Sample ToolKit for Ambassadors in Drinking and Waste Water Treatment

(1) **Electronic Documents** to be stored on OSU-EPN or EECO Website Ambassador pages:

- "Washing Water" Activity for Grades 6-12 from *Healthy Water, Healthy People* curriculum.
- "Water Filtration" Activity for Grades 4-8 from US EPA
- "Decision Making: A Mock Town Meeting on a Proposed Tank Farm" Activity for Grades 9-12 from US EPA
- Vocabulary List for Drinking Water Treatment
- EnviroScape© Drinking Water and Wastewater Treatment Model description, and Resource Links to user's manual and supplemental materials
- EnVision 3000© Ground Water Flow Model description and Resource Links to user's manual and supplemental materials from National Ground Water Association
- Contact List of County Soil & Water Conservation Districts Where the Models can be borrowed
- Materials from Training Webinars
- Alignment of "Washing Water" activity and two models with Ohio's Academic Content Standards by grade level

(2) **Physical Models and Career Profile DVDs** That Can Be Borrowed from Local SWCD Offices and EECO Regional Directors:

- EnviroScape© Drinking and Wastewater Treatment
- EnVision© Ground Water Flow Model
- Two-DVD set of Career Pathway: Environmental Related Occupations

(3) **Training**: Webinars or Workshops in Summer 2014 training drinking/wastewater Ambassadors on use of the models and how to make presentations engaging, age appropriate, and standards-aligned.

Washing Water

Summary

Students model how water travels from its source, through drinking water treatment, contamination, wastewater treatment, and back to the source. Engineering, chemistry, and problem-solving skills are applied as the students design methods for cleaning polluted water.

Objectives

Students will:

- demonstrate the drinking water treatment process using common items.
- create a process for wastewater treatment.
- evaluate the effectiveness of drinking water and wastewater treatment techniques.

Materials

Drinking water treatment materials:

- *1-gallon (3.8 l) jugs of source water* (2)
- *2-liter bottle with cap* (1 per group)
- *Scissors or knife*
- *Copies of* ***Drinking Water Worksheet*** *Student Copy Page (1 per group)*
- *Copies of* ***Treatment System Illustrations*** *Student Copy Page* (1 per group)
- *Alum* (potassium aluminum sulfate, available in pharmacies, or the spice/baking aisles in grocery stores)

Grade Level:
6–12

Subject Areas:
General Science, Chemistry, Environmental Science, Mathematics, Health Science

Duration:
Preparation:
30 minutes

Activity:
Three to four 50-minute periods

Setting:
Classroom

Skills:
Gather, Measure, Plan, Manipulate, Model

Vocabulary:
aeration, coagulation, sedimentation, filtration, hydrologic cycle, floc, flocculation, source water, disinfection, sludge, potable

- *Plastic spoons* (at least 1 per group)
- *Fine sand* (1 cup per group)
- *Coarse sand* (1 cup per group)
- *Small gravel* (1 cup per group)
- *Large beaker or jar* (1 per group)
- *Coffee filter* (1 per group)
- *Rubber band* (1 per group)
- *Clock*
- *Cardboard box top; lid from a box of paper* (forms a base to support 2-liter bottle)

Wastewater materials

- *Copies of* ***Wastewater Worksheet*** *Student Copy Page* (1 per group) (Small amounts or a sample of some of the following):
- *Coffee grounds*
- *Salt*
- *Vegetable oil*
- *Soil*
- *Yeast*
- *Soap*
- *Food scraps*
- *Vinegar*

Possible cleaning materials:

- *Screens to use as filters* (cheese cloth)
- *Coffee filters*
- *Alum*
- *Bowls or cups*
- *Straws or pipettes*
- *Spoons*
- *Baking soda*
- *Charcoal*
- *Talc*
- *Sand and gravel*

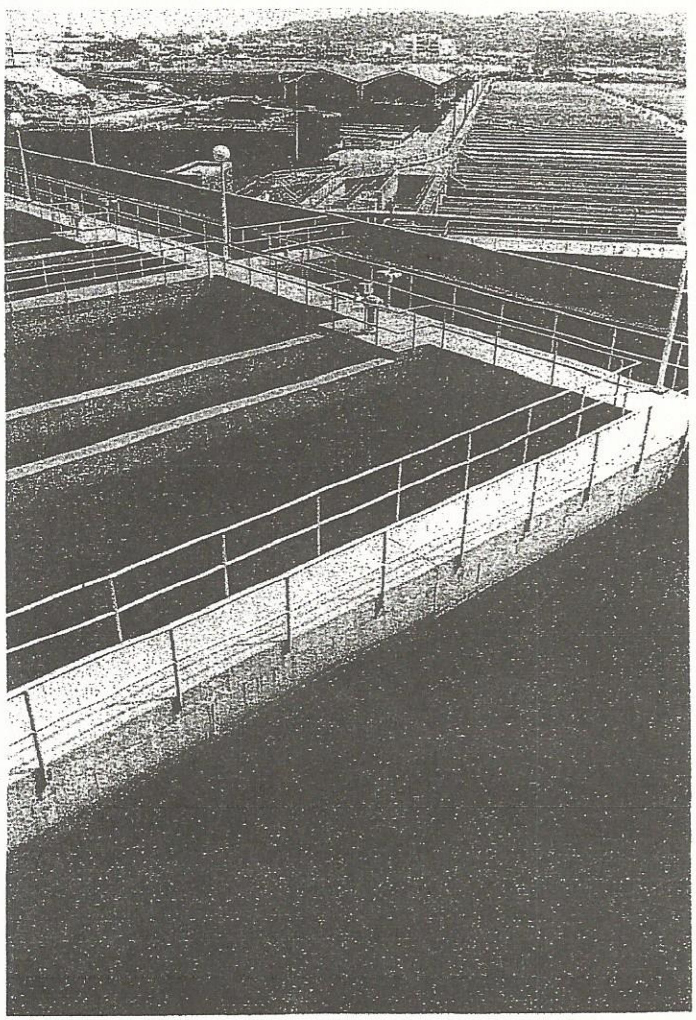
Possible testing materials:

- *pH paper (litmus paper)*
- *Brown paper bag*

Background

The process known as the hydrologic cycle describes water's constant movement between oceans and atmosphere, clouds and rivers, ground water and lakes. Several processes of the hydrologic cycle help purify water— evaporation, freezing, and infiltration. During evaporation and freezing, dissolved and suspended particles are left behind as the water changes between states. During infiltration, suspended particles are filtered as water moves through soil, sand, and gravel.

While this system is very effective, it also takes a long time. Because of the human demand for clean drinking water and because humans produce so much wastewater, the hydrologic cycle simply can't keep up. Therefore, we must treat water both before and after we use it. The process of purifying water for human use is not unlike the steps water passes through in the hydrologic cycle. Once source water (water from lakes, ground water, or rivers) reaches a water treatment plant (via pipes), the process begins.



Wastewater treatment facility. American Water Works Association

First water is screened to remove large debris. Next, in a step called *pre-chlorination*, chlorine is added to destroy any pathogenic bacteria. In the next step, *flocculation*, alum ($Al_2(SO_4)_3$) and slaked lime ($Ca(OH)_2$) are added and react together to form a sticky compound which attracts and clumps suspended particles. These clustered particles, or *flocs*, settle to the bottom of a tank in a process called *settling*, or *sedimentation*. Next the water is filtered through sand and gravel to remove any remaining suspended particles. This is called *sand filtration*. At this point, the water is considered potable (suitable for drinking) but must undergo a final step called *post-chlorination* where chlorine is added to keep the water bacteria-free during delivery from the water treatment plant, through pipes, to homes and businesses. Other optional steps that water treatment facilities can use include aeration to improve the taste of water, fluoridation to reduce tooth decay, and pH adjustment to prevent corrosion of pipes.

After water is used and has disappeared down the drain, it flows through another set of pipes to a wastewater treatment plant. There it again passes through a series of purifying steps designed to make it relatively free of waste before it is returned to a source water system.

Primary wastewater treatment, which involves filtration, settling, and skimming procedures, removes 45-50% of pollutants. Most developed countries apply secondary treatments, mainly biological processes, which remove 85-90 percent of remaining pollutants. Additionally, microorganisms are introduced to the water to consume other organic waste material. Later, in settling tanks, solids and microorganisms are separated from the wastewater, which is then disinfected with chemicals like chlorine to kill remaining bacteria. Then it is released into nearby waterways.

Though this process is extensive, some pollutants like nitrates, phosphates, heavy metals, pesticides and cleansers can remain. Some advanced wastewater treatment facilities impose tertiary processes like activated charcoal filtration to remove organic materials, distillation to remove salts, and flocculation to remove suspended matter.

Unfortunately the costs to build and operate such advanced treatment plants are often prohibitive and few communities have them. The expense and difficulty of removing some pollutants means it is best to keep them from reaching water in the first place. Properly disposing of items we use every day like motor oil, gasoline, paint thinner, and pesticides, combined with choosing less caustic cleansers (vinegar, water, baking soda and others) can help keep our water safe.

Procedure

Warm Up

1. Ask students to list the source of their school's drinking water. Is this water treated before it reaches the school? If so, where and how is it treated?
2. Where does their water go after they flush their school's toilets? Where and how is this wastewater treated?
3. Was the school's source water (water that is treated for drinking) previously someone else's wastewater? If a local map is available, have students trace their source water upstream to see if another community is dumping their treated wastewater into it. This is often the case as we "all live downstream" from someone.
4. Explain that we actively treat our water before drinking it to ensure it is potable, and after we use it to ensure that it does not impact the water quality of the waterway that receives it. Inform students that in this activity they will model the processes of water treatment and wastewater treatment.

The Activity

Part I:

Making drinking water Note: Remind students to **NEVER** drink the water during this entire activity!

1. **Preparation: Collect source water (such as that from a river, pond, or lake, or add dirt or mud to tap water) in two 1-gallon (3.8 l) jugs with lids.**
2. **Explain to students that they will attempt to make this source water into drinking water just as a municipal water treatment plant does.** However, since they do not have the proper equipment, remind students to **NEVER** drink this water, even after treatment.
3. **Write the terms Aeration, Pre-Chlorination, Coagulation, Sedimentation, Sand Filtration, and Post-Chlorination on the board or a flipchart. Explain to students that these are the primary steps in drinking water treatment.** The chlorination steps will be omitted in this activity for safety reasons. Ask students to define these terms as best they can before giving them an overview of the process. The process begins with *Aeration,* which adds oxygen to the water and removes trapped gasses. Next, *Pre-chlorination* destroys pathogenic bacteria. *Coagulation,* which removes suspended solids, is initiated by adding alum to the water. *Sedimentation* allows the floc (coagulated particles) to settle out. *Sand Filtration* removes finer suspended particles. *Post-chlorination* ensures that bacteria will not infect the water as it travels through the distribution system to the consumer. Ozone and ultraviolet radiation are also used in place of chlorine.
4. **Divide students into groups. Distribute a copy of the *Drinking Water Worksheet* and a set of drinking water treatment materials to each group.** Have them cooperatively complete the ***Drinking Water Worksheet*** in their groups.
5. **Pre-measure a teaspoon (4.9 ml) of alum crystals for each group and carefully distribute it to groups as they request it for their coagulation (Step 3 of the worksheet).** (Advise students not to touch the alum, but if they do, they must immediately wash the affected area with soap and water.)
6. **After the groups have completed their Drinking Water**

Worksheets, have them share their results and discuss the activity. Instruct them to pour their treated water back into the original source water.

Part II: Treating Wastewater

1. **Explain to students that after water is purified for drinking, it is distributed to homes and industries where it is used for bathing, washing dishes and clothes, and in manufacturing processes. Pipes then carry wastewater to a wastewater treatment facility, where it is cleaned before it is returned to the source water.** Inform students they will be challenged to model this wastewater treatment process using common materials and their own design.
2. **Have students "make" wastewater by adding soil, coffee grounds, vegetable oil, soap, salt, vinegar, yeast, and food scraps to the two 1-gallon (3.8 l) jugs of source water.**
3. **Shake the jugs thoroughly and distribute about .5 liters of the wastewater to each group in the bottom half of their 2-liter bottle.**
4. **Distribute copies of the *Wastewater Worksheet* and a set of testing materials to each group.**
5. **Tell students their task is to clean the water. Groups should use their *Wastewater Worksheet* to record their procedures for cleaning the water.** Encourage them to use a series of steps, so they can evaluate each step separately. They may wish to use some of the techniques learned in ***Part I,*** but are not required to do so.
6. **Describe the materials that can be used for the wastewater treatment and instruct students about safety procedures** (do not touch the alum or baking soda, and wash their hands or affected areas immediately after touching the wastewater or cleaning agents).
7. **After attempting to clean their water, students should evaluate the results. Evaluation criteria may include color, smell, pH, and the presence of oil.** Are there any contaminants that they could not remove?
8. **After all groups have completed their worksheets, have them share their procedures and results.** They should then compare the treatment procedures of all groups and determine which techniques worked well and which did not.
9. **Distribute the Wastewater Treatment Illustration to the groups.** Review the treatment processes and have students compare their procedures with the actual wastewater treatment process.

Wrap Up

Have students draw or write a description of the process of water treatment from the source water, through drinking water treatment, contamination during use, wastewater treatment, and back to the source water. Challenge them to complete this assessment without looking at the illustrations provided during the activity.

Ask students to name shortfalls that they noticed in the water treatment system. List them on the board. Balance this list with components of the water treatment system that they see as indispensable. Invite a drinking water and wastewater treatment professional to your classroom to discuss the water treatment process, address the students' questions, and discuss the students' shortfall and indispensable components lists. Have this professional explain why all contaminants are not removed during treatment (money, available resources, time, space, or practicality).

Remind students that the chemicals they pour down their household drain can end up in a wastewater treatment plant, and therefore in drinking water. Have students brainstorm ways to reduce their impact on the drinking water and wastewater treatment systems (e.g., do not pour oil, paints, chemicals down the drains, conserve the amount of water they use and send to these facilities, substitute nontoxic cleaners for chemical cleaning agents, etc.).

Assessment

Have students:

- simulate the process of drinking water treatment using common items (*Activity*-Part I).
- design and implement a waste water treatment process using common items (*Activity*-Part II).

- evaluate the effectiveness of their drinking water and waste water treatment techniques (***Activity***- Part II).

Extensions

Contact your local drinking water and wastewater treatment facilities to find out the costs of these processes. Assign costs to the activity above for treatment chemicals, pumping water, cleaning and replacing filters, sludge removal, etc. Conduct the activity again, challenging students to clean their water for as low a cost as possible.

Have students research different ways to reduce their impact on the water treatment systems (e.g., do not pour oil, paints, chemicals down the drains, conserve the amount of water they use and send to these facilities, substitute nontoxic cleaners for chemical cleaning agents, etc). Ask students to present their findings to the class, then plan and conduct a campaign to educate other students and community members about the importance of reducing their impacts on the water treatment system.

Have representatives from a drinking water or wastewater treatment facility, county sanitarian, or water treatment engineer visit the class during the activity to assess the methods for cleaning water used by students. Have them discuss how this process is carried out in their local facility. Prior to the visit, encourage students to write down three questions that they would like to ask the expert. If an expert is not available to visit your classroom, organize a field trip for students to visit your local drinking water treatment plant and wastewater treatment plant.

Testing Kit Extensions

While conducting both ***Part I*** and ***Part II*** of the activity, evaluate the effectiveness of each step by measuring water quality parameters such as turbidity, conductivity, pH, etc. using the Healthy Water, Healthy People testing kit. Be sure to establish a baseline by measuring these parameters before and after treatment.

Internet Extension

Investigate the source for your municipal drinking water supply. Check for this information at the Web site: http://www.epa.gov/safewater/dwinfo.htm. Additionally, have students research and analyze the federal standards for allowable levels of drinking water and wastewater contaminants. Compare these standards with those of other countries if available.

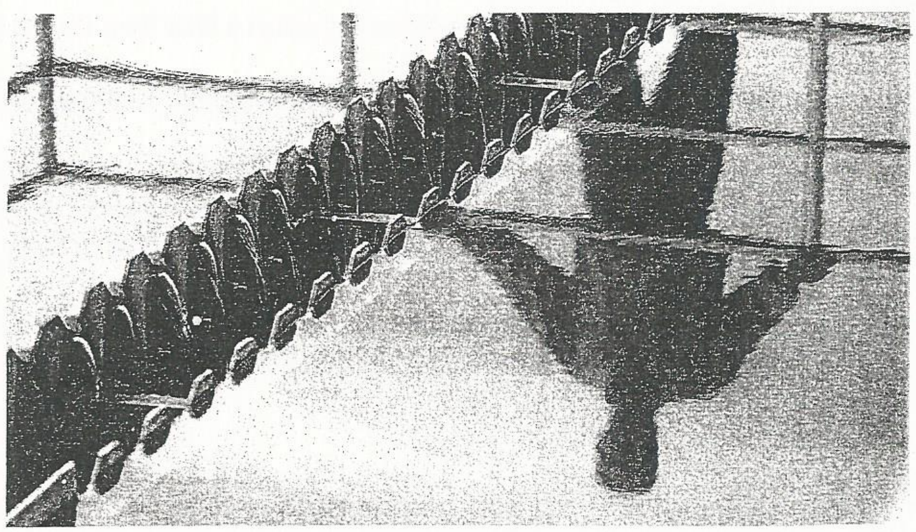
Resources

American Chemical Society. 2002. *ChemCom: Chemistry in the Community.* New York, NY: W.H. Freeman and Company.

United States Environmental Protection Agency. 2001. *EPA Environmental Education.* Retrieved on February 4, 2002, from the Web site: http://www.epa.gov/safewater/kids/exper.html

The Watercourse. 1995. *Project WET Curriculum and Activity Guide.* Bozeman, MT: The Watercourse.

For information on drinking water treatment, visit the American Water Works Association Web site: www.awwa.org. For information on wastewater treatment, visit the Water Environment Federation Web site: www.wef.org.



Operator examining a floc settling tank. American Water Works Association

Drinking Water Worksheet

1. Cut your 2-liter bottle in half. Place about .5 liters of the source water in the bottom half. Observe the color and smell of the water and record your observations:

2. Aeration: To aerate, pour the water back and forth between the top and bottom halves ten times. End with the water in the bottom half of the bottle. Discuss and record any changes observed:

3. Coagulation: To remove suspended solids, alum is added to encourage coagulation and settling (flocculation) of the particles. Add a teaspoon of alum crystals to the source water. *(Important: Do not to touch the alum! If you do, immediately wash hands or affected areas with soap and water.)* Slowly stir the mixture for five minutes. You should see particles forming clumps (floc). Record changes in the water's appearance:

4. Sedimentation: Floc is allowed to settle out. Let the water rest undisturbed for 20 minutes (begin Step 5 while waiting). Record what is causing the floc to settle. ______________________ Record observations of the sample every five minutes:
   Start: ______________________ 5 mins: ______________________
   10 mins: ______________________ 15 mins: ______________________
   20 mins: ______________________

5. Filtration: Removes finer suspended particles. Construct a filter from the top half of your 2-liter bottle as follows:
   a. Remove the cap and place a coffee filter over the mouth, securing it with a rubber band. Turn the bottle upside down.
   b. Pour one cup (.24 l) of pebbles or aquarium gravel into the bottle. Pour one cup (.24 l) of coarse sand on top of the pebbles. Pour one cup (.24 l) of fine sand on top of the coarse sand.
   c. **Slowly** pour several cups of clean tap water through the filter to clean it. Try not to disturb the fine sand layer as you pour.
   d. Pour your source water through the sand filter while holding it over a large beaker.
   e. Compare your source water now to the source water you started with. Record observable changes:

Wastewater Worksheet

1. Assess the appearance and smell of your wastewater. Test the pH and check for the presence of oil by placing a drop on brown paper. If oil is present, an oil smear will form around the drop. If oil is not present, no smear will form.

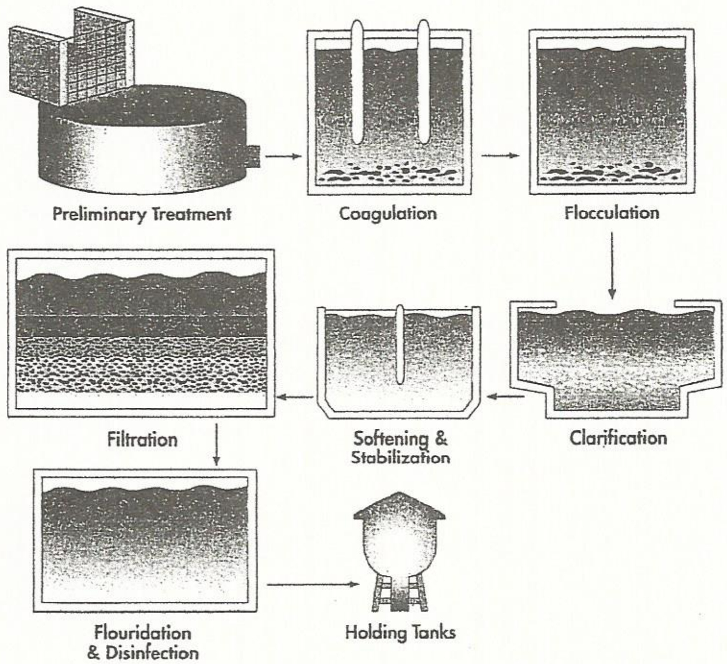
2. Formulate a plan to clean your wastewater. Use any of the available cleaning products provided. Be sure to list a series of steps so that you can later evaluate the effectiveness of each step.

3. Evaluate the effectiveness of each step in your wastewater treatment plan. For example, was there an observable change as a result of each step? Record these changes as you implement your wastewater treatment plan.

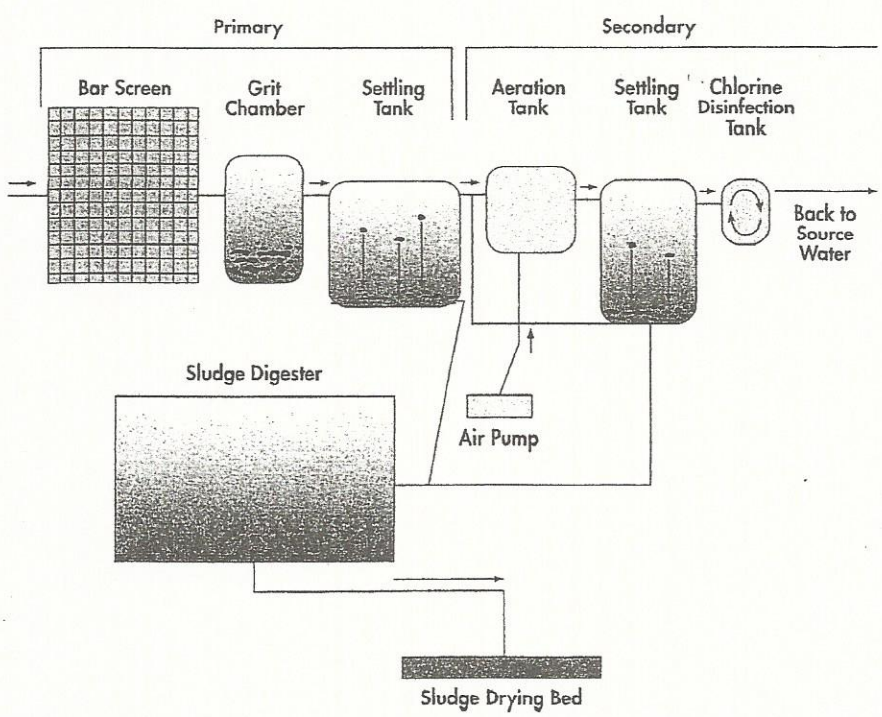
4. Assess the appearance and smell of your wastewater. How does the wastewater compare to the observations made in question 1? Be sure to test the pH and for the presence of oil.

5. Were there some contaminants that were not removed? Could they be removed if you had other equipment or more time?

Drinking Water Treatment System



Wastewater Treatment



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CORRELATIONS

Projects Correlated to Ohio Content Standards

Welcome

...to the interactive website for **Project Learning Tree, Project WET, Project WILD and Healthy Water Healthy People** activity correlations.

Use the form at the right to search the database. The results will show how the environmental education program activities relate to Ohio's academic content standards.

These award winning programs provide hands-on, interdisciplinary learning opportunities to investigate environmental issues and encourage young people to make informed responsible decisions.

Please note: Currently the activity guides for Project Learning Tree (PLT), WET, WILD and HWHP are only correlated to the Ohio Science and Social Studies Academic Content Standards. Future plans are to correlate activities to the remaining Ohio Academic Content Standards.

How to Search for Correlations

--Activity Guide--
--Activity Title--
--Subject--
--Grade Level Band--
--Grade Level--
--Standard--
--Benchmark--
--Organizer--
--Grade Level Indicator--

Search for Correlations

Other Education Guides Correlated to Ohio's Standards

Windows on the Wild (WOW) is a World Wildlife Fund education program whose goal is to teach people of all ages about biodiversity issues. WOW uses biodiversity as a "window" to explore the incredible web of life and how all-living things are interconnected.

Biodiversity Basics: An Educator's Guide to Exploring the Web of Life is the core module of the WOW curriculum.

Check out the Workshops section to find out how to obtain WET, WILD, PLT, HWHP and WOW Activity Guides.

Ohio.gov

CORRELATIONS

Search Results

Activity Guide	Activity Title	Grade Level Band	Grade Level	Content Standard	Benchmark	Organizer	Grade Level Indicator
WET-Healthy Water, Healthy People	Washing Water	9-10	10	Earth and Space Sciences (ES)	B-D	Earth Systems	5
WET-Healthy Water, Healthy People	Washing Water	9-10	10	Life Sciences (L)	B-G	Diversity and Interdependence of Life	18
WET-Healthy Water, Healthy People	Washing Water	9-10	10	Life Sciences (L)	B-G	Diversity and Interdependence of Life	19
WET-Healthy Water, Healthy People	Washing Water	9-10	9	Science and Technology (ST)	B-A	Abilities To Do Technological Design	2
WET-Healthy Water, Healthy People	Washing Water	9-10	10	Science and Technology (ST)	B-A	Abilities To Do Technological Design	3
WET-Healthy Water, Healthy People	Washing Water	9-10	9	Science and Technology (ST)	B-A	Abilities To Do Technological Design	3
WET-Healthy Water, Healthy People	Washing Water	9-10	9	Science and Technology (ST)	B-B	Understanding Technology	1
WET-Healthy Water, Healthy People	Washing Water	9-10	10	Science and Technology (ST)	B-B	Understanding Technology	1
WET-Healthy Water, Healthy People	Washing Water	9-10	10	Science and Technology (ST)	B-B	Understanding Technology	2
WET-Healthy Water, Healthy People	Washing Water	9-10	9	Scientific Inquiry (SI)	B-A	Doing Scientific Inquiry	2
WET-Healthy Water, Healthy People	Washing Water	9-10	9	Scientific Inquiry (SI)	B-A	Doing Scientific Inquiry	3
WET-Healthy Water, Healthy People	Washing Water	9-10	9	Scientific Inquiry (SI)	B-A	Doing Scientific Inquiry	5
WET-Healthy Water, Healthy People	Washing Water	9-10	9	Scientific Inquiry (SI)	B-A	Doing Scientific Inquiry	6
WET-Healthy Water, Healthy People	Washing Water	9-10	10	Scientific Inquiry (SI)	B-A	Doing Scientific Inquiry	1
WET-Healthy Water, Healthy People	Washing Water	9-10	10	Scientific Inquiry (SI)	B-A	Doing Scientific Inquiry	2

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CORRELATIONS

Search Results

Activity Guide	Activity Title	Grade Level Band	Grade Level	Content Standard	Benchmark	Organizer	Grade Level Indicator
WET-Healthy Water, Healthy People	Washing Water	11-12	11	Earth and Space Sciences (ES)	B-C	Earth Systems	11
WET-Healthy Water, Healthy People	Washing Water	11-12	11	Earth and Space Sciences (ES)	B-C	Earth Systems	13
WET-Healthy Water, Healthy People	Washing Water	11-12	11	Scientific Inquiry (SI)	B-A	Doing Scientific Inquiry	5
WET-Healthy Water, Healthy People	Washing Water	11-12	12	Scientific Inquiry (SI)	B-A	Doing Scientific Inquiry	3
WET-Healthy Water, Healthy People	Washing Water	11-12	12	Scientific Inquiry (SI)	B-A	Doing Scientific Inquiry	5
WET-Healthy Water, Healthy People	Washing Water	11-12	12	Scientific Inquiry (SI)	B-A	Doing Scientific Inquiry	1
WET-Healthy Water, Healthy People	Washing Water	11-12	11	Scientific Inquiry (SI)	B-A	Doing Scientific Inquiry	3
WET-Healthy Water, Healthy People	Washing Water	11-12	11	Scientific Inquiry (SI)	B-A	Doing Scientific Inquiry	4
WET-Healthy Water, Healthy People	Washing Water	11-12	11	Scientific Ways of Knowing (SWOK)	B-A	Nature of Science	2
WET-Healthy Water, Healthy People	Washing Water	11-12	12	Scientific Ways of Knowing (SWOK)	B-A	Nature of Science	2
WET-Healthy Water, Healthy People	Washing Water	11-12	11	Scientific Ways of Knowing (SWOK)	B-C	Science and Society	9
WET-Healthy Water, Healthy People	Washing Water	11-12	12	Scientific Ways of Knowing (SWOK)	B-C	Science and Society	8
WET-Healthy Water, Healthy People	Washing Water	11-12	11	Science and Technology (ST)	B-A	Understanding Technology	2
WET-Healthy Water, Healthy People	Washing Water	11-12	12	Science and Technology (ST)	B-A	Understanding Technology	3

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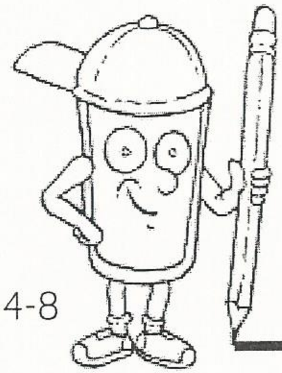


4-8

Water Filtration

BACKGROUND:

Water in lakes, rivers, and swamps often contains impurities that make it look and smell bad. The water may also contain bacteria and other microbiological organisms that can cause disease. Consequently, water from most surface sources must be "cleaned" before it can be consumed by people. Water treatment plants typically clean water by taking it through the following processes: (1) **aeration**; (2) **coagulation**; (3) **sedimentation**; (4) **filtration**; and (5) **disinfection**. Demonstration projects for the first four processes are included below.

✍ OBJECTIVE:

To demonstrate the procedures that municipal water plants may use to purify water for drinking.

MATERIALS NEEDED:

- ✔ **5 Liters of "swamp water"** (or add 2 1/2 cups of dirt or mud to 5 liters of water)
- ✔ **1 Two liter plastic soft drink bottle** with its cap (or cork that fits tightly into the neck)
- ✔ **2 Two liter plastic soft drink bottles**, one with its bottom cut off and one with the top cut off
- ✔ **1 large beaker (2 cups) or measuring bowl** that will hold the inverted two liter bottle or you can use another two liter plastic soft drink bottle with its top cut off so the other bottle will fit inside of it.
- ✔ **2 tablespoons of alum** (potassium aluminum sulfate available in the spice isle at grocery stores)
- ✔ **1 1/2 cups fine sand** (white play sand or beach sand)
- ✔ **1 1/2 cups coarse sand** (multi-purpose sand)
- ✔ **1 cup small pebbles** (washed, natural color aquarium rocks work best)
- ✔ **1 coffee filter**
- ✔ **1 rubber band**
- ✔ **1 tablespoon** (for the alum)
- ✔ **1 large spoon** (for stirring)
- ✔ **A clock** with a second hand or a stopwatch

PROCEDURE:

1. Pour your "Swamp Water" into the two liter bottle with a cap. Have students describe the appearance and smell of the water.

2. **Aeration** the first step in the treatment process, adds air to water. It allows gases trapped in the water to escape and adds oxygen to the water. Place the cap on the bottle and vigorously shake the bottle for 30 seconds. Continue the aeration process by pouring the water into another bottle or the beaker, then pouring the water back and forth between them about 10 times. Once aerated, gases have escaped (bubbles should be gone). Pour your aerated water into your bottle with its top cut off.

3. **Coagulation** is the process by which dirt and other suspended solid particles to chemically "stick together" into floc (clumps of alum and sediment) so they can easily be removed from water. Add two tablespoons of alum to the aerated water. Slowly stir the mixture for 5 minutes. You will see particles in the water clinging together to make larger clumps. This makes it harder for them to get through a filter at the plant.

4. **Sedimentation** is the process that occurs when gravity pulls the particles of floc to the bottom of the cylinder. Allow the water to stand undisturbed in the cylinder. Observe the water at 5 minute intervals for a total of 20 minutes. Write down what you see - what is the appearance of the water now? At a treatment plant, there are settling beds that collect floc that floats to the bottom, allowing the clear water to be drained from the top of the bed and continue through the process.

5. Construct a filter from the bottle with its bottom cut off as follows (see illustration below):

   a. Attach the coffee filter to the outside neck of the bottle with a rubber band.
   Turn the bottle upside down placing it in a beaker or cut-off bottom of a two liter bottle. Pour a layer of pebbles into the bottle - the filter will prevent the pebbles from falling out of the neck.

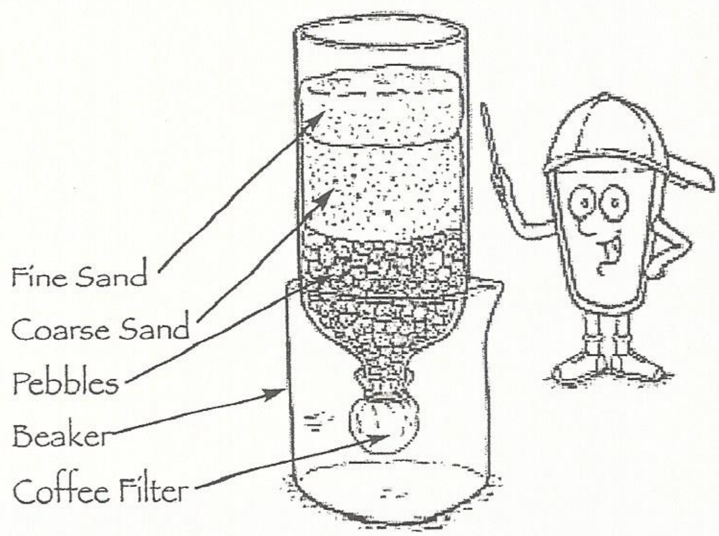
   b. Pour the coarse sand on top of the pebbles.

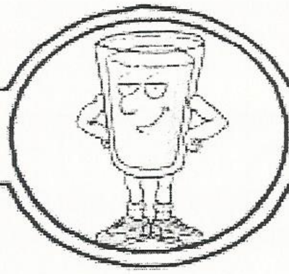
   c. Pour the fine sand on top of the coarse sand.

   d. Clean the filter by slowly and carefully pouring through 3 L (or more) of clean tap water.
   Try not to disturb the top layer of sand as you pour the water.

6. **Filtration** through a sand and pebble filter removes most of the impurities remaining in water after coagulation and sedimentation have taken place. After a large amount of sediment have settled on the bottom of the bottle of swamp water, carefully - without disturbing the sediment - pour the top two-thirds of the swamp water through the filter. Collect the filtered water in the beaker. Pour the remaining (one-third bottle) of swamp water back into the collection container. Compare the treated and untreated water. Ask students whether treatment has changed the appearance and smell of the water.

Advise students that the final step at the treatment plant is to add disinfectants to the water to purify it and kill any organisms that may be harmful. Because the disinfectants are caustic and must be handled carefully, it is not presented in this experiment. The water that was just filtered is therefore unfit to drink and can cause adverse effects. It is not safe to drink!





9-12

Decision Making
A Mock Town Meeting On A Proposed Tank Farm

INTRODUCTION:

Your class will represent all of the citizens who live and work in a small town called Priceford. A major business development company called Zanec Corporation has asked Priceford for permission to install five 10,000 gallon Underground Storage Tanks (USTs) on their property just outside of Priceford.

This proposed tank farm will supply fuel and manufacturing chemicals to an existing Ball Bearing Factory. Your class will divide into several groups each having very different interests, and will hold a town meeting to discuss and vote on Zanec's proposal.

✍ OBJECTIVE:

Your class will gain experience in recognizing potential hazards to a community's water supply and weighing the risks and benefits of community development, and will practice decision-making skills in a mock town meeting.

GENERAL PROCEDURES:

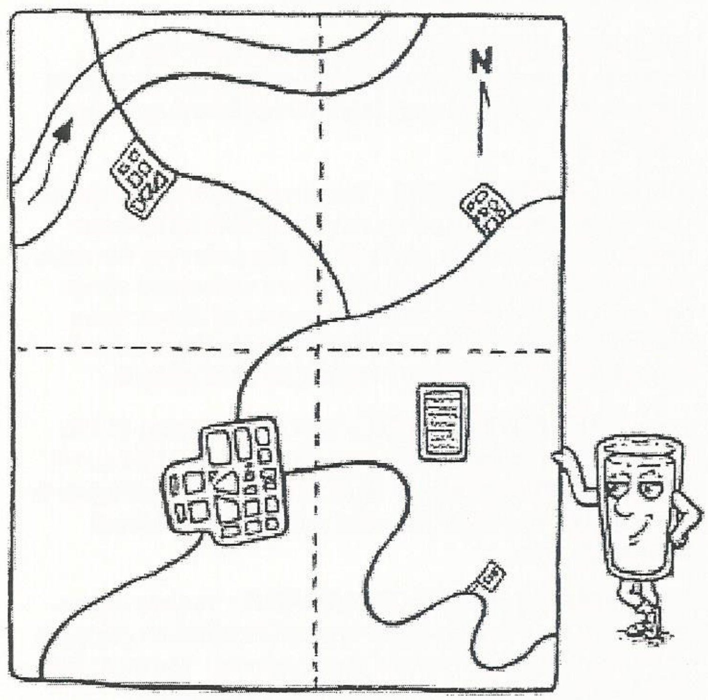
1. After reading over the activity's introduction and objectives as a class, begin preparing for the town meeting by randomly dividing your class into five groups.

2. Once the groups are formed, they should take (at home or in class) the time they need to:
   a. Study the facts of Priceford's water resources
   b. Elaborate on their own special group's interests.
   c. Discuss how each item of Zanec's proposal affects their interests.

The background information each group will need for these three tasks is given below. Each group should also select its own spokesperson to represent the group's interests at the meeting.

3. When each group is ready, the Town Council should call the town meeting to order, read the Agenda and introduce the Zanec and Business group to present their proposal. Each other group should then be allowed to comment on the proposal.

4. The Council will summarize the issues it believes to be important, BRIEFLY support or refute each issue and then vote on the proposal.



Priceford's Water Resources:

Priceford gets more than half its water from municipal and private wells. The vulnerability of the underlying aquifer in each quadrant of the map below was assessed in the Resource Management Activity (use the vulnerability "scores" calculated for the four quadrants in this activity).

- Quadrant 1 is largely undeveloped in the Priceford area. A small community, Riverville, is about 25 miles down the river. This quadrant is least acceptable to Zanec due to its distance from its property in Quadrant 4.
- Quadrant 2 is largely farmland but also contains a small community which relies on well water.
- Quadrant 3 includes Priceford town center and all the residential areas for the town's citizens.
- Quadrant 4 contains a factory just north of Bucky's Corner. Zanec proposes installing the USTs here.

Special Group Interests

1. THE TOWN COUNCIL - you must conduct the meeting, listen to all the arguments, and decide what is best for all citizens. Based on the facts you gather, the most logical arguments made by any of the groups and your best judgment, you will vote on whether to:

   1) Allow Zanec to install the tank farm as proposed, OR
   2) Allow installation only with certain changes in the proposal, OR
   3) Reject the proposal completely

2. ZANEC and the local BUSINESS GROUP ñ You must stress the need to allow the Ball Bearing plant to expand and to attract new businesses for Priceford's economic well-being.

3. LOCAL HOME OWNERS - You are divided. Some desire the new jobs and prosperity made possible by developments like this; others worry about the potential for water, air and noise pollution; still others are concerned about property values; and others are concerned about taxes needed to meet the increased solid waste disposal and sewage demands which are related to development.

4. SAVE THE ENVIRONMENT - Your local chapter of this national group opposes the installation of any USTs until extensive testing has been done and sufficient safeguards are in place. You favor the least vulnerable (but least accessible) site.

5. THE COUNTY HEALTH DEPARTMENT - You are essentially neutral as long as the proposed installation complies with all county health laws and procedures. You must find out whether the proposal meets these standards.

Zanec's Proposal:

Zanec is a major development company which has already invested heavily in the Priceford area. The proposed tank farm is only one improvement in its existing developments. Zanec believes its proposal is in the interest of Priceford for the following reasons:

- The tank farm will allow the Ball Bearing plant to expand, bringing about 250 new jobs to an area that has an unemployment rate which is above the state average.
- The company will bring revenues to Priceford, not only through wages, but also through property taxes, income taxes and more consumer spending by its workers and their families.
- The Ball Bearing plant expansion will be attractively designed, well-maintained and an asset to the community.
- The UST Installation will comply with all current regulations and is critical to whether Zanec can continue to build in Priceford.
- The new jobs will result in new home building and increased property values.
- Taxes paid by the plant will help finance school and road improvements while helping to keep home owner's taxes low.
- Zanec requests permission to site its tank farm on its property in Quadrant 4 (see map)

Town Meeting Agenda

This notice was published in the Priceford newspaper.

TO ALL CONCERNED PARTIES

An open meeting will be held for community review and input on Zanec Corporation's proposed installation of five 10,000 gallon underground storage tanks on property to the Ball Bearing factory. All interested groups are to have selected spokespersons who will each be given 4 minutes to present their views. The public is invited to comment on the following issues:

1. Should Zanec be allowed to install the USTs at the proposed site?
2. If not, what alternative location is acceptable to all parties?
3. What are the risks related to the proposal?
4. How can the risks be minimized to protect ground water?

The remainder of the meeting will consist of a question and answer period after which the Council will vote on the proposal.

Location: Priceford Town Hall
Time: Friday Afternoon

The town meeting Agenda should serve as a guide for the Town Council to conduct the meeting. As stated in the notice the Council should allow each group only 4 minutes to offer their views on each of the questions on the Agenda.

When all groups have been heard, each Town Council member may ask one question of one group. Finally, the Council will vote on the proposal. The Council's vote should be based to a large degree on the most logical and persuasive arguments raised by the groups.

Aeration Adds oxygen to water, removes trapped gasses.

Pre-chlorination Destroys pathogenic bacteria.

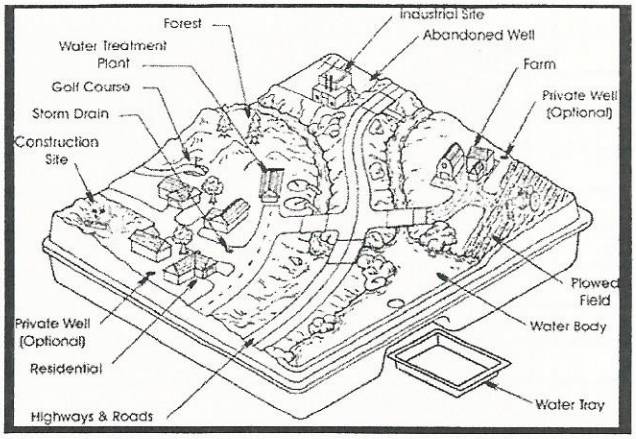
Coagulation Removes suspended solids by adding alum to water.

Sedimentation Allows the floc (coagulated particles) to settle out.

Sand Filtration Removes finer suspended particles.

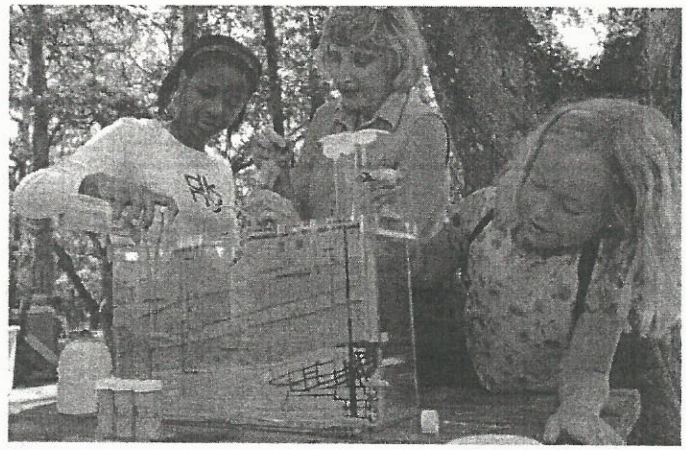
Post Chlorination Ensures that bacteria will not infect the water as it travels through the distribution system to the consumer. (Ozone and ultraviolet radiation also used in place of chlorine.)

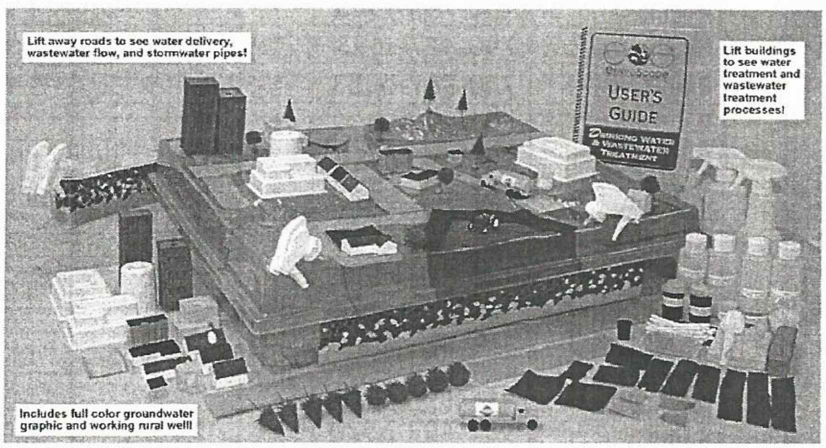
Models available from many Ohio Soil and Water Conservation Districts



EnviroScape Watershed and Nonpoint Source Pollution Model (card table size)

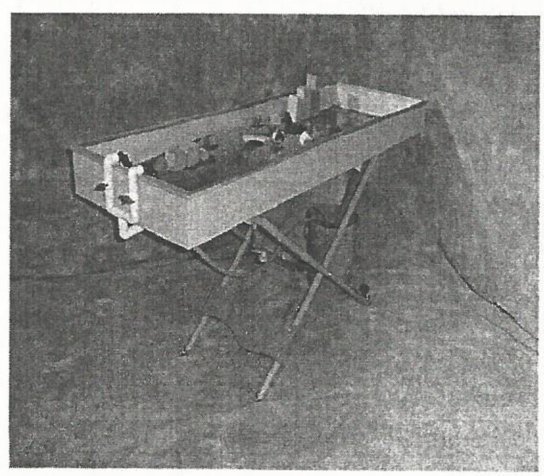
Ground Water Flow Model





Drinking Water and Wastewater Treatment Model

Streamulator Stream Table



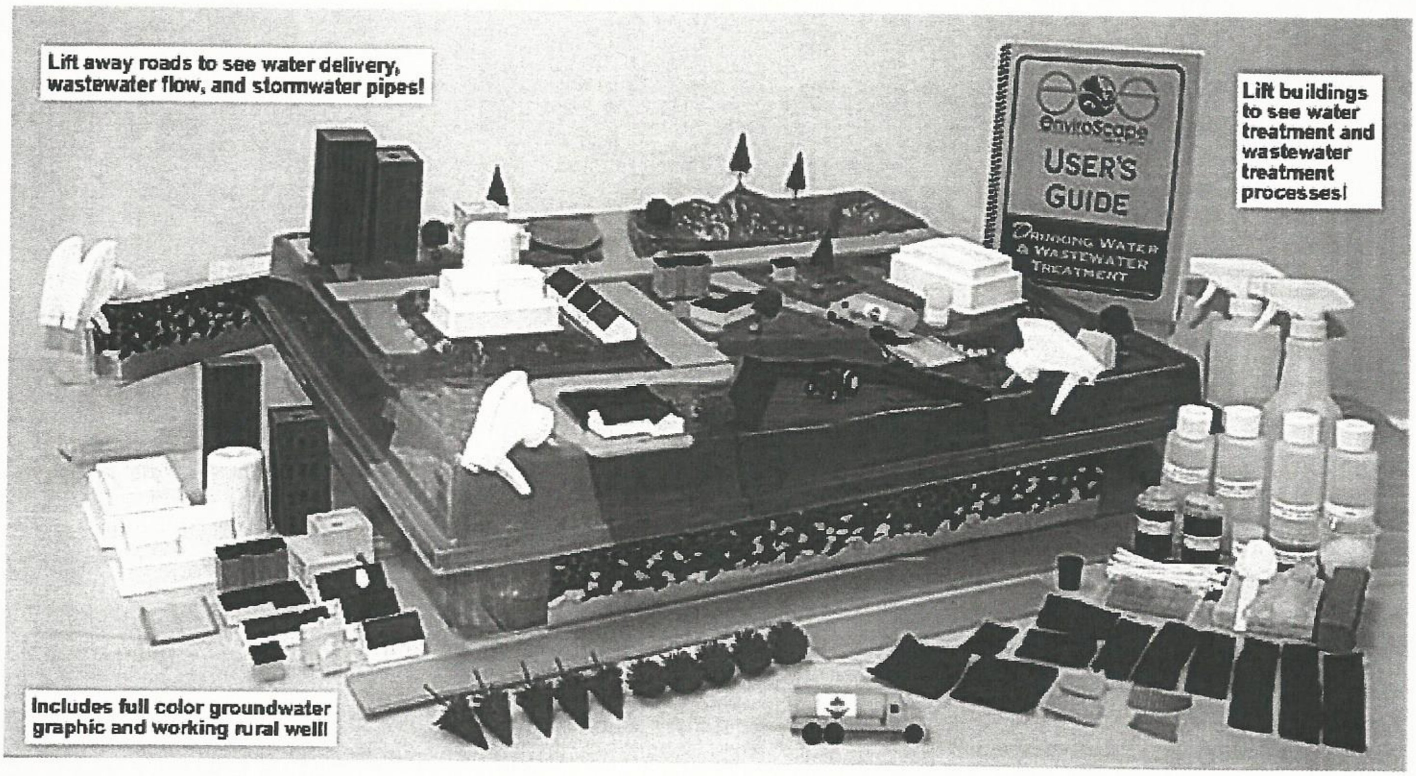
EnviroScape Watershed (ES), Ground Water Flow (GW), Drinking Water (DW), and Stream Table (ST)

Models available from Ohio's Soil and Water Conservation Districts

SWCD	Phone #	ES	GW	DW	ST
Adams	937-798-4018		*	*	*
Allen	419-223-0040	*			
Ashland	419-281-7645	*	*		*
Ashtabula	440-576-4946	*	*		*
Athens	740-797-9686	*	*	*	*
Auglaize	419-738-4016	*	*		
Belmont	740-526-0027	*	*	*	
Brown	937-378-4424	*	*	*	
Butler	513-887-3720	*	*	*	
Carroll	330-627-9852	*	*	*	*
Champaign	937-484-1507	*	*	*	*
Clark	937-521-3880	*	*		
Clermont	513-732-7075	*	*		*
Clinton	937-382-2461	*			
Columbiana	330-332-8732	*	*	*	
Coshocton	740-622-8087		*	*	
Crawford	419-562-8280		*		
Cuyahoga	216-524-6580	*	*	*	*
Darke	937-548-2410	*	*		
Defiance	419-782-8751	*	*	*	*
Delaware	740-368-1921	*	*	*	*
Erie	419-626-5211	*	*	*	
Fairfield	740-653-8154	*	*	*	
Fayette	740-636-0279	*	*		
Franklin	614-486-9613	*	*	*	*
Fulton	419-337-9217	*	*		*
Gallia	740-446-6173	*	*	*	*
Geauga	440-834-1122	*	*		*
Greene	937-372-4478	*	*	*	*
Guernsey	740-432-5624	*	*	*	
Hamilton	513-772-7645	*	*		*
Hancock	419-422-6569	*			*
Hardin	419-673-0456	*			
Harrison	740-942-8837	*	*	*	
Henry	419-592-2926	*	*		
Highland	937-393-1922	*	*	*	
Hocking	740-385-3016		*	*	*
Holmes	330-674-2811	*	*		
Huron	419-668-4113	*	*		*
Jackson	740-286-5208	*	*		*
Jefferson	740-264-9790	*	*	*	
Knox	740-393-6724	*	*	*	*
Lake	440-350-2730	*	*	*	*
Lawrence	740-867-4737	*	*	*	*
Licking	740-670-5330		*	*	
Logan	937-593-2946	*	*	*	*
Lorain	440-326-5800		*		*
Lucas	419-893-1966	*	*	*	*
Madison	740-852-4004	*	*	*	*
Mahoning	330-740-7995	*	*	*	
Marion	740-387-1314	*	*		
Medina	330-722-2628	*	*	*	*
Meigs	740-992-4282	*	*	*	
Mercer	419-586-3289		*	*	
Miami	937-335-7645	*	*	*	
Monroe	740-472-5477	*	*		
Montgomery	937-854-7645	*	*		*
Morgan	740-962-4234	*	*		
Morrow	419-946-7923	*	*		*
Muskingum	740-454-2027		*	*	*
Noble	740-732-4318	*	*	*	*
Ottawa	419-898-1595	*	*	*	
Paulding	419-399-4771	*	*		
Perry	740-743-1325	*	*	*	*
Pickaway	740-477-1693	*	*	*	*
Pike	740-947-5353	*			*
Portage	330-297-7633	*	*	*	
Preble	937-456-5159		*		*
Putnam	419-523-5159	*	*		
Richland	419-747-8686	*	*		
Ross	740-772-4110	*			*
Sandusky	419-334-6324	*			
Scioto	740-259-9231	*	*	*	
Seneca	419-447-7073		*		
Shelby	937-492-6520	*	*	*	*
Stark	330-830-7700	*	*		
Summit	330-929-2871		*	*	*
Trumbull	330-637-2056	*	*	*	*
Tuscarawas	330-339-7976	*	*	*	*
Union	937-642-5871	*	*		*
Van Wert	419-238-9591	*	*	*	
Vinton	740-596-5676	*			
Warren	513-695-1337	*	*		
Washington	740-373-4857	*	*	*	*
Wayne	330-262-2836	*	*		*
Williams	419-636-9395	*	*	*	
Wood	419-354-5517	*	*	*	*
Wyandot	419-294-2312	*	*	*	

Last update 9/19/11

Enviroscape Drinking Water and Wastewater Treatment Model



Some SWEETs are using the Enviroscape Drinking Water and Wastewater Treatment Model (the fact sheet indicates which team has this model). The model can show:

- **Drinking Water Sources and Treatment** - shows where drinking water (residential and commercial, rural and urban) comes from and how it is delivered to us;
- **Wastewater Treatment** - shows what happens to water and waste after we use it (how sewage/wastewater is treated)
- What **biosolids** are and how they are being used or disposed.
- How drinking water can become **contaminated**.

Students can trace the path of water we use in our communities:

- from the river to the water treatment plant
- from the treatment plant to houses and city buildings
- from use in the houses and city to the wastewater treatment plant, and
- from wastewater treatment back into the river

The model also includes:

- Septic system and rural water sources
- Stormwater discharged directly to a waterbody OR sent on to the wastewater treatment plant; and

- Demonstration of a combined sewer overflow
- Groundwater & much more!

RESOURCES FOR USING THE ENVIROSCAPE

- Enviroscape Web Page
- Enviroscape Manual
- Enviroscape Simplified Guide
- Users Tips
- Replacement Parts List
- Find out where the Drinking Water Comes from in the Community you are visiting - *Many schools and communities get their water from a public water system. Almost all of the Public Water Systems in Ohio have had a Drinking Water Source Assessment completed as required by the* Source Water Assessment and Protection (SWAP) program. *These reports contain information on the source of their drinking water (ground water or surface water), and are available online via a secure web site. A* registration form *is available if you are not registered.*

Water Treatment Plants

- USGS Posters
- Drinking Water Basics
- Public Drinking Water Standards for Ohio
- AWWA Poster: Drinking Water Treatment Plants

Wastewater Treatment Plants

- Wastewater Treatment Interactive Guide
- USGS: A Visit to a Wastewater Treatment Plant
- OSU Extension Fact Sheet: Wastewater Treatment Principles and Regulations
- Wikipedia: Sewage Treatment
- USGS Posters
- AWWA Poster: Wastewater Treatment Process

Combined Sewer Overflows

- Combined Sewer Overflows In Ohio
- USEPA: Combined Sewer Overflows

Septic Systems

- How do Septic Systems Work?
- Why do Septic Systems Malfunction?
- USEPA Fact Sheet: A Homeowner's Guide to Septic Systems
- Septic Systems and their Maintenance
- Household Sewage Disposal Systems - Ohio Rules

Biosolids

- Frequently Asked Questions about Biosolids
- Ohio EPA Biosolids Program
- Fields in Ohio Approved for Biosolids Applications (GIS interactive map)

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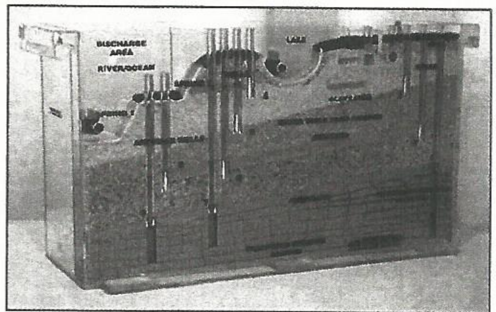
Manufacturer of Environmental Education Products and Groundwater Flow Models



click on photo for additional images

Envision 3000 Model

--Sand/Gravel and Bedrock/Karst Aquifers

Envision 3000 -Bedrock/Karst Aquifer Model

This simulator shows all the key features of the Envision 2000 with the added features of a bedrock aquifer. It shows groundwater flow and contamination in both unconfined and confined sand and gravel aquifers overlying cavernous limestone and fractured-bedrock aquifers. Presenters can easily compare and contrast the different flow patterns between the various types of aquifers. This simulator is particularly useful in areas where the local geology contains caves, sinkholes, fractured non-porous bedrock or has been extensively deep-mined.

Model is 19.5 long x 12 in high x 8 in deep.

- 9 wells (including 2 artesian wells)
- 2 springs
- Lake
- Stream/Ocean
- Septic System
- Sand & Gravel Aquifers
- Confined Bedrock Aquifer
- Cavernous Limestone/Karst Aquifer
- Fractured Bedrock Aquifer

- Unconfined Aquifer
- Underground Storage Tank
- Recharge & Discharge Areas
- Recirculating Reservoir and Tank system
- Top display showing watershed/surface activities
- AC/DC power supply
- Manual pumping mechanisms simulating high and low volume well pumps

Detailed instruction manual with experiments national ground water association

ngwa summit 2013 The National and International Conference on Groundwater

April 28 - May 2 ~ San Antonio, Texas

Educator resources

The National Ground Water Association has developed this list of groundwater re
materials to help elementary and secondary education professionals prepare less
subject of groundwater,. These materials may also be useful to anyone interested
themselves and others about groundwater.

Please note that external Web sites and documents provided here are not endors
are provided for information purposes only.

Attention teachers: Please give us your feedback on our educator resources. W
want to make them as useful as possible to you.

Sign up in the Educator Resources Guest Book and receive a free hydrologic cyc
poster (18 x 24 inches) while supplies last. (Free only to teachers in the continen
United States.)

Ground Water Flow Model Presentation

1. Introduce ground water as a very important resource to citizens in the state of Ohio. It is often considered a mystery because we can't see it in the ground, but it is really all part of the **water cycle**. Depending on grade level, have students act out or illustrate the water cycle, share what they know about the water cycle within a small group, or give a presentation on the water cycle to the class.

2. Share information on Ohio's **hydrologic budget**, including average amount of rainfall, amount lost to runoff, and amount that becomes ground water.

3. Show model, point out special features, and define terms or have students research **definitions** of confined and unconfined aquifer, water table, saturated zone, recharge and discharge areas, piezometer, pumping, injection, and artesian wells.

4. Depending on the grade level, introduce the following concepts and facilitate discussion with the students:

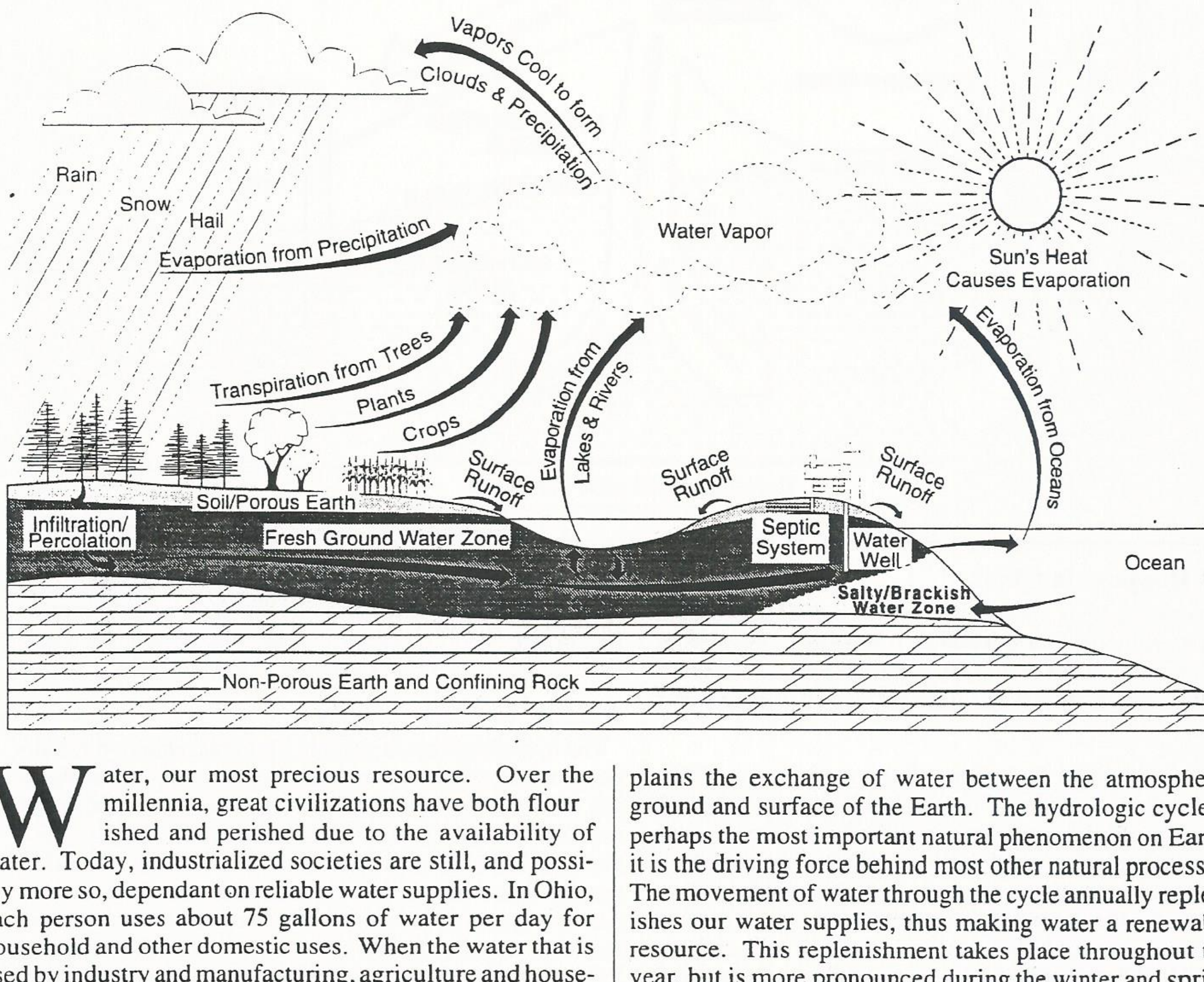
    a. Ground water is usually recharged by precipitation and snowmelt.
    b. It is contained in spaces between soil particles or cracks in rocks.
    c. It flows from upland areas to low areas or from areas of high hydraulic head to areas of low hydraulic head.
    d. It is withdrawn from the ground through wells for use in homes, farms, and industries.
    e. It is related to surface water and other forms of water through water cycle.
    f. Differences in types of aquifers and the separating layers.
    g. Saturated and unsaturated zones, water table, and monitoring wells.
    h. Water movement in artesian aquifers.
    i. Potentiometric surface in a well penetrating a confined aquifer.
    j. Texture of materials in an aquifer affects the rate of ground water flow.
    k. Pumping wells draw water toward them from all directions (cone of depression).
    l. Human activities at or near the land surface can contaminate ground water and wells.
    m. Contaminated ground water may pollute surface water, and vice versa.
    n. Capillary action can cause upward movement of water.
    o. Once ground water becomes contaminated, the contamination may persist for long periods and extend over long distances.
    p. Ground water flow lines have curved paths.

5. As you begin cleaning up the model, discuss the difficulty of cleaning up contaminated ground water resources.

Ohio Department of Natural Resources
Division of Water Fact Sheet

Fact Sheet 93–18

The Hydrologic Cycle



Water, our most precious resource. Over the millennia, great civilizations have both flour ished and perished due to the availability of water. Today, industrialized societies are still, and possibly more so, dependant on reliable water supplies. In Ohio, each person uses about 75 gallons of water per day for household and other domestic uses. When the water that is used by industry and manufacturing, agriculture and households is added together, an average of over 11.7 billion gallons of water are used daily in Ohio, nearly 1,100 gallons per person. Even with more efficient use and other conservation efforts, as the population increases, so does the need for water.

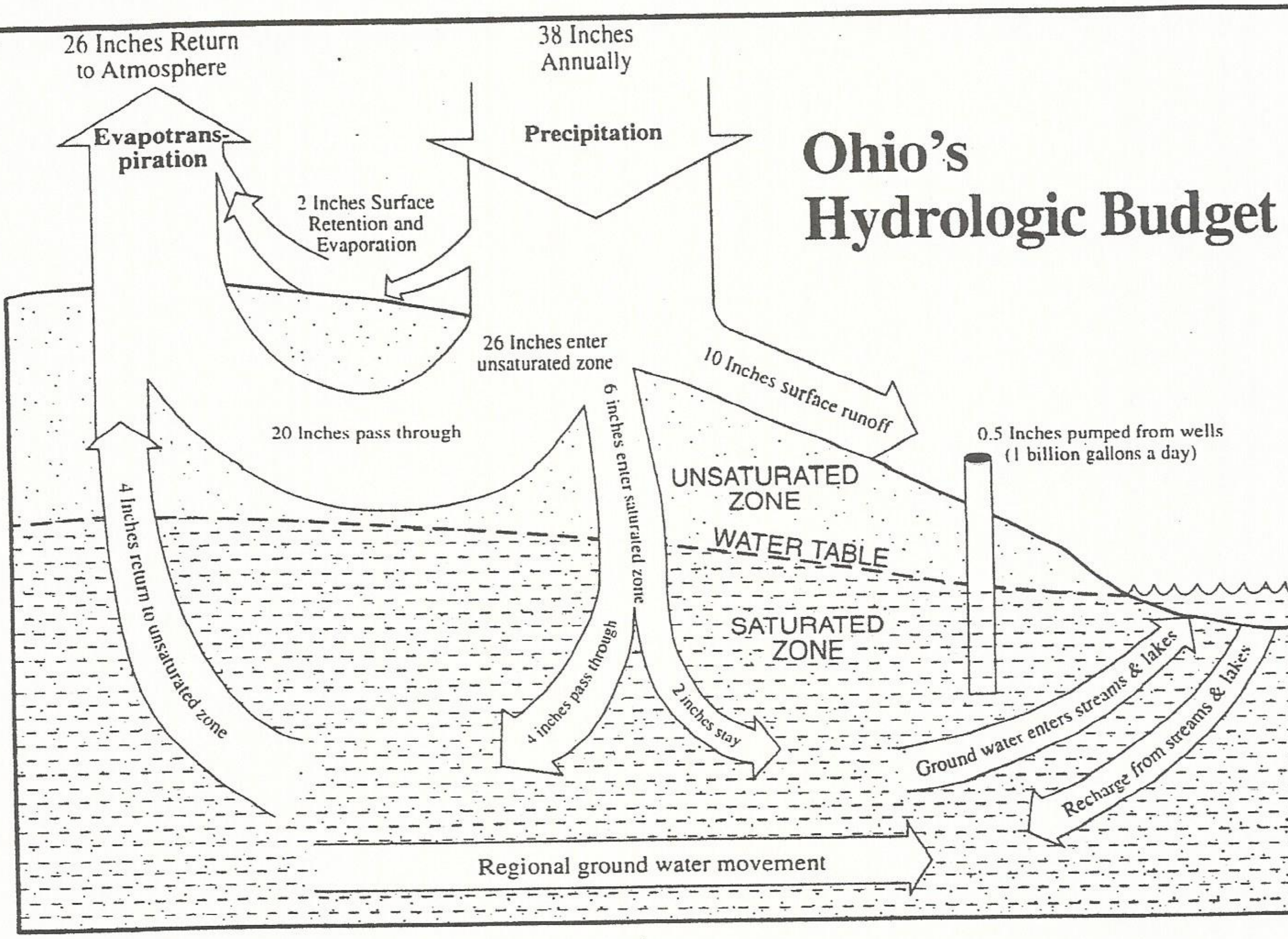
A Renewable Resource

The amount of water on Earth has essentially never changed. It is continuously being recycled, moving from one storage place to another, including lakes, streams and oceans, underground, in glaciers and ice caps, and in the atmosphere. This recycling movement is called the water or hydrologic cycle. The hydrologic cycle (above) explains the exchange of water between the atmosphere, ground and surface of the Earth. The hydrologic cycle is perhaps the most important natural phenomenon on Earth; it is the driving force behind most other natural processes. The movement of water through the cycle annually replenishes our water supplies, thus making water a renewable resource. This replenishment takes place throughout the year, but is more pronounced during the winter and spring months.

The hydrologic cycle is an ever fluctuating, dynamic system. Small changes often occur in the quantities of water located in the various segments of the cycle. Many of these fluctuations relate to seasonal changes. For example, the amount of rainfall, the effect of temperature on evaporation, and the uptake of water by plants during the growing season all affect how much water will be available in any segment of the water cycle. Thus, the movement of water in the cycle is always changing. Even small changes in the cycle at a regional or local scale may look like large changes to us as in the form of droughts or floods.

Continued on back!

Ohio's Hydrologic Budget



What Happens in Ohio?

The water cycle is not unique to Ohio, rather the process occurs worldwide. A water budget is used to understand its effect on local water resources and to predict or estimate quantities of available water from surface or ground water sources.

The water budget for Ohio is illustrated above. Ohio averages about 38 inches of precipitation a year. Of this, 10 inches run off the land surface directly to streams and rivers, two inches are temporarily retained on the surface in puddles, etc. and then evaporate, and 26 inches enter or infiltrate into the ground. Of this latter 26 inches, 20 inches pass directly through the unsaturated zone (soil) and are returned to the atmosphere by evaporation from the soil and by plants through transpiration. The other six inches infiltrate into the saturated zone (aquifer). Of these six inches, four inches pass through the saturated zone and are returned to the atmosphere through evaporation and transpiration. The remaining two inches become part of the ground water system, eventually discharging to streams, lakes and springs or are pumped to the surface by wells. Evaporation from lakes and streams (and oceans) returns the surface runoff and ground water discharge to the atmosphere, thus completing and balancing the cycle.

A Reliable Water Supply

The hydrologic cycle assures a reliable, although fluctuating, water supply by annually replenishing, or recharging, both surface and ground water sources. When water removal (evaporation, transpiration, water supply, etc.) exceeds replenishment (precipitation), water levels fall as usually observed during the summer and fall months; conversely, water levels rise when replenishment exceeds removal, usually during the winter and spring months. Properly designed wells and reservoirs with adequate storage for dry periods can provide a reliable water source for drinking, industry and agriculture thanks to the hydrologic cycle.

Ohio Department of Natural Resources
Division of Water
Water Resources Section
1939 Fountain Square
Columbus, OH 43224-1336
Voice: (614) 265-6740 Fax: (614) 265-6767
E-mail: water@dnr.state.oh.us
Web site: http://www.dnr.state.oh.us/odnr/water/

Bob Taft *Governor* • Samuel W. Speck *Director* • James R. Morris, P.E. *Chief*

R 7/22/99

Ohio Department of Natural Resources
Division of Water Fact Sheet

Fact Sheet 93–24

What's Ground Water?

According to the dictionary, "ground water" is water saturating the voids, pores, fractures, and holes in the soil and rock at some depth below the earth's surface. While this definition is technically correct, it does not even begin to explain all the complex and varied aspects of ground water, or the importance of ground water to the nation and Ohio.

How Does It Occur?

There has always been some mystery connected with ground water because its source is unseen. Stories of underground lakes and rivers in Ohio are common, despite evidence disproving the existence of such bodies of water. In reality, the ultimate source of all ground water is precipitation. Part of the rain and snow that falls on the earth's surface seeps downward through the soil and collects in porous geologic formations. These formations act something like sponges and temporarily store the water. If these geologic formations are capable of yielding usable quantities of ground water to a well, they are called "aquifers."

There are two basic types of aquifers in Ohio, sand and gravel aquifers and bedrock aquifers. Ground water in sand and gravel aquifers occurs in pore spaces between individual grains of sand and gravel. In bedrock aquifers, ground water occurs in pore spaces and along fractures, joints, voids, and contacts between different formations.

The Hydrologic Cycle

Ground water flow is an important component of the natural circulation of all water on earth, commonly called the hydrologic cycle. The hydrologic cycle begins with precipitation falling on the land surface. Some of the water runs off into streams and lakes, some infiltrates into the earth and becomes ground water, and a third portion evaporates back into the atmosphere. The portion which becomes ground water ultimately discharges into streams, lakes, and other surface water bodies. The water in streams and rivers flows into lakes and oceans where it is evaporated into the atmosphere. Water in the atmosphere eventually falls as precipitation on the earth's surface and starts the cycle all over again. More information on the hydrologic cycle may be obtained from the Division of Water fact sheet number 18, entitled "The Hydrologic Cycle."

Like water in streams and rivers, ground water moves, but at a very slow rate. Ground water flow is usually measured in terms of feet per day; in some formations ground water flow may only be a few inches per year.

Ground water flows from areas where precipitation percolates down to the water table, called recharge areas, to locations where it flows out of an aquifer and becomes surface water. If ground water flows out of an aquifer at the land surface, that spot is called a "spring." Most ground water, however, flows directly into streams, rivers, lakes, and wetlands through the stream bed or the bottom of the lake or wetland. Have you ever wondered why streams and rivers still flow during periods of drought? Most of the flow in streams and rivers during drought times is ground water discharging from aquifers into the stream channel. Hydrologists call this component of stream flow "base flow." Base flow can also be a significant component of stream flow during normal times. In many streams, base flow sustains aquatic life during prolonged dry spells.

How Important Is Ground Water?

Over 98 percent of the available fresh water on earth is ground water. According to the USEPA, 48 percent of the population of the United States relies on ground water to meet its daily water needs. In Ohio, over 40 percent of the population (more than 4.5 million people) depends on ground water. This includes large municipalities, such as Dayton, Canton, and Columbus, which rely on ground water to provide all or part of their water supply, and over 700,000 domestic water wells supplying individual homes throughout the state.

Industries in Ohio pump over 240 million gallons of ground water per day; irrigation withdrawals total almost 2 million gallons per day. Total ground water pumped for all uses in Ohio is 730 million gallons per day. That's over 266 billion gallons per year, enough water to flood the entire City of Columbus to a depth of almost 7 feet.

Where Is Ground Water Found?

Although the quantity of ground water used in Ohio is impressive, ground water does not occur everywhere with the same prevalence. The most productive aquifers in the state are the buried valley aquifers in the southwest, south-central, and east-central portions of the state. These aquifers consist of thick layers of sand and gravel deposited in valleys eroded deeply into the surrounding bedrock.

Continued on back!

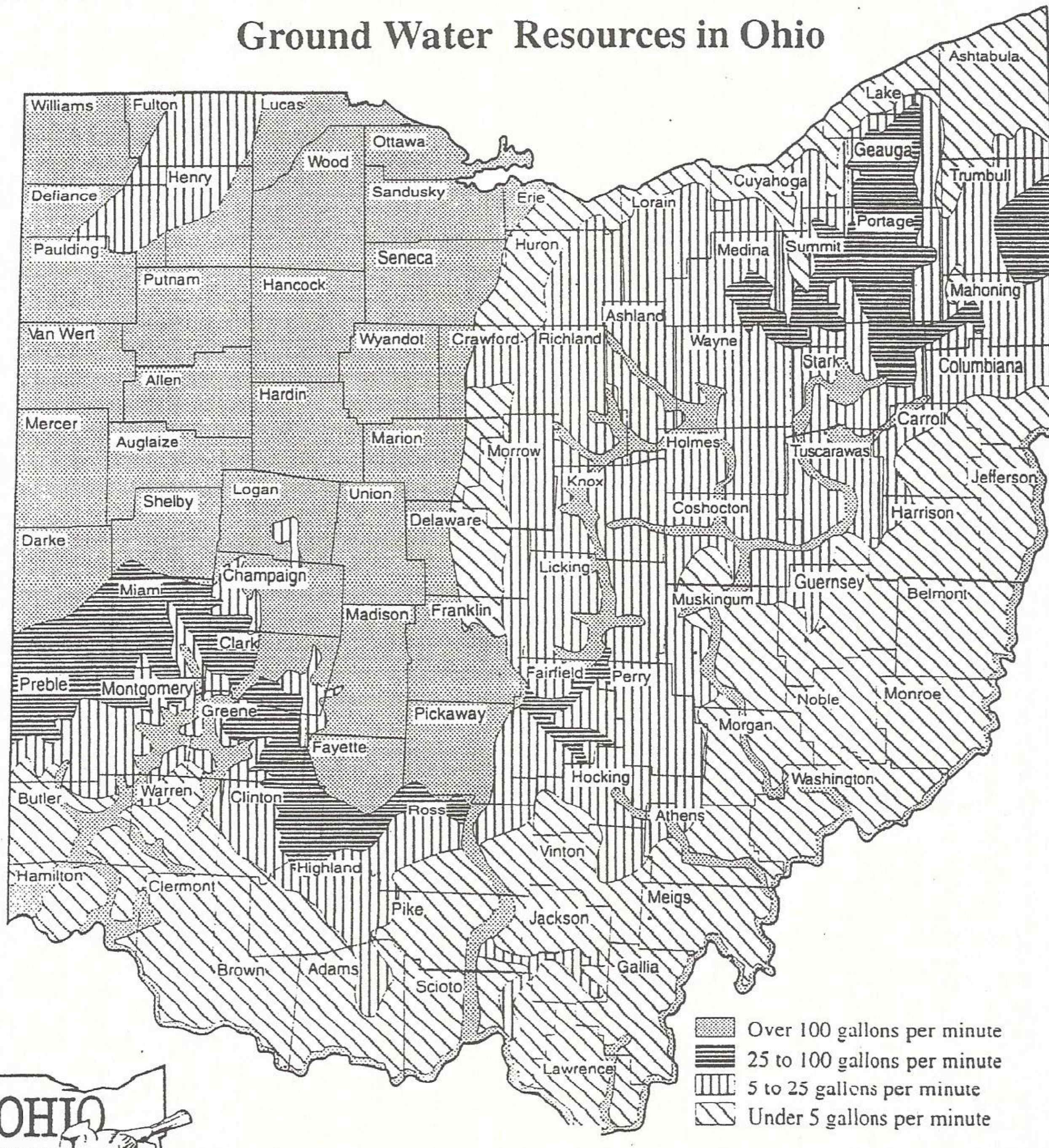
Some of the poorest aquifers in the state occur where the bedrock resists the flow of ground water. These types of formation are especially prevalent in the southeast portion of state, but also occur in some parts of the southwest and south-central portions of the state, and in a band along the eastern Lake Erie shore. The bedrock aquifers in these locations contain a very high percentage of clay minerals. Formations with high clay content are poor aquifers because they have very few or very small pore spaces for ground water to be stored in, or flow through.

The map below illustrates, in a very general way, the availability of ground water in Ohio.

If you would like more information about ground water in general, or if you have a question about the occurrence of ground water at a particular location in Ohio, give us a call or stop by. Our phone number and address are:

Ohio Department of Natural Resources
Division of Water
Water Resources Section
1939 Fountain Square
Columbus, OH 43224-1336
Voice: (614) 265-6740 Fax: (614) 265-6767
E-mail: water@dnr.state.oh.us
Web site: http://www.dnr.state.oh.us/odnr/water/

Ground Water Resources in Ohio



OHIO Department of Natural Resources

Ground-Water Movement

Introduction

Ground water must be able to move through underground materials at rates fast enough to supply useful amounts of water to wells or springs in order for those materials to be classified as an aquifer. For water to move in an aquifer, some of the pores and fractures must be connected to each other. Water moves through different materials at different rates, faster through gravel, slower through sand, and even slower through clay. Gravels and sands are possible aquifers; clays usually are not aquifers. The following activity demonstrates how different sizes of rock materials that make up an aquifer affect water movement.

Objectives--Students will:

1. Identify several sources of rock materials that make up an aquifer.
2. Discuss how water moves through gravel, sand, and clay.

Materials

1. At least 10 students.
2. Large area to conduct activity.

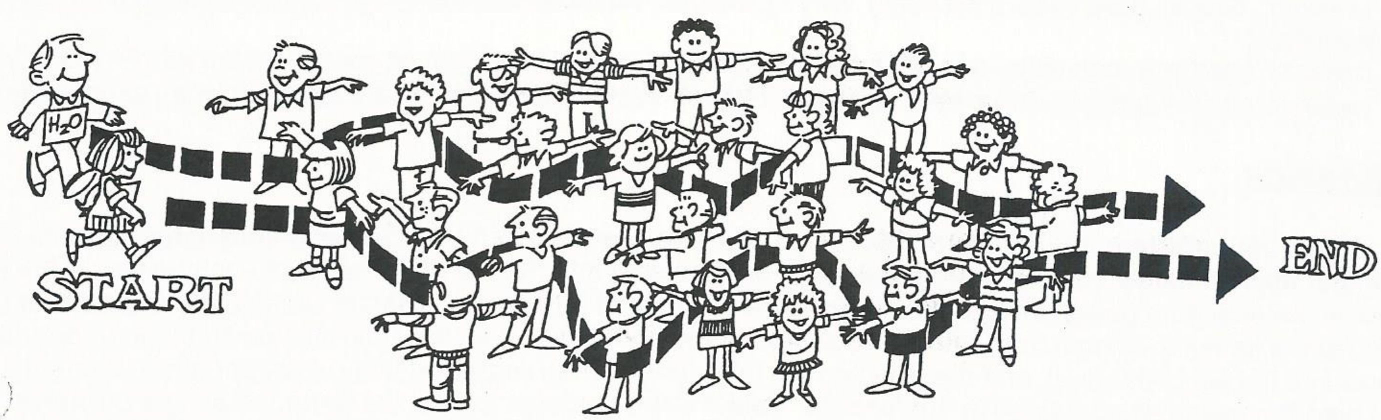
Teacher Preparation

This activity can be conducted in the classroom, gymnasium, or outside the school building. If conducted in the classroom, move all furniture to allow for sufficient room for the movement of students. This is a three-part demonstration that may create some excitement.

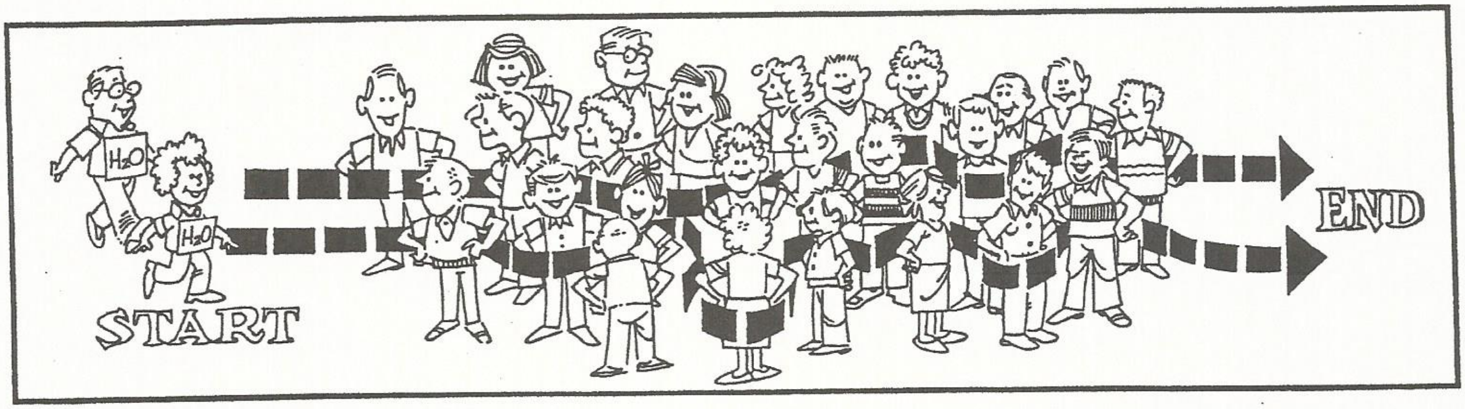
Procedures

Select two or three students to be molecules of water. The remaining students will be rock materials.

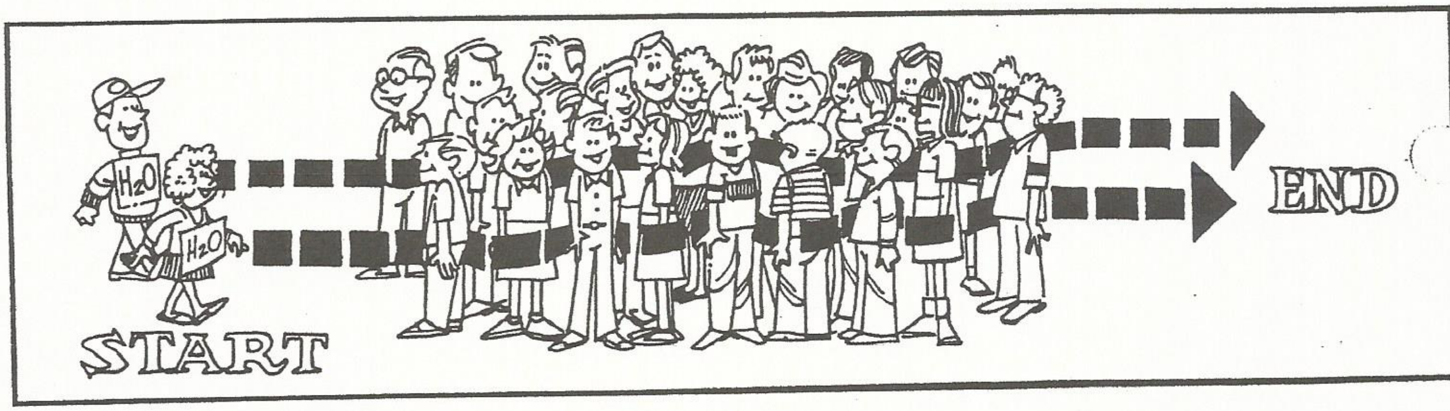
1. **Activity One:** Water movement through gravel. The students represent gravel by holding arms outstretched, leaving a 15- to 30- centimeter (cm) space between their outstretched arms. Locate these students in the center of the activity area. The students representing water molecules are to start on one side of their "gravel" classmates and move through them, exiting on the other side. The water molecules will move easily through the gravel.



2. **Activity Two:** Water movement through sand. The students represent sand by extending arms, bending them at the elbows and touching their waists with their fingers. Locate these students in the center of the activity area, spacing them approximately 15 cm apart. Once again, have the water molecules slowly make their way through their "sand" classmates. The water molecules will experience some difficulty, but should still reach the oth side.



3. **Activity Three:** Water movement through clay. Students become clay particles by placing their arms straight down the sides of their bodies and standing approximately 10 cm apart. Locate these students in the center of the activity area. It will be a formidable task for water molecules to move through the clay. Without being rough, the water molecules should slowly make their way through the clay. The water molecules may not be able to move through the clay at all.



Interpretive Questions

1. Which one of the materials — gravel, sand, or clay — was the easiest for the water molecules to move through? (Answer: Gravel, then sand, then clay.) Why? (Answer: Because there are larger spaces between the gravel particles.)
2. If there were three rock units, one of gravel, one of sand, and one of clay, all containing the same quantity of water, in which would you drill a well? (Answer: Gravel. Water moves easier through gravel than sand or clay.)

Extension

Obtain 250 milliliters (mL) of sand, 250 mL of pea-size gravel, 250 mL of clay, and three large funnels (top diameter approximately 12 cm). Force a piece of cheesecloth into the top of the spout of each funnel. This will prevent material from going through the funnel spout. Put each funnel into separate clear containers so that the spout of the funnel is at least 5 cm above the bottom of the container. Pour the sand into the first funnel, pea-size gravel into the second funnel, and the clay into the third funnel. Pour equal amounts of water (approximately 200 mL) onto the materials contained in the funnels. Select three students to pour the water, creating a permeat race. Time how long it takes the water to flow through the materials. Record on a data sheet. Which material did the water flow through the fastest? Why?

This activity was adapted from "Get the Ground Water Picture," National Project WET.

ACTIVITY
Recharge - Discharge

Introduction

Recharge is the addition of water to an aquifer. Recharge can occur from precipitation or from surface-water bodies such as lakes or streams. Water is lost from an aquifer through discharge. Water can be discharged from an aquifer through wells and springs, and to surface-water bodies such as rivers, ponds, and wetlands. The following activity is designed to demonstrate the recharge and discharge of water to a model aquifer.

Objectives--Students will:

1. Identify several sources of recharge for ground water.
2. Identify several sources of discharge for ground water.
3. Discuss how water moves from recharge to discharge areas.
4. Discuss the connection between surface water and ground water.

Materials

1. One clear container at least 15-cm wide x 22-cm long x 6-cm deep for each group. Possible containers include clear plastic salad containers or clear baking pans.
2. Sufficient pea-size gravel to fill the container approximately 2/3 full.
3. Two 472-mL paper cups for each group.
4. One pump dispenser from soft-soap or hand-lotion containers for each group.
5. 472 mL of water.
6. Grease pencils, one for each group.
7. Twigs or small tree branches, to represent trees on the model (optional).
8. Colored powdered-drink mix or food coloring (optional).

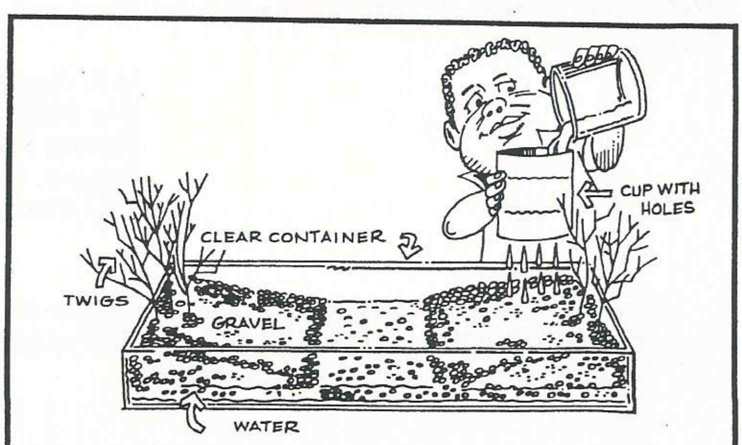
Teacher Preparation

1. Display a copy of the poster titled "Ground Water: The Hidden Resource" on the classroom wall several days prior to conducting this activity.
2. Using an ice pick or awl, punch 8 to 10 small holes in the bottom of one of the paper cups. When filled with water, this cup will be used to simulate rain.
3. Fill the clear containers 2/3 full with pea-size gravel.

Procedure

☛ Divide the class into small groups. Provide each group with one clear container filled 2/3 with pea-size gravel, one 472-mL cup with holes punched in the bottom, one 472-mL cup with no holes, and one pump dispenser.

☛ Students make models to represent hills and a valley. One student from each group fills the 472-mL cup without holes in the bottom with water. Each group makes a valley in the center of the model by pushing gravel to the farthest opposite ends of the container so the valley extends completely across the width of the container. About 2 cm of pea-sized gravel remains in the bottom of the valley.



- ☛ Explain to the students that the gravel mounds on both sides of the container represent hills with a valley in between. The students can place twigs or small branches on the hills to represent trees. Instruct a student to hold the 472-mL cup with holes over the model. Then add 472 mL of water to this cup. Tell the students that they are simulating rain. Have the students observe how the water infiltrates into the gravel and becomes ground water.

- ☛ Introduce the word recharge—the addition of water to the ground-water system. Observe that water is standing in the valley. Have the students use a grease pencil to draw a line identifying the water level in the container. The line should traverse the entire model, identifying the water level under the hills and in the valley. There will be a pond in the valley.

- ☛ Explain that they have just identified the top of the ground water in their model. The top of the ground water is called the water table. Discuss with the students how the ground water becomes a pond in the valley. This is because the water table is higher than the land surface (gravel) in the valley.

- ☛ Have the students insert the pump into one of the hills on the side of the valley, pushing the bottom down to the ground water. Allow each of the students in the group to press the pump 20-30 times after the water in the pump has begun to flow. Catch the water in the paper cup with no holes in the bottom. After each student takes a turn pumping, instruct them to observe the location of the water table in relation to the grease-pencil line. Where did the water go? What happened to the pond? Discuss discharge, the removal of water from the ground. Discuss the effect of ground-water pumping on streams and lakes.

Interpretive Questions

1. Where does ground water come from?

Answer: Precipitation (rain, snow, sleet, etc.) Also, if the water table is at or below the surface of the water in a stream or pond, water can move from the stream or pond to recharge the ground-water system.

2. What would happen in the students' neighborhood (name a local stream or pond) if a well was drilled near stream or pond and enough water pumped to lower the water table around the stream or pond?

Answer: Some water from the stream or pond would be removed by the pump through the well. If enough water is removed, a pond or small stream could go dry.

Extension

Sprinkle a colored powdered-drink mix or food coloring on top of one of the hills and repeat the above activity by having it rain on the model. Discuss the movement of "pollution" from the hill to the ground water to the lake.

ORDERING INFORMATION

Single copies of the first three posters in the series (see Poster Series panel) and a limited supply of the "Ground Water" poster (color for grades 3-5 and 6-8 or black and white) can be obtained at no cost from the U.S. Geological Survey.

U.S. Geological Survey
Box 25286
Denver Federal Center
Denver, CO 80225
Telephone: (303) 236-7477

Also, the poster entitled "Water: The Resource That Gets Used & Used & Used for Everything!" has been translated into Spanish. A limited supply of color or black-and-white copies can be obtained at no cost from U.S. Geological Survey at the above address.

THE GROUNDWATER CHALLENGE

Objective
To build the most efficient water filtration device using the items they are given.

Materials
Filter Materials (you will need the following items for each team)
- 2 cups of gravel
- 2 cups of sand
- ½ cup of activated charcoal
- Sponge
- Coffee filter
- Paper clip
- Straw
- Cotton ball
- 2-liter pop bottle, cut in half
- Rubberband
- Tape
- Panty-hose
- Modeling clay or putty
- Scissors
- Yarn, 12" long

Contamination Materials
- Large bucket filled with water
- Food coloring
- Raisins
- Potting soil
- Baking soda
- Soy sauce
- Paper plate, ripped into small pieces

Source
The Groundwater Foundation

Background
Have you ever wondered how a municipal water treatment plant is designed? It is an intricate and tedious process that has gone through many years of work to create the modern water treatment processes we see today.

Procedure
In Advance
1. Decide how many teams you want and how many students will be on each team. We recommend smaller teams of 2-3 students as to allow all students the opportunity to get involved.

2. Each team will need one 2-liter pop bottle, cut in half. Take the top portion of the bottle and turn it upside down and place it in the bottom portion. The filter will be built inside the inverted, top portion of the bottle. The base portion will act as a reservoir and collect the water that runs out of the filter.

3. Now make the contamination liquid that will be poured through the students filter. Take the bucket of water and mix in the "contamination materials". The food coloring represents chemicals, the raisins represent animal/human waste, the potting soil represents earth, the baking soda represents road salt, the soy sauce represents motor oil, and the torn paper plate represents litter.

Activity
1. Discuss filtration systems with students

2. Provide each team with the filter materials and explain to them that they have been hired by a water treatment plant to design the most efficient water filtration system possible with the materials supplied. The teams may only use eight items, not counting the pop bottle, to construct their filtration device. Grant them fifteen minutes to discuss and construct their filter.

3. At the end of the fifteen minutes, pour the "contaminated" water on to the top of each of the filtration systems. This part can be messy, so it's best to move outside. The team that has the clearest, most debris free water in its collection base is the declared the winner.

Taken from **Making a Difference**, Groundwater Activities for the Classroom and Community. Groundwater Foundation, 2000

Science Standards Correlations Project
Activities by Grade Level Band—Ground Water Flow Model

K-2	3-5	6-8	9-10	11-12
NA	Ground Water Flow Model Presentation	Ground Water Flow Model Presentation	Ground Water Flow Model Presentation	Ground Water Flow Model Presentation
	Get the Ground Water Picture, Part I	Get the Ground Water Picture, Part III	Get the Ground Water Picture, Parts I & III	Get the Ground Water Picture, Parts I & III
	Ground Water Movement	A Grave Mistake	A Grave Mistake	A Grave Mistake
	Recharge - Discharge	Ground Water Challenge	Ground Water Challenge	Ground Water Challenge

Activity: Ground Water Flow Model

Standard	Organizer	Benchmark and Grade Level Indicator
Earth and Space Sciences (ES)	Earth Systems	B-C 3.5 Investigate the properties of soil (e.g., color, texture, capacity to retain water, ability to support plant growth).
		B-C 3.6 Investigate that soils are often found in layers and can be different from place to place.
	The Universe	B-C 3.4 Observe and describe the composition of soil (e.g., small pieces of rock and decomposed pieces of plants and animals, and products of plants and animals).

Activity: Get the Ground Water Picture Part I

Standard	Organizer	Benchmark and Grade Level Indicator
Earth and Space Sciences (ES)	Earth Systems	B-C 3.5 Investigate the properties of soil (e.g., color, texture, capacity to retain water, ability to support plant growth).
		B-C 3.6 Investigate that soils are often found in layers and can be different from place to place.
Scientific Inquiry (SI)	Doing Scientific Inquiry	B-C 4.3 Develop, design and conduct safe, simple investigations or experiments to answer questions.
		B-C 4.4 Explain the importance of keeping conditions the same in an experiment.
		B-C 4.5 Describe how comparisons may not be fair when some conditions are not kept the same between experiments.
		B-B 5.2 Evaluate observations and measurements made by other people and identify reasons for any discrepancies.
		B-B 5.3 Use evidence and observations to explain and communicate the results of investigations.
		B-C 5.4 Identify one or two variables in a simple experiment.

Activity: Ground Water Movement

Standard	Organizer	Benchmark and Grade Level Indicator
Earth and Space Sciences (ES)	Earth Systems	B-C 3.5 Investigate the properties of soil (e.g., color, texture, capacity to retain water, ability to support plant growth).
		B-C 3.6 Investigate that soils are often found in layers and can be different from place to place.
Scientific Inquiry (SI)	Doing Scientific Inquiry	B-B 3.5 Record and organize observations (e.g., journals, charts and tables).
		B-B 4.2 Analyze a series of events and/or simple daily or seasonal cycles, describe the patterns and infer the next likely occurrence.
		B-C 5.4 Identify one or two variables in a simple experiment.
Scientific Ways of Knowing (SWOK)	Nature of Science	B-C 4.2 Record the results and data from an investigation and make a reasonable explanation.
		B-B 4.3 Explain discrepancies in an investigation using evidence to support findings.

Activity: Recharge - Discharge

Standard	Organizer	Benchmark and Grade Level Indicator
Earth and Space Sciences (ES)	Earth Systems	B-E 4.2 Identify how water exists in the air in different forms (e.g., in clouds, fog, rain, snow and hail).
		B-D 4.3 Investigate how water changes from one state to another (e.g., freezing, melting, condensation and evaporation).
Science and technology (ST)	Abilities To Do Technological Design	B-B 5.3 Explain how the solution to one problem may create other problems.
	Understanding Technology	B-A 5.1 Investigate positive and negative impacts of human activity and technology on the environment.

1

Scientific Inquiry (SI)	Doing Scientific Inquiry	B-B 3.2 Discuss observations and measurements made by other people.
		B-C 3.6 Communicate scientific findings to others through a variety of methods (e.g., pictures, written, oral and recorded observations).
		B-A 4.1 Select the appropriate tools and use relevant safety procedures to measure and record length, weight, volume, temperature and area in metric and English units.
		B-B 4.2 Analyze a series of events and/or simple daily or seasonal cycles, describe the patterns and infer the next likely occurrence.
		B-B 5.2 Evaluate observations and measurements made by other people and identify reasons for any discrepancies.
		B-B 5.3 Use evidence and observations to explain and communicate the results of investigations.
		B-C 5.6 Explain why results of an experiment are sometimes different (e.g., because of unexpected differences in what is being investigated, unrealized differences in the methods used or in the circumstances in which the investigation was carried out, and because of errors in observations).
Scientific Ways of Knowing (SWOK)	Nature of Science	B-B 5.2 Develop descriptions, explanations and models using evidence to defend/support findings.

Activity: Ground Water Flow Model

Standard	Organizer	Benchmark and Grade Level Indicator
Earth and Space Sciences (ES)	Earth Systems	B-C 7.4 Analyze data on the availability of fresh water that is essential for life and for most industrial and agricultural processes. Describe how rivers, lakes and groundwater can be depleted or polluted becoming less hospitable to life and even becoming unavailable or unsuitable for life.
Life Sciences (L)	Diversity and Interdependence of Life	B-D 7.5 Explain that some environmental changes occur slowly while others occur rapidly (e.g., forest and pond succession, fires and decomposition).
Science and technology (ST)	Understanding Technology	B-A 6.1 Explain how technology influences the quality of life.
		B-A 6.2 Explain how decisions about the use of products and systems can result in desirable or undesirable consequences (e.g., social and environmental).
		B-A 7.3 Recognize that science can only answer some questions and technology can only solve some human problems.
		B-A 8.2 Examine how choices regarding the use of technology are influenced by constraints caused by various unavoidable factors (e.g., geographic location, limited resources, social, political and economic considerations).
Scientific Inquiry (SI)	Doing Scientific Inquiry	B-B 7.5 Analyze alternative scientific explanations and predictions and recognize that there may be more than one good way to interpret a given set of data.
		B-B 7.6 Identify faulty reasoning and statements that go beyond the evidence or misinterpret the evidence.

Activity: Get the Ground Water Picture Part III

Standard	Organizer	Benchmark and Grade Level Indicator
Earth and Space Sciences (ES)	Earth Systems	B-C 7.4 Analyze data on the availability of fresh water that is essential for life and for most industrial and agricultural processes. Describe how rivers, lakes and groundwater can be depleted or polluted becoming less hospitable to life and even becoming unavailable or unsuitable for life.
		B-E 8.11 Use models to analyze the size and shape of Earth, its surface and its interior (e.g., globes, topographic maps, satellite images).
Life Sciences (L)	Diversity and Interdependence of Life	B-D 7.5 Explain that some environmental changes occur slowly while others occur rapidly (e.g., forest and pond succession, fires and decomposition).
Physical Sciences (P)	Nature of Energy	B-C 6.8 Describe how renewable and nonrenewable energy resources can be managed (e.g., fossil fuels, trees and water).
Science and technology (ST)	Understanding Technology	B-A 6.2 Explain how decisions about the use of products and systems can result in desirable or undesirable consequences (e.g., social and environmental).

Activity: A Grave Mistake

Standard	Organizer	Benchmark and Grade Level Indicator
Earth and Space Sciences (ES)	Earth Systems	B-C 7.4 Analyze data on the availability of fresh water that is essential for life and for most industrial and agricultural processes. Describe how rivers, lakes and groundwater can be depleted or polluted becoming less hospitable to life and even becoming unavailable or unsuitable for life.
Life Sciences (L)	Diversity and Interdependence of Life	B-C 7.5 Explain that some environmental changes occur slowly while others occur rapidly (e.g., forest and pond succession, fires and decomposition).
Science and technology (ST)	Abilities To Do Technological Design	B-B 6.5 Design and build a product or create a solution to a problem given one constraint (e.g., limits of cost and time for design and production, supply of materials and environmental effects).

3

		B-B 8.4 Evaluate the overall effectiveness of a product design or solution.
	Understanding Technology	B-A 6.1 Explain how technology influences the quality of life.
		B-A 6.2 Explain how decisions about the use of products and systems can result in desirable or undesirable consequences (e.g., social and environmental).
		B-A 8.1 Examine how science and technology have advanced through the contributions of many different people, cultures and times in history.
Scientific Inquiry (SI)	Doing Scientific Inquiry	B-B 6.3 Distinguish between observation and inference
		B-B 6.4 Explain that a single example can never prove that something is always correct, but sometimes a single example can disprove something.
		B-B 7.5 Analyze alternative scientific explanations and predictions and recognize that there may be more than one good way to interpret a given set of data.
		B-B 7.6 Identify faulty reasoning and statements that go beyond the evidence or misinterpret the evidence.
		B-B 7.7 Use graphs, tables and charts to study physical phenomena and infer mathematical relationships between variables (e.g., speed and density).
		B-B 8.3 Read, construct and interpret data in various forms produced by self and others in both written and oral form (e.g., tables, charts, maps, graphs, diagrams and symbols).
Scientific Ways of Knowing (SWOK)	Ethical Practices	B-A 6.2 Describe why it is important to keep clear, thorough and accurate records.
		B-B 8.2 Explain why it is important to examine data objectively and not let bias affect observations.
	Nature of Science	B-A 6.1 Identify that hypotheses are valuable even when they are not supported.
		B-A 8.1 Identify the difference between description (e.g., observation and summary) and explanation (e.g., inference, prediction, significance and importance).
	Science and Society	B-C 6.3 Identify ways scientific thinking is helpful in a variety of everyday settings.
		B-C 6.4 Describe how the pursuit of scientific knowledge is beneficial for any career and for daily life.

Activity: Ground Water Challenge

Standard	Organizer	Benchmark and Grade Level Indicator
Science and Technology (ST)	Abilities To Do Technological Design	B-B 6.5 Design and build a product or create a solution to a problem given one constraint (e.g., limits of cost and time for design and production, supply of materials and environmental effects).
		B-B 7.4 Design and build a product or create a solution to a problem given two constraints (e.g., limits of cost and time for design and production or supply of materials and environmental effects).
		B-B 8.3 Design and build a product or create a solution to a problem given more than two constraints (e.g., limits of cost and time for design and production, supply of materials and environmental effects).
		B-B 8.4 Evaluate the overall effectiveness of a product design or solution.
Scientific Inquiry (SI)	Doing Scientific Inquiry	B-A 6.2 Choose the appropriate tools or instruments and use relevant safety procedures to complete scientific investigations.
		B-A 7.4 Choose the appropriate tools and instruments and use relevant safety procedures to complete scientific investigations.
		B-A 8.1 Choose the appropriate tools or instruments and use relevant safety procedures to complete scientific investigations.

Activity: Ground Water Flow Model

Standard	Organizer	Benchmark and Grade Level Indicator
Earth and Space Sciences (ES)	Earth Systems	B-D 10.5 Explain how the acquisition and use of resources, urban growth and waste disposal can accelerate natural change and impact the quality of life.
		B-B 9.4 Explain the relationships of the oceans to the lithosphere and atmosphere (e.g., transfer of energy, ocean currents and landforms).
	Historical Perspectives and Scientific Revolutions	B-F 10.7 Describe advances and issues in Earth and space science that have important long-lasting effects on science and society (e.g., geologic time scales, global warming, depletion of resources and exponential population growth).
Life Sciences (L)	Diversity and Interdependence of Life	B-G 10.18 Describe ways that human activities can deliberately or inadvertently alter the equilibrium in ecosystems. Explain how changes in technology/biotechnology can cause significant changes, either positive or negative, in environmental quality and carrying capacity.
		B-G 10.19 Illustrate how uses of resources at local, state, regional, national, and global levels have affected the quality of life (e.g., energy production and sustainable vs nonsustainable agriculture).
		B-D 10.9 Describe how matter cycles and energy flows through different levels of organization in living systems and between living systems and the physical environment. Explain how some energy is stored and much is dissipated into the environment as thermal energy (e.g., food webs and energy pyramids).
Physical Sciences (P)	Forces and Motion	B-D 9.21 Demonstrate that motion is a measurable quantity that depends on the observer's frame of reference and describe the object's motion in terms of position, velocity, acceleration and time.
		B-D 9.24 Demonstrate that whenever one object exerts a force on another, an equal amount of force is exerted back on the first object.
	Nature of Energy	B-E 9.13 Demonstrate that near Earth's surface an object's gravitational potential energy depends upon its weight (mg where m is the object's mass and g is the acceleration due to gravity) and height (h) above a reference surface (PE=mgh).
Scientific Inquiry (SI)	Doing Scientific Inquiry	B-A 10.4 Draw conclusions from inquiries based on scientific knowledge and principles, the use of logic and evidence (data) from investigations.
		B-A 9.1 Distinguish between observations and inferences given a scientific situation.
		B-A 9.3 Construct, interpret and apply physical and conceptual models that represent or explain systems, objects, events or concepts.
Scientific Inquiry (SI)	Doing Scientific Inquiry	B-A 9.6 Draw logical conclusions based on scientific knowledge and evidence from investigations.

Activity: Get the Ground Water Picture Part I

Standard	Organizer	Benchmark and Grade Level Indicator
Earth and Space Sciences (ES)	Earth Systems	B-D 10.5 Explain how the acquisition and use of resources, urban growth and waste disposal can accelerate natural change and impact the quality of life.
		B-B 9.4 Explain the relationships of the oceans to the lithosphere and atmosphere (e.g., transfer of energy, ocean currents and landforms).
	Historical Perspectives and Scientific Revolutions	B-F 10.7 Describe advances and issues in Earth and space science that have important long-lasting effects on science and society (e.g., geologic time scales, global warming, depletion of resources and exponential population growth).

Standard	Organizer	Benchmark and Grade Level Indicator
Life Sciences (L)	Diversity and Interdependence of Life	B-G 10.18 Describe ways that human activities can deliberately or inadvertently alter the equilibrium in ecosystems. Explain how changes in technology/biotechnology can cause significant changes, either positive or negative, in environmental quality and carrying capacity.
Physical Sciences (P)	Forces and Motion	B-D 9.21 Demonstrate that motion is a measurable quantity that depends on the observer's frame of reference and describe the object's motion in terms of position, velocity, acceleration and time.
Scientific Inquiry (SI)	Doing Scientific Inquiry	B-A 9.3 Construct, interpret and apply physical and conceptual models that represent or explain systems, objects, events or concepts.
		B-A 9.4 Decide what degree of precision based on the data is adequate and round off the results of calculator operations to the proper number of significant figures to reasonably reflect those of the inputs.
		B-A 9.5 Develop oral and written presentations using clear language, accurate data, appropriate graphs, tables, maps and available technology.
Scientific Ways of Knowing (SWOK)	Nature of Science	B-A 10.2 Describe that scientists may disagree about explanations of phenomena, about interpretation of data or about the value of rival theories, but they do agree that questioning, response to criticism and open communication are integral to the process of science.
		B-A 10.3 Recognize that science is a systematic method of continuing investigation, based on observation, hypothesis testing, measurement, experimentation, and theory building, which leads to more adequate explanations of natural phenomena.

Activity: A Grave Mistake

Standard	Organizer	Benchmark and Grade Level Indicator
Earth and Space Sciences (ES)	Historical Perspectives and Scientific Revolutions	B-F 9.8 Use historical examples to explain how new ideas are limited by the context in which they are conceived; are often initially rejected by the scientific establishment; sometimes spring from unexpected findings; and usually grow slowly through contributions from many different investigators (e.g., heliocentric theory and plate tectonic theory).
Life Sciences (L)	Diversity and Interdependence of Life	B-F 10.15 Explain how living things interact with biotic and abiotic components of the environment (e.g., predation, competition, natural disasters and weather).
		B-G 10.18 Describe ways that human activities can deliberately or inadvertently alter the equilibrium in ecosystems. Explain how changes in technology/biotechnology can cause significant changes, either positive or negative, in environmental quality and carrying capacity.
		B-G 10.19 Illustrate how uses of resources at local, state, regional, national, and global levels have affected the quality of life (e.g., energy production and sustainable vs nonsustainable agriculture).
		B-D 10.9 Describe how matter cycles and energy flows through different levels of organization in living systems and between living systems and the physical environment. Explain how some energy is stored and much is dissipated into the environment as thermal energy (e.g., food webs and energy pyramids).
	Evolutionary Theory	B-J 10.26 Use historical examples to explain how new ideas are limited by the context in which they are conceived These ideas are often rejected by the scientific establishment; sometimes spring from unexpected findings; and usually grow slowly through contributions from many different investigators (e.g., biological evolution, germ theory, biotechnology and discovering germs).
Science and technology (ST)	Understanding Technology	B-B 9.1 Describe means of comparing the benefits with the risks of technology and how science can inform public policy.
		B-A 9.2 Identify a problem or need, propose designs and choose among alternative solutions for the problem.
		B-A 9.3 Explain why a design should be continually assessed and the ideas of the design should be tested, adapted and refined.

Scientific Inquiry (SI)	Doing Scientific Inquiry	B-A 10.2 Present scientific findings using clear language, accurate data, appropriate graphs, tables, maps and available technology.
		B-A 10.4 Draw conclusions from inquiries based on scientific knowledge and principles, the use of logic and evidence (data) from investigations.
		B-A 10.5 Explain how new scientific data can cause any existing scientific explanation to be supported, revised or rejected.
		B-A 9.1 Distinguish between observations and inferences given a scientific situation.
Scientific Inquiry (SI)	Doing Scientific Inquiry	B-A 9.6 Draw logical conclusions based on scientific knowledge and evidence from investigations.
Scientific Ways of Knowing (SWOK)	Nature of Science	B-C 9.2 Illustrate that the methods and procedures used to obtain evidence must be clearly reported to enhance opportunities for further investigations.
		B-A 9.3 Demonstrate that reliable scientific evidence improves the ability of scientists to offer accurate predictions.
	Scientific Theories	B-B 9.6 Explain that inquiry fuels observation and experimentation that produce data that are the foundation of scientific disciplines Theories are explanations of these data.
		B-B 9.7 Recognize that scientific knowledge and explanations have changed over time, almost always building on earlier knowledge.

Activity: Ground Water Challenge

Standard	Organizer	Benchmark and Grade Level Indicator
Science and technology (ST)	Abilities To Do Technological Design	B-B 10.1 Cite examples of ways that scientific inquiry is driven by the desire to understand the natural world and how technology is driven by the need to meet human needs and solve human problems.
		B-A 10.3 Explain that when evaluating a design for a device or process, thought should be given to how it will be manufactured, operated, maintained, replaced and disposed of in addition to who will sell, operate and take care of it. Explain how the costs associated with these considerations may introduce additional constraints on the design.
	Understanding Technology	B-B 9.1 Describe means of comparing the benefits with the risks of technology and how science can inform public policy.
Science and technology (ST)	Understanding Technology	B-A 9.2 Identify a problem or need, propose designs and choose among alternative solutions for the problem.
		B-A 9.3 Explain why a design should be continually assessed and the ideas of the design should be tested, adapted and refined.
Scientific Inquiry (SI)	Doing Scientific Inquiry	B-A 10.2 Present scientific findings using clear language, accurate data, appropriate graphs, tables, maps and available technology.
		B-A 10.4 Draw conclusions from inquiries based on scientific knowledge and principles, the use of logic and evidence (data) from investigations.
		B-A 9.3 Construct, interpret and apply physical and conceptual models that represent or explain systems, objects, events or concepts.
		B-A 9.5 Develop oral and written presentations using clear language, accurate data, appropriate graphs, tables, maps and available technology.
		B-A 9.6 Draw logical conclusions based on scientific knowledge and evidence from investigations.
Scientific Ways of Knowing (SWOK)	Nature of Science	B-C 9.2 Illustrate that the methods and procedures used to obtain evidence must be clearly reported to enhance opportunities for further investigations.
	Scientific Theories	B-B 9.6 Explain that inquiry fuels observation and experimentation that produce data that are the foundation of scientific disciplines Theories are explanations of these data.

Activity: Ground Water Flow Model

Standard	Organizer	Benchmark and Grade Level Indicator
Earth and Space Sciences (ES)	Earth Systems	B-C 11.11 Analyze how materials from human societies (e.g., radioactive waste and air pollution) affect both physical and chem[illegible] cycles of Earth.
		B-C 11.12 Explain ways in which humans have had a major effect on other species (e.g., the influence of humans on other organisms occurs through land use, which decreases space available to other species and pollution, which changes the chemical composition of air, soil and water).
		B-C 11.13 Explain how human behavior affects the basic processes of natural ecosystems and the quality of the atmosphere, hydrosphere and lithosphere.
		B-C 11.14 Conclude that Earth has finite resources and explain that humans deplete some resources faster than they can be renewed.
		B-B 11.6 Explain how interactions among Earth's lithosphere, hydrosphere, atmosphere and biosphere have resulted in the ongoing changes of Earth's system.
		B-B 12.6 Describe how scientists estimate how much of a given resource is available on Earth.
Life Sciences (L)	Characteristics and Structure of Life	B-B 11.5 Investigate the impact on the structure and stability of ecosystems due to changes in their biotic and abiotic components as a result of human activity.
	Diversity and Interdependence of Life	B-F 11.11 Investigate issues of environmental quality at local, regional, national and global levels such as population growth, resource use, population distribution, over-consumption, the capacity of technology to solve problems, poverty, the role of economics, politics and different ways humans view the earth.
		B-E 11.8 Recognize that populations can reach or temporarily ex[illegible]d the carrying capacity of a given environment. Show that the limit[illegible] not just the availability of space but the number of organisms in relation to resources and the capacity of earth systems to support life.
		B-F 11.9 Give examples of how human activity can accelerate rates of natural change and can have unforeseen consequences.
		B-E 12.8 Based on the structure and stability of ecosystems and their nonliving components, predict the biotic and abiotic changes in such systems when disturbed (e.g introduction of non-native species, climatic change, etc.).
Science and technology (ST)	Understanding Technology	B-A 12.3 Research how scientific inquiry is driven by the desire to understand the natural world and how technological design is driven by the need to meet human needs and solve human problems.
Scientific Inquiry (SI)	Doing Scientific Inquiry	B-A 11.1 Formulate testable hypotheses. Develop and explain the appropriate procedures, controls and variables (dependent and independent) in scientific experimentation.
		B-A 12.1 Formulate testable hypotheses. Develop and explain the appropriate procedures, controls and variables (dependent and independent) in scientific experimentation.
Scientific Ways of Knowing (SWOK)	Nature of Science	B-A 11.1 Analyze a set of data to derive a hypothesis and apply that hypothesis to a similar phenomenon (e.g., biome data).
		B-A 12.4 Analyze a set of data to derive a principle and then apply that principle to a similar phenomenon (e.g., predator-prey relationships and properties of semiconductors).
	Science and Society	B-C 11.9 Explain how natural and human-induced hazards present the need for humans to assess potential danger and risk. Many changes in the environment designed by humans bring benefits to society as well as cause risks.
		B-C 12.9 Recognize the appropriateness and value of basic questions "What can happen?" "What are the odds?" and "How do scientists and engineers know what will happen?"

Activity: Get the Ground Water Picture Part I

Standard	Organizer	Benchmark and Grade Level Indicator
Scientific Inquiry (SI)	Doing Scientific Inquiry	B-A 11.1 Formulate testable hypotheses. Develop and explain the appropriate procedures, controls and variables (dependent and independent) in scientific experimentation.
Scientific Inquiry (SI)	Doing Scientific Inquiry	B-A 12.1 Formulate testable hypotheses. Develop and explain the appropriate procedures, controls and variables (dependent and independent) in scientific experimentation.
Scientific Ways of Knowing (SWOK)	Nature of Science	B-A 11.1 Analyze a set of data to derive a hypothesis and apply that hypothesis to a similar phenomenon (e.g., biome data).
		B-A 12.4 Analyze a set of data to derive a principle and then apply that principle to a similar phenomenon (e.g., predator-prey relationships and properties of semiconductors).
	Science and Society	B-C 11.9 Explain how natural and human-induced hazards present the need for humans to assess potential danger and risk. Many changes in the environment designed by humans bring benefits to society as well as cause risks.
		B-C 12.9 Recognize the appropriateness and value of basic questions "What can happen?" "What are the odds?" and "How do scientists and engineers know what will happen?"

Activity: A Grave Mistake

Standard	Organizer	Benchmark and Grade Level Indicator
Earth and Space Sciences (ES)	Earth Systems	B-C 11.11 Analyze how materials from human societies (e.g., radioactive waste and air pollution) affect both physical and chemical cycles of Earth.
		B-C 11.12 Recognize that ecosystems change when significant climate changes occur or when one or more new species appear as a result of immigration or speciation.
		B-C 11.13 Explain how human behavior affects the basic processes of natural ecosystems and the quality of the atmosphere, hydrosphere and lithosphere.
Life Sciences (L)	Characteristics and Structure of Life	B-A 11.1 Describe how the maintenance of a relatively stable internal environment is required for the continuation of life, and explain how stability is challenged by changing physical, chemical and environmental conditions as well as the presence of pathogens.
		B-B 11.3 Relate how birth rates, fertility rates and death rates are affected by various environmental factors.
	Diversity and Interdependence of Life	B-F 11.11 Investigate issues of environmental quality at local, regional, national and global levels such as population growth, resource use, population distribution, over-consumption, the capacity of technology to solve problems, poverty, the role of economics, politics and different ways humans view the earth.
		B-E 12.8 Based on the structure and stability of ecosystems and their nonliving components, predict the biotic and abiotic changes in such systems when disturbed (e.g introduction of non-native species, climatic change, etc.).
Science and technology (ST)	Understanding Technology	B-A 11.2 Predict how decisions regarding the implementation of technologies involve the weighing of trade-offs between predicted positive and negative effects on the environment and/or humans.
		B-A 12.1 Explain how science often advances with the introduction of new technologies and how solving technological problems often results in new scientific knowledge.
		B-A 12.2 Describe how new technologies often extend the current levels of scientific understanding and introduce new areas of research.
Scientific Inquiry (SI)	Doing Scientific Inquiry	B-A 11.3 Design and carry out scientific inquiry (investigation), communicate and critique results through peer review.
		B-A 12.1 Formulate testable hypotheses Develop and explain the appropriate procedures, controls and variables (dependent and independent) in scientific experimentation.

		B-A 12.4 Create and clarify the method, procedures, controls and variables in complex scientific investigations.
Scientific Ways of Knowing (SWOK)	Nature of Science	B-A 12.3 Select a scientific model, concept or theory and explain how it has been revised over time based on new knowledge, perceptions or technology.
	Science and Society	B-C 11.9 Explain how natural and human-induced hazards prese the need for humans to assess potential danger and risk. Many changes in the environment designed by humans bring benefits to society as well as cause risks.

Activity: Ground Water Challenge

Standard	Organizer	Benchmark and Grade Level Indicator
Earth and Space Sciences (ES)	Earth Systems	B-C 11.11 Analyze how materials from human societies (e.g., radioactive waste and air pollution) affect both physical and chemical cycles of Earth.
		B-C 11.12 Explain ways in which humans have had a major effect on other species (e.g., the influence of humans on other organisms occurs through land use, which decreases space available to other species and pollution, which changes the chemical composition of air, soil and water).
		B-C 11.13 Explain how human behavior affects the basic processes of natural ecosystems and the quality of the atmosphere, hydrosphere and lithosphere.
		B-B 11.6 Explain how interactions among Earth's lithosphere, hydrosphere, atmosphere and biosphere have resulted in the ongoing changes of Earth's system.
Life Sciences (L)	Characteristics and Structure of Life	B-A 11.1 Describe how the maintenance of a relatively stable internal environment is required for the continuation of life, and explain how stability is challenged by changing physical, chemical and environmental conditions as well as the presence of pathogens.
		B-B 11.5 Investigate the impact on the structure and stability of ecosystems due to changes in their biotic and abiotic componen a result of human activity.
	Diversity and Interdependence of Life	B-F 11.11 Investigate issues of environmental quality at local, regional, national and global levels such as population growth, resource use, population distribution, over-consumption, the capacity of technology to solve problems, poverty, the role of economics, politics and different ways humans view the earth.
		B-E 12.8 Based on the structure and stability of ecosystems and their nonliving components, predict the biotic and abiotic changes in such systems when disturbed (e.g introduction of non-native species, climatic change, etc.).
	Historical Perspectives and Scientific Revolutions	B-G 12.12 Describe advances in life sciences that have important, long-lasting effects on science and society (e.g., biotechnology).
Physical Sciences (P)	Nature of Matter	B-A 12.2 Describe how a physical, chemical or ecological system in equilibrium may return to the same state of equilibrium if the disturbances it experiences are small. Large disturbances may cause it to escape that equilibrium and eventually settle into some other state c equilibrium.
Science and technology (ST)	Understanding Technology	B-A 11.2 Predict how decisions regarding the implementation of technologies involve the weighing of trade-offs between predicted positive and negative effects on the environment and/or humans.
		B-A 12.1 Explain how science often advances with the introduction of new technologies and how solving technological problems often results in new scientific knowledge.
		B-A 12.3 Research how scientific inquiry is driven by the desire to understand the natural world and how technological design is driven by the need to meet human needs and solve human problems.
Scientific Inquiry (SI)	Doing Scientific Inquiry	B-A 11.1 Formulate testable hypotheses Develop and explain the appropriate procedures, controls and variables (dependent and independent) in scientific experimentation.

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		B-A 11.2 Evaluate assumptions that have been used in reaching scientific conclusions.
		B-A 11.3 Design and carry out scientific inquiry (investigation), communicate and critique results through peer review.
		B-A 11.4 Explain why the methods of an investigation are based on the questions being asked.
		B-A 11.5 Summarize data and construct a reasonable argument based on those data and other known information.
		B-A 12.1 Formulate testable hypotheses Develop and explain the appropriate procedures, controls and variables (dependent and independent) in scientific experimentation.
		B-A 12.2 Derive simple mathematical relationships that have predictive power from experimental data (e.g., derive an equation from a graph and vice versa, determine whether a linear or exponential relationship exists among the data in a table).
		B-A 12.3 Research and apply appropriate safety precautions when designing and/or conducting scientific investigations (e.g., OSHA, MSDS, eyewash, goggles and ventilation).
		B-A 12.4 Create and clarify the method, procedures, controls and variables in complex scientific investigations.
		B-A 12.5 Use appropriate summary statistics to analyze and describe data.
Scientific Ways of Knowing (SWOK)	Nature of Science	B-A 11.1 Analyze a set of data to derive a hypothesis and apply that hypothesis to a similar phenomenon (e.g., biome data).
		B-A 11.2 Apply scientific inquiry to evaluate results of scientific investigations, observations, theoretical models and the explanations proposed by other scientists.
		B-A 11.3 Demonstrate that scientific explanations adhere to established criteria, for example a proposed explanation must be logically consistent, it must abide by the rules of evidence and it must be open to questions and modifications.
		B-A 12.3 Select a scientific model, concept or theory and explain how it has been revised over time based on new knowledge, perceptions or technology.
		B-A 12.4 Analyze a set of data to derive a principle and then apply that principle to a similar phenomenon (e.g., predator-prey relationships and properties of semiconductors).
		B-A 12.5 Describe how individuals and teams contribute to science and engineering at different levels of complexity (e.g., an individual may conduct basic field studies, hundreds of people may work together on major scientific questions or technical problem).
	Science and Society	B-C 11.8 Explain that the decision to develop a new technology is influenced by societal opinions and demands and by cost benefit considerations.
		B-C 11.9 Explain how natural and human-induced hazards present the need for humans to assess potential danger and risk. Many changes in the environment designed by humans bring benefits to society as well as cause risks.
		B-C 12.11 Research how advances in scientific knowledge have impacted society on a local, national or global level.
		B-C 12.8 Recognize that individuals and society must decide on proposals involving new research and the introduction of new technologies into society Decisions involve assessment of alternatives, risks, costs and benefits and consideration of who benefits and who suffers, who pays and gains, and what the risks are and who bears them.
		B-C 12.9 Recognize the appropriateness and value of basic questions "What can happen?" "What are the odds?" and "How do scientists and engineers know what will happen?"