HOLD IT!

Grades 6–8

Lesson at a Glance

Students investigate: 1) the rate at which water moves through various soils and the ways in which groundwater accumulates in the islands; and 2) where to put a new landfill on their island.

Key Concepts

Groundwater and some contaminants move slowly through openings between rocks and in cracks within lava flows. Relatively impermeable dike rock and relatively impermeable caprock help to hold water within the islands. The more permeable the soil, the faster contaminants reach our groundwater.

Hawai‘i Content and Performance Standards III, Language Art

Grade 6			
Strand		Reading	
Standard 1: Reading: CONVENTION AND SKILLS: Use knowledge of the conventions of language and texts to construct meaning for a range of literary and informational texts for a variety of purposes.			
Topic		Locating Sources/Gathering Information	
Benchmark LA.6.1.2		Use grade-appropriate online and print sources to research a topic (*e.g., how do we manage our water resources? What roles do special interest groups play in watershed alliances? Where are the watersheds in my neighborhood?*).	
Sample Performance Assessment (SPA)		The student: Finds and reads online (e.g., CD-ROM, internet, intranet, newsgroups) and traditional sources (e.g., encyclopedia, books, periodicals) to answer an inquiry arising from class or personal activities.	
Rubric			
Advanced	Proficient	Partially Proficient	Novice
Use substantive information from an extensive variety of grade-appropriate print and online resources to thoroughly research a topic.	Use relevant information from a variety of grade-appropriate print and online resources to research a topic.	Use some relevant information from a selection of grade-appropriate print and online resources to research a topic.	Use very little relevant information from grade-appropriate print and online resources to research a topic.

Hawai‘i Content Performance Standard III, Science, Grade 6

Strand		The Scientific Process	
Standard 2: The Scientific Process: NATURE OF SCIENCE—Understand that science, technology, and society are interrelated.			
Topic		Science, Technology, and Society	
Benchmark SC.6.2.1		Explain how technology has an impact on society and science (*e.g., to solve and improve environmental problems such as groundwater pollution*).	
Sample Performance Assessment (SPA)		The student: Explains ways in which technology has changed our society and science.	
Rubric			
Advanced	Proficient	Partially Proficient	Novice
Explain and provide examples of how technology has an impact on society and science.	Explain how technology has an impact on society and science.	Give a partial explanation of how technology has an impact on society and science.	Recognize that technology has an impact on society and science.

Hawai‘i Content Performance Standard III, Science, Grade 7

Strand		The Scientific Process	
Standard 2: The Scientific Process: NATURE OF SCIENCE—Understand that science, technology, and society are interrelated.			
Topic		Science, Technology, and Society	
Benchmark SC.8.2.1		Explain the use of reliable print and electronic sources to provide scientific information and evidence *(e.g., how to use sources to learn about the environment and solve environmental problems such as where to put a new landfill*).	
Sample Performance Assessment (SPA)		The student: Explains how the evidence found in a wide variety of print and electronic sources (e.g., database programs, internet) can be used to develop conclusions (*e.g., based on evidence found in a wide variety of print and electronic sources, a new landfill should be located in this part of an island*).	
Rubric			
Advanced	Proficient	Partially Proficient	Novice
Explain how print and electronic sources can be used to provide scientific information and evaluate the sources used for validity and reliability.	Explain the use of reliable print and electronic sources to provide scientific information and evidence.	Explain that print and electronic sources can be used to provide scientific information and evidence.	Recognize that print and electronic sources can be used to provide scientific information and evidence.

Hawai‘i Content Performance Standard III, Science, Grade 8

Strand		The Scientific Process	
Standard 2: The Scientific Process: NATURE OF SCIENCE—Understand that science, technology, and society are interrelated.			
Topic		Science, Technology, and Society	
Benchmark SC.8.2.1		Describe significant relationships among society, science, and technology and how one impacts the other.	
Sample Performance Assessment (SPA)		The student: Provides earth and space examples of how science, technology, and society have impacted each other. *For example, the effects of land use on our groundwater supplies, how knowledge of science (geology and chemistry) and technology (groundwater remediation technologies, landfill construction) are used to clean up groundwater supplies. Other examples, where to locate a new landfill land how people can prevent groundwater pollution.*	
Rubric			
Advanced	Proficient	Partially Proficient	Novice
Evaluate and describe the relationships among society, science, and technology and how one impacts the other.	Describe significant relationships among society, science, and technology and how one impacts the other.	List a few relationships between society, science, or technology.	Recognize relationships among society, science, and technology.

Objectives

Students will be able to:

1. Test the permeability of sand, gravel and soil.
2. Describe how the permeability of rocks affects the storage of groundwater in the islands.
3. Describe how permeability and pollution affects the quality of groundwater supplies.
4. Describe how land use impacts our groundwater supplies.
5. Implements habits to help prevent pollution of our groundwater supplies.

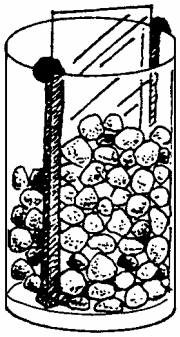
Time
three to four class periods

Subject Areas
science, social studies

Materials
student activity sheet (provided)
large beaker or glass jar
small lava rocks (to fill jar)
red and blue food coloring
1 sheet of acetate
small amount of floral putty or tube of silicone*
colored pens or pencils
watch with a second hand

for each student group:
4 paper cups
1/2 cup of sand, soil, and gravel
2 cups of water
old newspapers

*Silicone can be obtained as an aquarium sealant. It will work well for the model building, but needs approximately 20 minutes to dry.



Preparation
Collect some small lava rocks to fill the beaker. If possible, obtain a sample of dike rock, ʻaʻā, pāhoehoe, and caprock. See the Field Sites Appendix for suggested sites to obtain rocks.

Place a strip of putty or silicone against the inner sides and bottom of a clear glass beaker (see illustration). Measure the diameter of the beaker and cut a piece of acetate to fit snugly in the center of the beaker. Insert the acetate into the putty strip inside the beaker so that two separate compartments are formed. (The acetate represents a relatively impermeable dike inside the shield volcano.) Gently add lava rocks to both sides of the beaker.

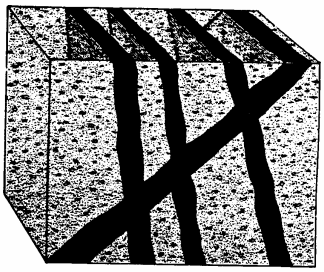
Fill two large cups with water. Add blue food coloring to one cup and red food coloring to the other.

Prepare the three cups each group of students will need for the permeability experiment. Fill each cup half way with a different material—sand, soil or gravel.

Teacher Background

Water moves through the **pore spaces** between particles of soil, sand, and gravel at different rates, depending on the size of the particles and the size of spaces between them. Water moves through the openings in layers of **permeable** lava flows in a similar manner. Permeability is a measure of how easily water moves through the rock or soil. The permeability of most Hawaiian lava rocks is very high. The holes in rocks and cracks in lava flows allow water to move sideways and downward. This **groundwater** stops moving when it reaches impermeable rock or denser salt water.

In Hawai‘i, most groundwater is contained within a **freshwater lens**—a lens-shaped body of water held within the rocks deep within each island. Each island may have more than one freshwater lens. Below sea level, the volcano is saturated with fresh and salt water. Since fresh water is slightly less dense than salt water, the fresh water floats on the salt water. The top of this layer of fresh water is called the **water table**. For every meter of fresh water above sea level, there will be about 40 m below sea level. There is a zone of **brackish** water where the fresh water and salt water mix. Two scientists, Ghyben and Herzberg, first identified the mechanics of this groundwater lens. The freshwater lens is now called the Ghyben-Herzberg lens. (See diagram on student activity sheet.)



When magma rises to the surface along rift zones to erupt on the surface as lava, not all of the magma is erupted, so it cools slowly. Very little gas can escape from the cooling magma because this occurs under great pressure. The result is nearly vertical sheets of dense, relatively impermeable rocks called dikes. Between these vertical dikes are older lava flows. A considerable amount of water is contained within dike compartments. The water table stands high above sea level. This is one reason we have natural springs in the mountains high above the Ghyben-Herzberg lens. Dikes range from several centimeters to 15 m thick (1 in. to 45 ft). Most dikes are between 0.3 and 3 m (1 to 9 ft) thick. When tunnels are bored into a dike compartment, the water held within the pāhoehoe and ‘a‘ā lavas escape, adding millions of gallons of water per day to the public water supply and agricultural supply.

Caprock is formed when interbedded coastal plain sediments from the land and the marine environment, including coral fragments, shell, algae, silt, young lava flows, and ash become cemented together. Caprock is found on flat areas near the shore on older islands where reefs have had a chance to form. It is wedge-shaped. The seaward edge can be over 300 m (1,000 ft) thick and extending well below the current sea level. Caprock plays an important role in retarding the movement of groundwater from the freshwater lens to the sea. (See diagram on student sheet.) A younger island with relatively little caprock has many low-tide springs where a shallow lens leaks into the sea.

Fresh water is contained under pressure below caprock. This water will often escape through cracks in the caprock, both below sea level and on land, as artesian springs. This pressurized water can also be released into wells drilled through the caprock.

Pollution of our environment can affect our groundwater quality. Pesticides, herbicides, fertilizers, paint, oil, gas, cleaning solvents, and other contaminants can seep into the ground over time and reach our groundwater supply. For more information on water pollution, see the student reading “Holding More Than Just Water” and “Save our Water” in the Humans and the Environment Unit.

Teaching Suggestions

Testing Permeability

- Divide the class into small groups and distribute some old newspapers and the cups of sand, soil, and gravel. Have students use a ballpoint pen to poke a small hole in the bottom of each cup.

- Ask students to predict what will happen when they pour water into the cups. Distribute an extra cup to each group to catch the water that drains out. Which material do they predict will be the most permeable—that is, which will allow water to pass through most rapidly?

- Ask them to test the permeability of the materials by pouring a half cup of water into each and timing how long it takes the water to drain. Complete the testing per student activity sheet and graph the results on the sheet provided. (If the soil contains a lot of clay, the water will take a while to drain.)

- Compare the movement of water through the cups to the movement of water through island rocks and sand. Ask students if water would move more quickly through sand at the beach or through soil in the schoolyard. (Larger pore spaces between sand grains allow the water to drain more quickly.)

Permeable Lava and Highly Impermeable Dikes

- Pour a small amount of blue water onto one side of the dike model prepared earlier. Have students observe how water moves around the lava rocks. Compare the rocks in the beaker to layers of lava on an island and explain that water moves through permeable lava and through cracks in lava flows. If you have samples of pāhoehoe and ʻaʻā rocks available, point out the holes that allow water to move through.

- Pour a larger amount of red water on the other side of the model. Why doesn't the red water mix with the blue water? The "dike" is holding the water in a separate compartment. Note that the acetate is impermeable whereas the dikes are only semi-impermeable.

- Compare the acetate to a sheet of highly impermeable dike rock inside the island. Remind students that dikes are formed where molten magma cooled inside the volcano.

- If you have dike rock available, pass it around so students can examine the dense qualities of the rock. Ask students if they believe water would flow through the dense rock. The rock will become saturated, but more slowly than more porous rock. Let students try dropping water on the rock and see what happens. The shape of the dike sample will be prismatic. Explain that the flat surfaces are faces of cracks, which water will move through.

Where does fresh water accumulate?

- Distribute and review the student activity sheet.

- Ask students what they believe keeps the water in the lens from flowing out to sea. Explain that, like the dike rock, caprock is semi-permeable. Describe how caprock is formed.

✓ • Ask students to complete the activity sheet and discuss their answers. The answers to the questions are: a) groundwater, lens; b) caprock; c) dikes; d) permeable, impermeable.

Pollution and Permeability

- Have students do the Student Activity "Holding More Than Just Water."

Extended Activities

- Students could write descriptions of what would happen to the islands' water supply if all of the relatively impermeable rock were suddenly changed to more permeable rock.

- Have students investigate why an artesian well "fountains." Take a garden hose full of water and see what happens when the closed end of the hose is raised. Because the raised water creates pressure, the water will bubble out. Water from an artesian well is under pressure due to the height of the water table above it. When a well is drilled into this pressurized water, the water shoots out.

- Students research the different types of ground cover and their effectiveness.

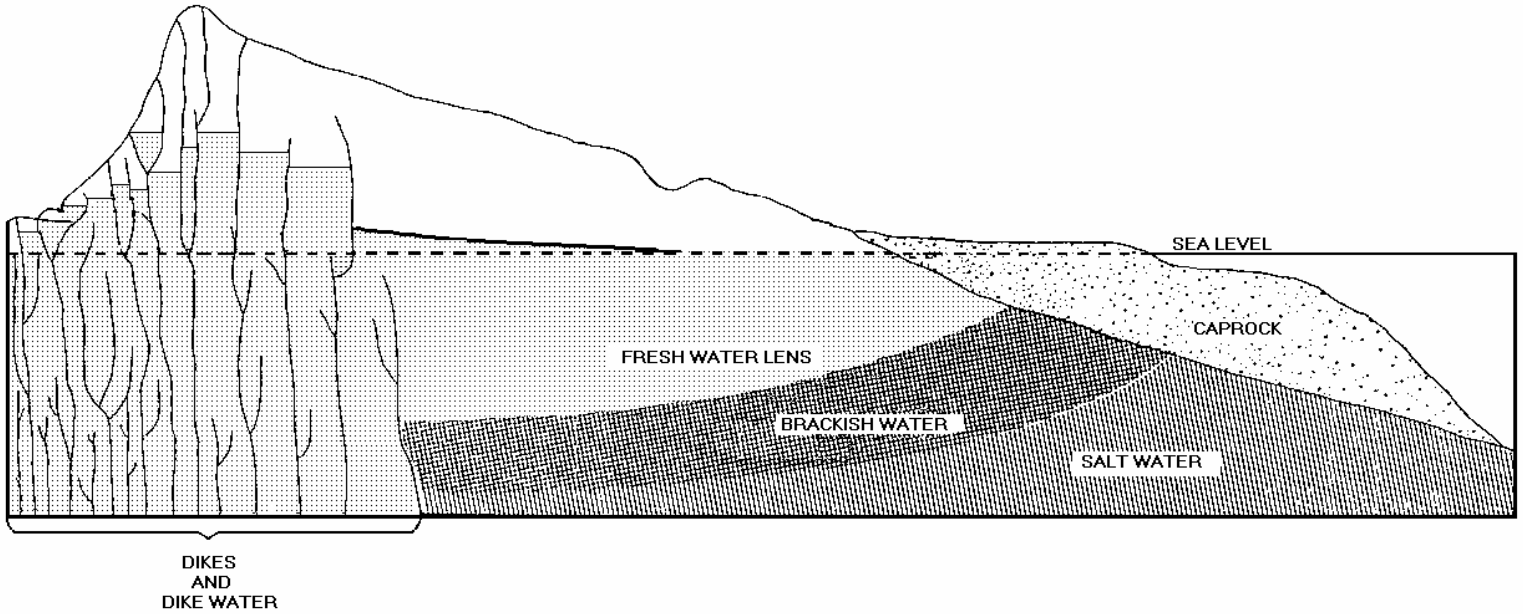
- Students can research phytoremediation projects such as the one that uses *'ākulikuli* to clean up the AlaWai Canal on O'ahu.

- Write a research paper on groundwater on your island based on the following: water quality, soil permeability, pesticides and land use. Write about any of the five questions below:
  1. What is the distribution of groundwater on your island? Plot on a map at least three from three DIFFERENT places on the island.
  2. Is any groundwater supply on your island contaminated? If so, how did it get contaminated? Is there a remediation system, i.e., carbon treatment system, in place? If there is a remediation system, what was the cost to build it and what is the cost to maintain it?
  3. Are the pollutants in the contaminated drinking water still being used? Have any been banned?
  4. Are there areas where the wells are not contaminated? Why?
  5. Describe the connection between soil permeability, the contaminant in the drinking water supply, and land use.
  6. Are any wells on your island closed? If so, why?

7. Find two other drinking water supplies in the state and investigate their water quality. Plot all three drinking water supplies on a map.
8. How does the groundwater supply on your island compare to those on another island?

You may use the following resources:

1. Groundwater wells and groundwater contamination: Department of Health
2. US Geological Survey http://www.water.usgs.gov
3. Soil permeability: USDA Natural Resources Conservation Service in Honolulu or online at http://www.ctahr.hawaii.edu/soilsurvey/soils.htm
4. Groundwater: your local water company
   a. Honolulu Board of Water Supply http://www.hbws.org
   b. Kaua‘i Department of Water http://kauaiwater.gov
   c. Hawai‘i Department of Water Supply http://www.hawaii-county.com/water/DWS-main.htm
   d. Maui Department of Water Supply http://ccmaui.com/~h2oeng/
   e. Hawai‘i Department of Health, Safe Drinking Water Branch http://www.hawaii.gov/health/eh/sdwb/index.html
   f. Pesticide usage in Hawai‘i: Hawai‘i Department of Agriculture; http://www.hawaiiag.org/hdoa/pi_pest.htm



1) Use a blue marking pen to fill in the areas on the diagram where fresh water is stored.

2) Color the dikes and caprock brown.

3) Complete the sentences below with words from the following list:

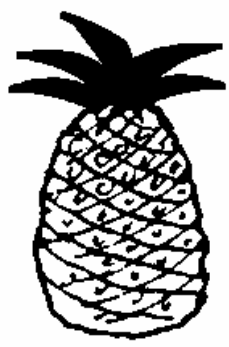
permeable, impermeable, dikes, caprock, groundwater, lens

a. _____ is stored in a freshwater _____ floating on top of sea water in rocks within the islands.

b. _____ prevents groundwater from moving out of the lens into the sea.

c. Tunnels drilled through _____ tap water for public and agricultural use.

d. Water moves through _____ lava rock and is stored behind relatively high _____ dikes.



Have you ever wondered how pure the water is that comes out of your faucet? Could the water in another community be more or less pure than the water in your community? How could that happen? Pollution is one answer. Pollution of the environment can definitely affect groundwater quality. Pollutants are generally classified into two broad categories. One comes from an identifiable source, such as a particular sewage treatment plant or farm. This is known as **point source pollution**. The other, **non-point source pollution**, is more difficult to trace. Non-point sources can be pesticides, herbicides, fertilizers, paint, oil, gas, cleaning solvents, and other contaminants.

Contaminants can seep into the ground and reach our groundwater supply. Since most of our drinking water comes from the ground, pollution of the water supply is a critical concern. Soil permeability controls the rate at which a contaminant travels through the ground. Soils with high permeability, such as coarse and sandy soils, will make it easier for contaminants to reach our groundwater. On the other hand, soils containing clay and organic matter, which allow pesticides to cling to them, have a low permeability.

Once groundwater is contaminated, it remains contaminated for many years. Soluble chemicals break down easily in water while others are more persistent—they break down slowly and remain in the environment for a long time. Soluble chemicals are more likely to find their way into our groundwater.

In the 1800s, the population in the islands was growing. Much of the land in Hawai‘i was planted in sugar cane. Water was needed badly to meet the needs of Hawai‘i’s people, particularly agriculture. In 1879, James Campbell drilled Hawai‘i’s first artesian well 68 m (223 ft) deep on the ‘Ewa Plain of O‘ahu to tap the water held in the porous lava rocks below the caprock. Artesian means that the water in the well is forced up by pressure. This was the beginning of deep well drilling in Hawai‘i. The land was now supplied with well water that fed Campbell’s sugar plantation. Many artesian wells and nonartesian wells were drilled after Campbell’s success in drilling the first one. Much of the water was used for agriculture.

PINEAPPLE PROBLEMS

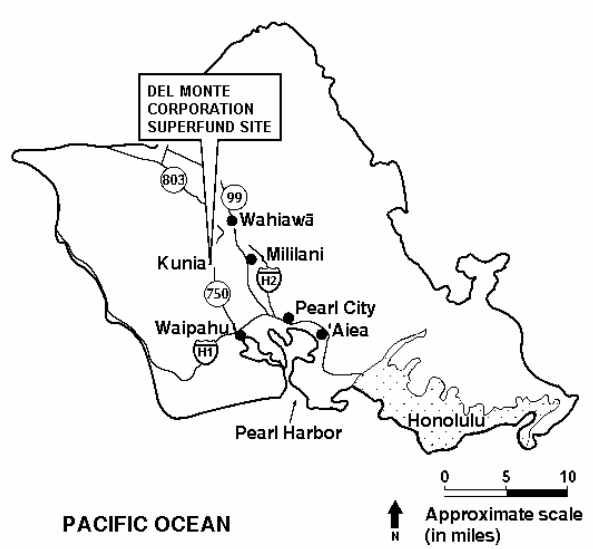
In addition to sugar cane, pineapple became an important crop in the Hawaiian Islands today. Pineapple continues to be an important crop on O‘ahu and Maui. Unfortunately, it is susceptible to nematodes, which is a type of worm that eats the roots of plants such as pineapples, grapes, and apples. Pineapple growers in Hawai‘i used pesticides called dibromochloropropane (DBCP) and ethylene dibromide (EDB) to prevent nematodes from reproducing. A pesticide is a chemical that kills pests such as rodents and insects. Both DBCP and EDB are probable carcinogens (cancer-causing agents) in humans. These chemicals were normally stored in drums, which are large metal containers. The pesticides were diluted by mixing them with water and other chemicals before being injected into the ground.

On April 7, 1977, there was a major spill of EDB in a Del Monte pineapple plantation in Kunia, O‘ahu. The Hawai‘i Department of Health (DOH) tested the Kunia well water, the only source of

water for Kunia village where the pineapple workers lived. DOH found no contamination. In 1979 the Environmental Protection Agency (EPA) banned DBCP everywhere in the country except for pineapple fields in Hawai'i. DOH tested the Kunia well again in 1980 and found not only EDB but also DBCP. Del Monte disconnected the Kunia well from the drinking water system the next day. The people of Kunia village now receive their water from other wells.

CLEANING UP KUNIA

After the big spill in Kunia, Del Monte, DOH and the Department of Agriculture (DOA) checked the soil in the Kunia spill area to establish the extent of contamination including the locations where pesticides had been stored and mixed. As part of the pesticide cleanup process, in 1981, Del Monte removed 2,000 tons of contaminated soil from the EDB spill area. In 1983, Del Monte removed an additional 16,000 tons of contaminated soil and laid it out on nearby fallow pineapple fields. Cow manure was spread over the contaminated soil, which was then broken up together to allow the pesticides to volatilize (vaporize). EPA tested the soil and found that no chemicals were detected at levels that might pose risks.



Location of Kunia, O'ahu. Adapted from EPA fact sheet, Del Monte Corporation (Oahu Plantation) Added to Superfund National Priority List, Sept. 1995.

Kunia groundwater comes from two distinct aquifers: perched (shallow—100 ft below ground surface) and basal (deep—850 ft below ground surface). The perched aquifer, which was not used, was contaminated from the spill. The basal aquifer, which was where the community's water came from, was also contaminated but not as much as the perched aquifer. Concern about the basal aquifer arose because the contaminated water from the perched aquifer could infiltrate down to the basal aquifer. From 1990–1994, Del Monte pumped contaminated water from the perched aquifer, Kunia well, and three extraction wells. The contaminated water was used to irrigate a noncrop field and to control dust; however, this was stopped because of environmental concerns by the EPA of reusing untreated groundwater.

SOLVING WATER WOES

In 1983, DOH tested six wells in Mililani, O'ahu and found them to be contaminated with DBCP and TCP, or trichloropropane. TCP is a solvent meaning it can dissolve substances such as oil and waxes. TCP is used in industrial solvents, paint and varnish removers, and cleaners. TCP is a byproduct in the production of DCP. In testing laboratory rats, TCP caused cancer. After DBCP and TCP were found in Mililani wells and EDB was found in Waipahu wells, DOH tested wells throughout the state. In 1984, EDB usage was stopped. In 1985, DBCP was banned from all uses even in pineapple fields.

The discovery of the contaminated wells was bad news for the public. People had many questions. How could this happen? How could the contaminated water affect their health? Who was responsible? What was going to be done about it? What were they suppose to drink now?

What about our future drinking water? Several government agencies joined forces to address the problems of the contaminated wells:

- Department of Health (DOH): this state agency oversees the health of the people of Hawai‘i.
- Department of Agriculture (DOA): this state agency oversees agriculture in Hawai‘i. One of its responsibilities is to regulate the distribution and use of pesticides.

- Honolulu Board of Water Supply (HBWS): this semi-autonomous agency under the City and County of Honolulu is charged with providing municipal water supply to meet domestic needs and fire protection for the island of O‘ahu. HBWS provided water wagons to areas that were affected by contaminated groundwater wells. It has constructed treatment facilities using granular activated carbon (GAC) filters to remove the pesticides.
- Environmental Protection Agency (EPA): this federal agency is charged with protecting human health and safeguarding the natural environment. The EPA enforces the **Safe Drinking Water Act**, which sets requirements for the level of contaminants in drinking water, and standards by which water supply system operators must comply to meet these levels.
- Governor: branch of government that enforces state laws and oversees the general welfare of the State of Hawai‘i.
- Legislature: branch of government responsible for making laws in the state of Hawai‘i.

In 1984, the state legislature formed an adhoc committee from the Hawai‘i State Office of Environmental Quality Control (OEQC) to establish a system for the prevention, monitoring, and lessening of pesticide contamination. The system is outlined as follows:

1) Monitor water sources
2) Establish a database on pesticide use patterns and practices
3) Coordinate an action plan
4) Assess the possibility of a sale and distribution reporting system for pesticides and other organic contaminants
5) Determine the possibility of a usage record system
6) Coordinate a contingency plan that addresses the possibility of unforeseen events
7) Evaluate the possibility of developing criteria to assess health risk
8) Coordinate and distribute public information

CLEANING UP WATER

Groundwater wells had to be monitored quarterly for contaminants like EDB and DBCP. Over time, the presence of EDB, DBCP, and other chemicals were found in more groundwater wells, which subsequently led to their closures. Some groundwater wells have been temporarily closed because the contaminants found in them had reached the maximum allowable levels. Water from many production wells have been remediated, or fixed, by costly carbon treatment plants. Before this water can be drunk, the water in the well is “cleaned” by a process called “adsorption,” in which molecules attach to the surfaces of solid bodies. This treatment system is similar to water

filters used in some aquariums. In treating contaminated water, the water is pumped through granular activated carbon (GAC) filters, which attracts some chemicals such as DBCP and EDB much the way magnets attract and hold metal filings. Once the filters are covered with the chemicals, they are replaced. These filters were installed at Kunia and Mililani in 1986.

Since 1998, Del Monte has been pumping the contaminated water and using it to water the introduced plant, koa haole. The koa haole in turn breaks down the DBCP from the soil. Any water that is not absorbed by the koa haole is put back into the treatment system. This process of using plants to clean the contaminated water is referred to as phytoremediation. Phytoremediation is only a part of Del Monte's solution to cleaning up the site.

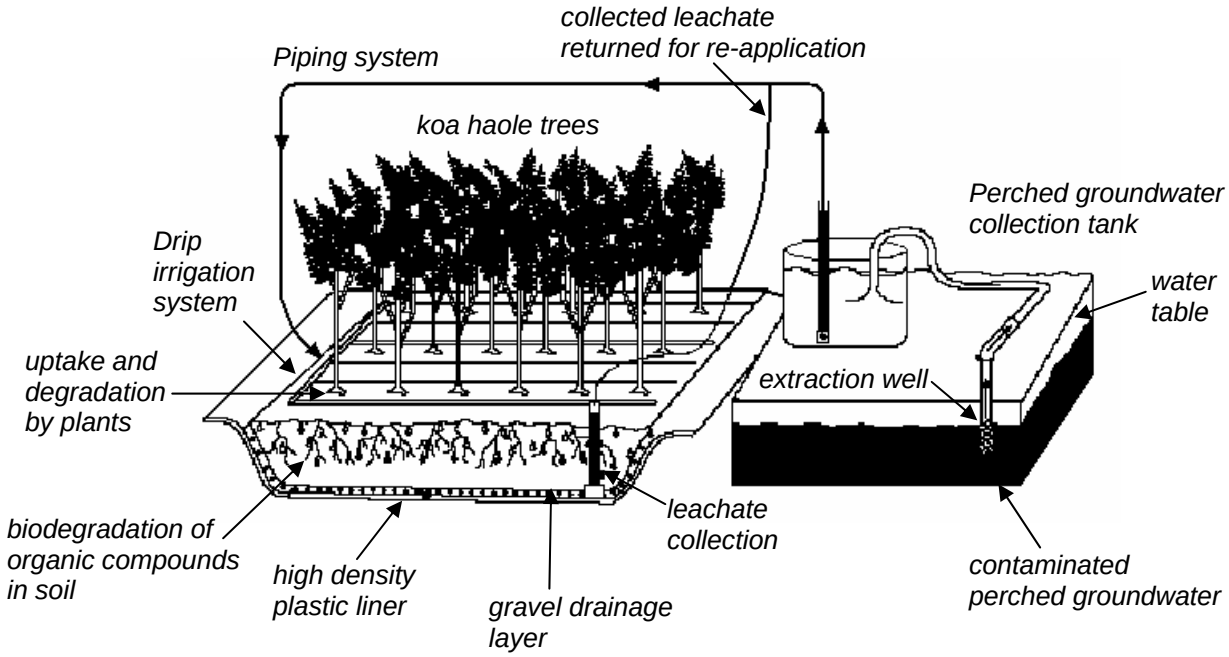


Diagram of Del Monte's phytoremediation system. From EPA Proposes Final Remedy for Site, Del Monte corporation Oahu Plantation Superfund Site, March 2003.

Superfund is a federal program designed to clean up our country's environments of hazardous wastes. The EPA identifies a superfund site as one that has been contaminated by hazardous waste and is in need of cleanup because it poses a serious risk to human health and/or the environment. The EPA identified the Kunia spill site as a Superfund site.

OTHER CHEMICALS IN GROUNDWATER

The herbicides atrazine and diuron were also found in groundwater. Atrazine and diuron are used for controlling broadleaf and grassy weeds in sugar cane and pineapple fields. Herbicides destroy plants or inhibit their growth. Diuron and atrazine work against plants by inhibiting photosynthesis, the process that plants use to make food (carbohydrates: sugar and starches). Atrazine was found in wells downgradient (direction of water flow due to gravity) from sugarcane fields.

Other chemicals that were found in some of Hawai'i's groundwater are chlordane, DDT, dieldrin and lindane. Chlordane and dieldrin were used for termite control. DDT, or dichlorophenyltri-

chloroethane, is a pesticide that was used widely to control crop-eating insects and disease-carrying insects, such as insects that carry malaria. Lindane is used on livestock, Christmas trees, lumber, flea collars, and household sprays. It's also used to treat scabies and lice. In 1998, the EPA banned chlordane. DDT was banned in America in 1972, but it is still used in some countries. The EPA banned dieldrin in 1974 except for use in termite control. Lindane is banned in California, but is still widely used across the country.

The chemical nitrate can be found in groundwater and surface water. It occurs naturally in water and plants but is also found in synthetic (manmade) fertilizers. Other sources of nitrates are human sewage and livestock manure. Nitrates are very soluble and can easily travel to groundwater since they do not bind to soil. Nitrates do not evaporate and will remain in water until plants or other organisms use them. Actions by humans are usually the cause of high amounts of nitrates in soil. In recent times, there has been an increase in the amount of nitrates in our groundwater supply, especially the Pearl Harbor aquifer, O'ahu's most important source of drinking water. High levels of nitrates can negatively affect people's health, especially infants.

LANDFILLS AND GAS STATIONS

Urban activities affect our groundwater supplies. For example, urban planners need to be careful where to allow development. What would happen to groundwater quality if a landfill were developed over an aquifer? People dispose of all sorts of trash in landfills. Some of that trash contains harmful chemicals. For instance, since computer technology is always improving, more people are dumping their old computers with their regular trash and then buying newer models. Computer monitors alone contain about 4 to 6 lbs of lead! When rainwater passes through a landfill, it can carry contaminants from the waste material to our groundwater supply. This contaminated rainwater is referred to as a leachate. Landfills can be constructed over aquifers as long as they are lined with clay or synthetic liners and have leachate collection systems. They help prevent leachate from reaching our groundwater. Even after landfills are closed, they still need to be cared for and monitored. For instance, groundwater monitoring is necessary to detect any possible leaks of wastes into our groundwater supplies.

In Hawai'i, there is much debate as to whether to allow municipal landfills to be built over aquifers. On O'ahu, the City and County of Honolulu is trying to find a location for a new landfill because the existing one has reached its capacity. Several possible locations were chosen and the public and other government agencies have met all with opposition. Part of the opposition has to do with the new landfill being built over an aquifer and the potential of this landfill to contaminate the groundwater. Hawai'i does not have a lot of land and much of it sits over our water supplies and watersheds. Kunia was designated as a possible location for O'ahu's new landfill but there was much opposition because of Kunia's importance as a sole source aquifer. A sole source aquifer provides at least 50 percent of the drinking water consumed in an area overlying the aquifer. In choosing a new location, it would be preferable to build a landfill away from our water supplies, such as along the edge of our islands. Unfortunately, that's where people live and for aesthetic and health reasons, people do not want a landfill in their backyard! Many people also oppose landfills near the ocean where we swim and surf.

Gas stations can also release hazardous substances into the environment. The gasoline is stored in underground storage tanks. What would happen if there were a leak in the tank? The hazardous chemicals in gasoline and diesel fuels have been known to contaminate groundwater. Fortunately, current state and federal regulations require the cleanup of contaminated gas stations, as well as the installation of leak detection systems on new underground storage tanks.

E MĀLAMA I KA WAI

Through the continuing efforts of many agencies to monitor the purity of Hawai‘i’s groundwater, our water supply generally meets state and federal drinking water standards, and as long as it does, it is safe to drink. We must all do our part to keep our groundwater clean and safe.

Testing Permeability Student Activity

Use this worksheet to conduct your own experiment on the permeability of sand, gravel and soil. If necessary, use another sheet.

Problem:
Hypothesis:
Materials:
Steps:
Notes:
Conclusion:

Use this worksheet to graph the permeability of sand, gravel, and soil. Label your graph accordingly.