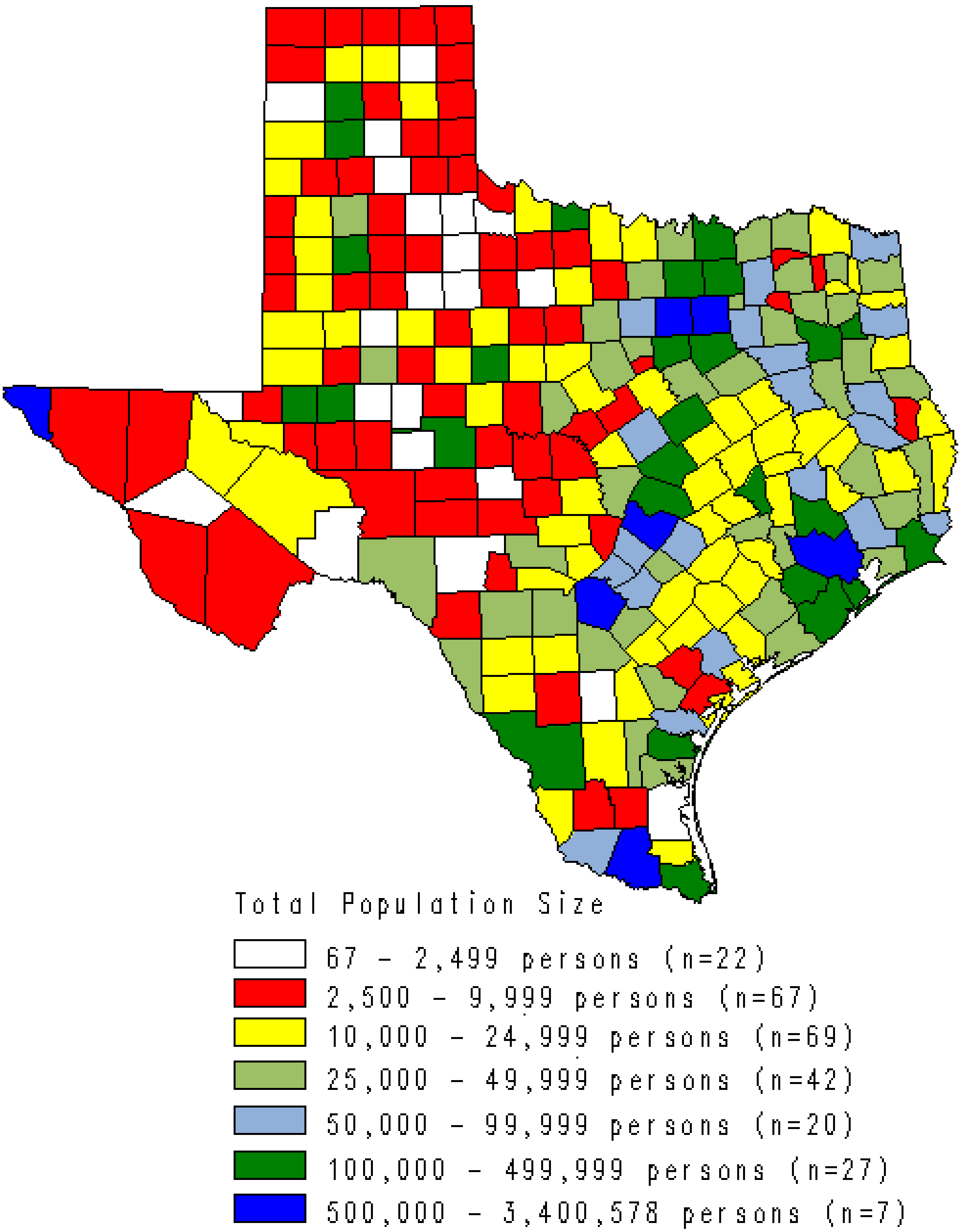

Texas Average
Annual Evaporation,
1940-2000
Evaporation (Inches)
42.00 - 44.00
44.01 - 48.00
48.01 - 52.00
52.01 - 56.00
56.01 - 60.00
60.01 - 64.00
64.01 - 68.00
68.01 - 72.00
72.01 - 76.00

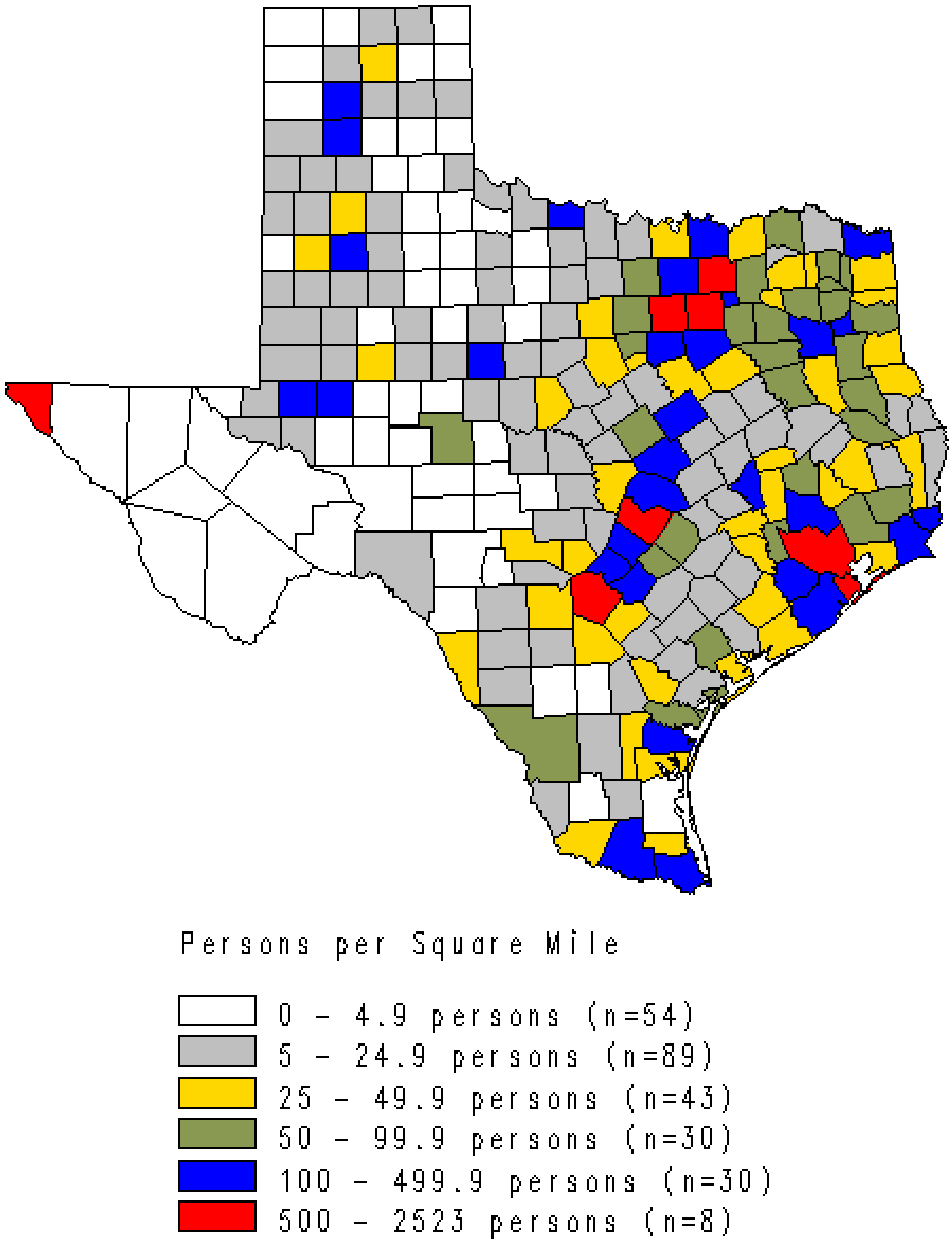

Texas Average
Annual Precipitation,
1940-2000
Precipitation (Inches)
11 - 20
21 - 30
31 - 40
41 - 50
51 - 60

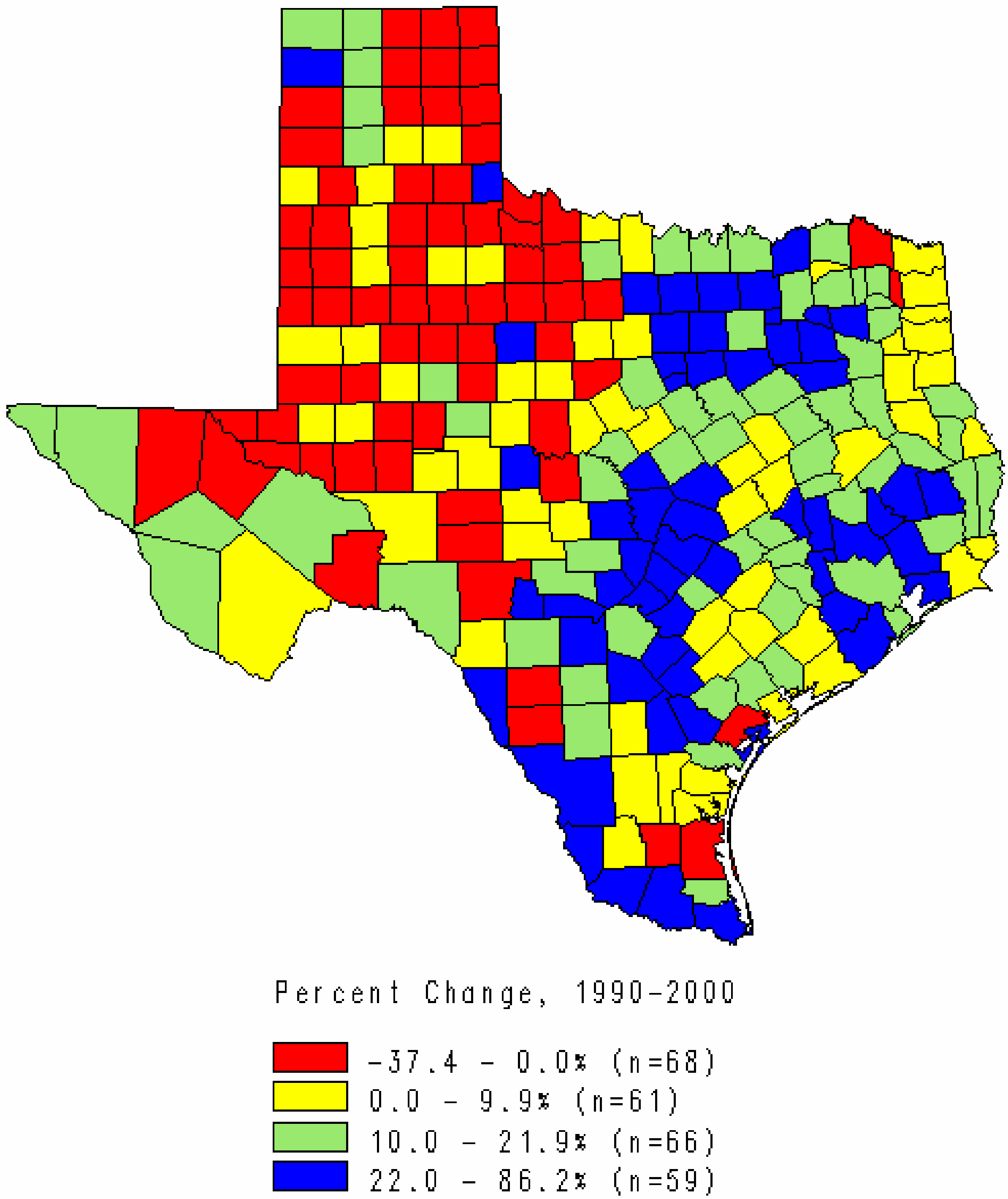

Regional Water Planning Groups
Panhandle
Llano Estacado
Region B
Region C
North East Texas
East Texas
Brazos G
Region F
Far West Texas
Region H
Plateau
South Central Texas
Lower Colorado
Lavaca
Coastal Bend
Rio Grande
N
W
E
S
0
50
100
150
200 Miles
REGIONAL WATER PLANNERS
Robert Flores (512) 463-8061 - Regions E & M
Sherry Cordry (512) 936-0824 - Region F
Temple McKinnon (512) 475-2057 - Regions A, O & B
Virginia Sabia (512) 475-2056 - Regions C & D
Bill Roberts (512) 936-0853 - Regions I & H
* For regions not listed, please call the
Water Resources Planning Division Office' @ (512) 936-0814

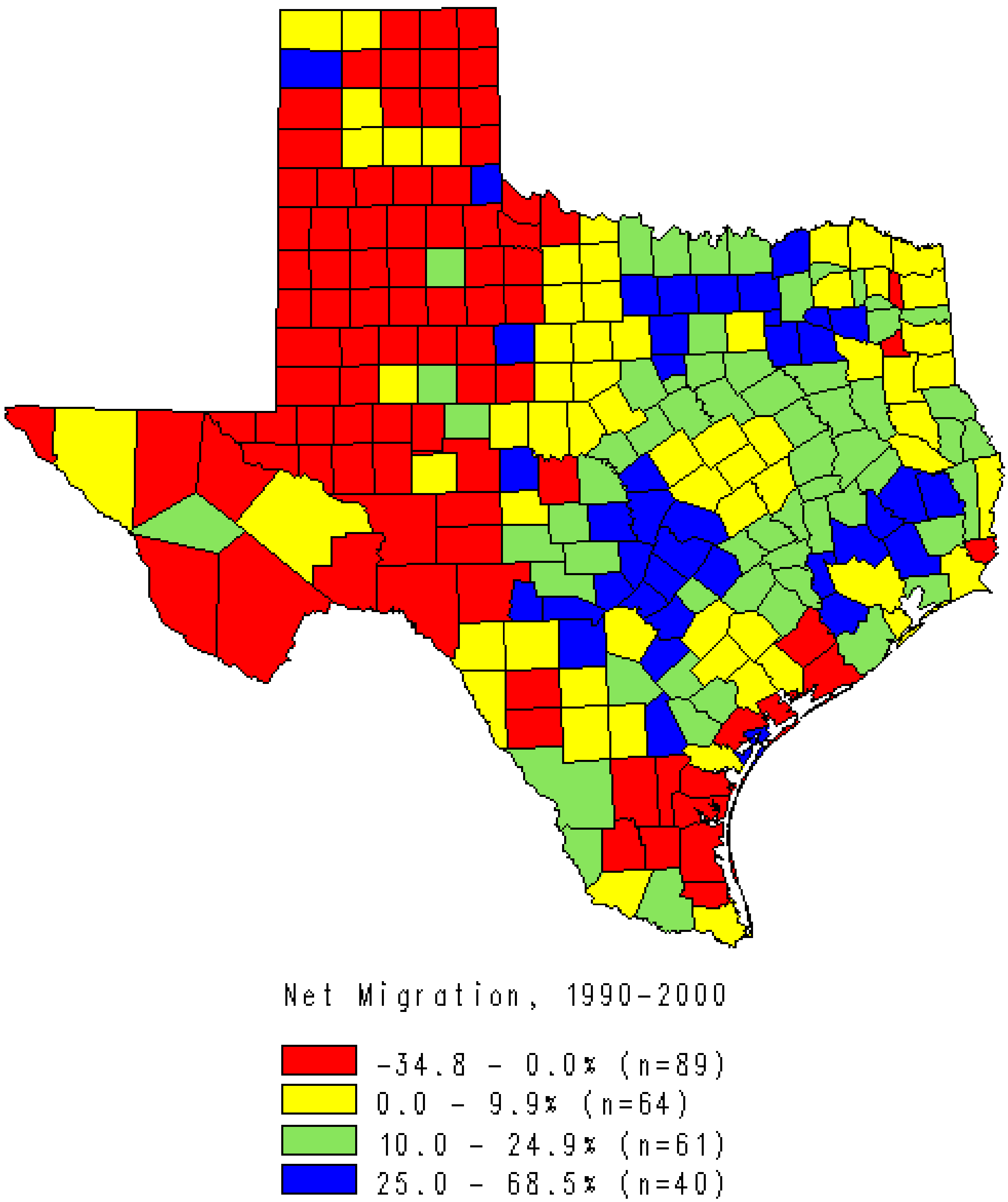

MAJOR TEXAS
WATER RESOURCES
LEGEND
Stream
Major river
River basin
Proposed reservoirs
Existing reservoirs
Major cities
Gulf of Mexico
County boundary
Ogallala Aquifer
Gulf Coast Aquifer
Edwards (BFZ) Aquifer
(downdip)
Carrizo-Wilcox Aquifer
(downdip)
Trinity Aquifer
(downdip)
Edwards-Trinity (Plateau) Aquifer
(downdip)
Seymour Aquifer
Hueco-Mesilla Bolson Aquifer
Cenozoic Pecos Alluvium Aquifer
December 2002


MAJOR SURFACE WATER RESOURCES
IN THE STATE OF TEXAS
Legend
Stream
Major river
River basin
Existing reservoir
Gulf of Mexico
City boundary
County boundary
N
W
E
S


Total Population Size
67 - 2,499 persons (n=22)
2,500 - 9,999 persons (n=67)
10,000 - 24,999 persons (n=69)
25,000 - 49,999 persons (n=42)
50,000 - 99,999 persons (n=20)
100,000 - 499,999 persons (n=27)
500,000 - 3,400,578 persons (n=7)


Persons per Square Mile
0 - 4.9 persons (n=54)
5 - 24.9 persons (n=89)
25 - 49.9 persons (n=43)
50 - 99.9 persons (n=30)
100 - 499.9 persons (n=30)
500 - 2523 persons (n=8)


Percent Change, 1990-2000
-37.4 - 0.0% (n=68)
0.0 - 9.9% (n=61)
10.0 - 21.9% (n=66)
22.0 - 86.2% (n=59)


Net Migration, 1990-2000
-34.8 - 0.0% (n=89)
0.0 - 9.9% (n=64)
10.0 - 24.9% (n=61)
25.0 - 68.5% (n=40)

Grade Level/ Content Area	TEKS
6th Grade Social Science	(3) Geography. The student uses maps, globes, graphs, charts, models, and databases to answer geographic questions.
	(5) Geography. The student understands how geographic factors influence the economic development, political relationships, and policies of societies.
	(7) Geography. The student understands the impact of interactions between people and the physical environment on the development of places and regions.
	(21) Social studies skills. The student applies critical-thinking skills to organize and use information acquired from a variety of sources including electronic technology.
	(22) Social studies skills. The student communicates in written, oral, and visual forms.
	(23) Social studies skills. The student uses problem-solving and decision-making skills, working independently and with others, in a variety of settings.
7th Grade Social Studies	8) Geography. The student uses geographic tools to collect, analyze, and interpret data.
	(9) Geography. The student understands the location and characteristics of places and regions of Texas.
	(10) Geography. The student understands the effects of the interaction between humans and the environment in Texas during the 19th and 20th centuries.
	(11) Geography. The student understands the characteristics, distribution, and migration of population in Texas in the 19th and 20th centuries.
	(20) Science, technology, and society. The student understands the impact of scientific discoveries and technological innovations on the political, economic, and social development of Texas.
	(21) Social studies skills. The student applies critical-thinking skills to organize and use information acquired from a variety of sources including electronic technology.
	(22) Social studies skills. The student communicates in written, oral, and visual forms.
	(23) Social studies skills. The student uses problem-solving and decision-making skills, working independently and with others, in a variety of settings.

WATER USE ACTIVITY

Overview

This activity integrates science processes and content and language arts skills. In this investigation, students will:

- Write a persuasive letter, enlisting their family's help in the investigation
- Gather data on water usage
- Graph and interpret data
- Recommend water saving strategies for their family

Materials

- Water Use Inventory Data Sheets — at least one per student
- Spreadsheet software program
- Graph paper or graphing program
- Letter Writing Rubric — one per student

This activity can easily be extended into a wider, community-based water use inventory, and a community service-learning project. You will find tips on how to get students involved in community water conservation efforts at the end of this activity.

Students will write a persuasive letter to their family, asking for their help in gathering data. Consider partnering with the Language Arts teacher in your school on the Letter Writing Assignment that follows. The letter should explain the investigation, the rationale for doing the investigation, and the importance of water conservation in Texas.

Before having students write their letters, ask them to read the Water Use Inventory Background article.

Vocabulary

Conservation — The act of conserving. To use something carefully or sparingly, avoiding waste. The protection, preservation, management or restoration of natural resources such as water.

Resource — A supply of something that can be used.

Shortage — Having less of something that you need or want

Precious — Something that is of high value, worth or cost

Grade Level/ Subject Area	**TEKS**
6th Grade Science	(2) Scientific processes. The student uses scientific inquiry methods during field and laboratory investigations. (3) Scientific processes. The student uses critical thinking and scientific problem solving to make informed decisions. (12) Science concepts. The student knows that the responses of organisms are caused by internal or external stimuli.
6th Grade Language Arts	(15) Writing/purposes. The student writes for a variety of audiences and purposes and in a variety of forms. The student is expected to: (B) write to influence such as to persuade, argue, and request (16) Writing/penmanship/capitalization/punctuation/spelling. The student composes original texts, applying the conventions of written language such as capitalization, punctuation, penmanship, and spelling to communicate clearly. (17) Writing/grammar/usage. The student applies standard grammar and usage to communicate clearly and effectively in writing. (19) Writing/evaluation. The student evaluates his/her own writing and the writings of others
7th Grade Science	(2) Scientific processes. The student uses scientific inquiry methods during field and laboratory investigations. (3) Scientific processes. The student uses critical thinking and scientific problem solving to make informed decisions. (12) Science concepts. The student knows that there is a relationship between organisms and the environment. (14) Science concepts. The student knows that natural events and human activity can alter Earth systems.
7th Grade Language Arts	(15) Writing/purposes. The student writes for a variety of audiences and purposes and in a variety of forms. The student is expected to: B) Write to influence such as to persuade, argue, and request (16) Writing/penmanship/capitalization/punctuation/spelling. The student composes original texts, applying the conventions of written language such as capitalization, punctuation, handwriting, penmanship and spelling to communicate clearly. (17) Writing/grammar/usage. The student applies standard grammar and usage to communicate clearly and effectively in writing (18) Writing/writing processes. The student selects and uses writing processes for self-initiated and assigned writing. (19) Writing/evaluation. The student evaluates his/her own writing and the writings of others.

Grade Level/ Subject Area	TEKS
8th Grade Science	(2) Scientific processes. The student uses scientific inquiry methods during field and laboratory investigations. (3) Scientific processes. The student uses critical thinking and scientific problem solving to make informed decisions. (6) Science concepts. The student knows that interdependence occurs among living systems.
8th Grade Language Arts	(15) Writing/purposes. The student writes for a variety of audiences and purposes and in a variety of forms. The student is expected to: B) Write to influence such as to persuade, argue, and request (16) Writing/penmanship/capitalization/punctuation/spelling. The student composes original texts, applying the conventions of written language such as capitalization, punctuation, penmanship, and spelling to communicate clearly (17) Writing/grammar/usage. The student applies standard grammar and usage to communicate clearly and effectively in writing. (18) Writing/processes. The student selects and uses writing processes for self-initiated and assigned writing. (19) Writing/evaluation. The student evaluates his/her own writing and the writings of others.

Background Information

Water is our most valuable resource. The average Texan uses 173 gallons of water per day. Around 30% of that water is used outside, on uses like landscaping and gardens. Water shortages are occurring in many parts of the world because of rising demand from growing populations, and unequal distribution of useable fresh water.

In Texas, we want to be smart about how we use this precious resource. We must all be aware of the water we use and learn ways to conserve water. By changing personal habits, such as running water while brushing teeth, people can save a lot of water.

As much as half of the water used now for domestic purposes can be saved by practicing certain conservation techniques. Water can be saved in the bathroom by using low volume shower heads, taking shorter showers, stopping leaks, and by using low volume or waterless toilets. Toilet flushing is the largest domestic water use. Each person uses 13,000 gallons of drinking quality water a year to flush toilets.

Approximate volumes of home water usage are as follows:

Water Used For…	Number of Times per Day	Estimated Amount	Total Gallons
Bath		30 gallons	
Brushing Teeth (2 times with water running)		5 gallons	
Brushing Teeth (2 times with water off)		.5 gallons	
Flushing Toilet		1.6 - 5 gallons/flush	
Laundry (1 load)		30-50 gallons	
Shower (5-10 minutes)		12.5-25 gallons	
Cooking		10 gallons/dinner	
Washing Dishes (by hand)		20 gallons	
Washing Dishes (full dishwasher)		7-14 gallons	
Washing Hands with water running		4 gallons	
Other			
		Total	

Preparation

Teacher’s Note — Writing a Letter

Your students will be gathering data over three days — Friday, Saturday and Sunday. They will need to enlist the help of their families in order to gather accurate data. Earlier in the week, have students write a letter to their family, explaining the investigation and the family’s role in it. Consider partnering with the Language Arts teacher in your school on the Letter Writing Assignment that follows.

Before asking students to write the letter, distribute the ***Letter Writing Rubric***. The point of the letter is to enlist the entire family in the collection of accurate data on water usage. The letter should explain the investigation, the rationale for doing the investigation, and the importance of water conservation in Texas.

Use the 5 W’s of journalistic reporting to frame the letters to families:

Who — Your class is asking for help from their families

What — To participate in an investigation of water use by gathering accurate data on how much water each family uses over three days

When — For three days, over a Friday, Saturday and Sunday

Where — In the home and in the yard surrounding the home

Why — Water shortages are a very real concern for Texas in the coming years. Gathering accurate data about current water use will help students learn how to conserve water, and plan their water future.

Activity

1. For three consecutive days, record your home's daily water use (bath, shower, clothes washing, etc.) in the STUDENT WORK SHEET.
2. Transfer your data into an Excel Spreadsheet.
3. Create at least three (3) charts. This will provide a visual graphic of your family's water use.
4. Convert the number of GALLONS into LITERS.

Student Name____ Date _______________________

Analyzing Your Data, Drawing Conclusions

Use your data to answer the following questions:

1. What day did your family use more water? What are the reasons for this increased use?

2. What was the total amount of water used by your family during the three days?

3. What is the average amount of water used by each person in your family?

4. Estimate the monthly and yearly average of water usage in your home.

5. Would the family's water usage vary during the year? Why?

6. Which single activity used the most water?

7. What recommendations would you make to your family in order to use less water?

8. If your family followed these recommendations, how much water would they save each year?

Water Use Inventory Data Sheet

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Water Use Inventory
Letter Writing Rubric

Element	Novice (1)	Developing (2)	Proficient (3)	Distinguished (4)
General Description (Holistic Scoring)	A poor letter: The letter is confused in purpose or does not demonstrate an awareness of the intended audience. Content is not presented in an organized or logical way. Includes few or no details. The reader will not be clear on what is being asked of them	A fair letter: This letter shows some awareness of the purpose and intended audience. Attempts to organize content and idea, but is not particularly smooth. Includes some details. Reader may not be clear on what is being asked of them	A good letter: This letter shows some awareness of the intended audience. Content and ideas are organized in a logical way, although transitions may not be smooth. Includes some details to clarify ideas and help the reader understand what is being asked of them.	An excellent letter: The letter shows a clear awareness of the intended audience. Content and ideas are organized in a logical way. Ideas flow in a way that is fluent and cohesive. Appropriate details clarify ideas and help the reader understand what is being asked of them.
Focus and Coherence	Individual paragraphs and/or the letter as a whole are not focused. The writer may shift abruptly from idea to idea, making it difficult for the reader to understand how the ideas included in the letter are related. The letter as a whole has little, or no, sense of completeness. The introduction and conclusion, if present, may be perfunctory. A substantial amount of writing may be extraneous because it does not contribute to the development or quality of the letter. In some cases, the letter overall may be only weakly connected to the prompt.	Individual paragraphs and/or the letter as a whole are somewhat focused. The writer may shift quickly from idea to idea, but the reader has no difficulty understanding how the ideas included in the letter are related. The letter as a whole has some sense of completeness. The writer includes an introduction and conclusion, but they may be superficial. Some of the writing may be extraneous because it does not contribute to the development or quality of the letter as a whole.	Individual paragraphs and the letter as a whole are, for the most part, focused. The writer generally shows the clear relationship between ideas, making few sudden shifts from one idea to the next. The letter as a whole has a sense of completeness. The introduction and conclusion add some depth to the letter. Most of the writing contributes to the development or quality of the letter as a whole.	Individual paragraphs and the letter as a whole are focused. This sustained focus enables the reader to understand and appreciate how the ideas included in the letter are related. The letter as a whole has a sense of completeness. The introduction and conclusion are meaningful because they add depth to the letter. Most, if not all, of the writing contributes to the development or quality of the letter as a whole.

Water Use Inventory
Letter Writing Rubric

Organization	The writer's progression of thought from sentence to sentence and/or paragraph to paragraph is not logical. Sometimes weak progression results from an absence of transitions or from the use of transitions that do not make sense. At other times, the progression of thought is simply not evident, even if appropriate transitions are included. An organizational strategy is not evident. The writer may present ideas in a random or haphazard way, making the letter difficult to follow. Wordiness and/or repetition may stall the progression of ideas.	The writer's progression of thought from sentence to sentence and/or paragraph to paragraph may not always be smooth or completely logical. Sometimes the writer needs to strengthen the progression by including more meaningful transitions; at other times the writer simply needs to establish a clearer link between ideas. The organizational strategy or strategies the writer chooses do not enable the writer to present ideas effectively. Some wordiness and/or repetition may be evident, but these weaknesses do not completely stall the progression of ideas.	The writer's progression of thought from sentence to sentence and paragraph to paragraph is generally smooth and controlled. For the most part, transitions are meaningful, and the links between ideas are logical. The organizational strategy or strategies the writer chooses are generally effective. Wordiness and/or repetition, if present, are minor problems that do not stall the progression of ideas.	The writer's progression of thought from sentence to sentence and paragraph to paragraph is smooth and controlled. The writer's use of meaningful transitions and the logical movement from idea to idea strengthen this progression. The organizational strategy or strategies the writer chooses enhance the writer's ability to present ideas clearly and effectively.
Voice	The writer does not engage the reader, therefore failing to establish a connection. There may be little or no sense of the writer's individual voice. The letter does not sound authentic or original. The writer is unable to express his/her individuality or unique perspective.	There may be moments when the writer engages the reader but fails to sustain the connection. Individual paragraphs or sections of the letter may sound authentic or original, but the writer has difficulty expressing his/her individuality or unique perspective.	The writer engages the reader and sustains that connection throughout most of the letter. For the most part, the composition sounds authentic and original. The writer is generally able to express his/her individuality or unique perspective.	The writer engages the reader and sustains this connection throughout the letter. The letter sounds authentic and original. The writer is able to express his/her individuality or unique perspective.

Water Use Inventory
Letter Writing Rubric

Conventions	There is little or no evidence in the letter that the writer can correctly apply the conventions of the English language. Severe and/or frequent errors in spelling, capitalization, punctuation, grammar, usage, and sentence structure may cause the writing to be unclear or difficult to read. These errors weaken the letter by causing an overall lack of fluency. The writer may misuse or omit words and phrases and may frequently write awkward sentences. These weaknesses interfere with the effective communication of ideas.	Errors in spelling, capitalization, punctuation, grammar, usage, and sentence structure throughout the letter may indicate a limited control of conventions. Although these errors do not cause the writing to be unclear, they weaken the overall fluency of the letter. The writer may include some simple or inaccurate words and phrases and may write some awkward sentences. These weaknesses limit the overall effectiveness of the communication of ideas.	The writer generally demonstrates a good command of spelling, capitalization, punctuation, grammar, usage, and sentence structure. Although the writer may make minor errors, they create few disruptions in the fluency of the letter. The words, phrases, and sentence structures the writer uses are generally appropriate and contribute to the overall effectiveness of the communication of ideas.	The overall strength of the conventions contributes to the effectiveness of the letter. The writer demonstrates a consistent command of spelling, capitalization, punctuation, grammar, usage, and sentence structure. When the writer attempts to communicate complex ideas through sophisticated forms of expression, he/she may make minor errors as a result of these risks. These types of errors do not detract from the overall fluency of the letter. The words, phrases, and sentence structures the writer uses enhance the overall effectiveness of the communication of ideas.