Water Treatment in the Classroom

Adapted from: "Taking the Swamp Out of Swampwater" in Earth: The Water Planet. The National Science Teachers Association, 1992.most

Grade Level: all

Duration: dependent on whether students make their own filters, 25 minutes to 1 hour

Setting: classroom or laboratory

Summary: Students will construct their own water filters and then use them to purify dirty water.

Objectives: Students will learn the basic processes used in water filtration and gain an understanding of how municipal water treatment facilities operate.

Vocabulary: surface water, groundwater, aeration, coagulation, floc, flocculation, sedimentation, filtration, chlorination

Related Module Resources:

Materials (Included in Module):

- water filters (large & small gravel, coarse & fine grain sand) in 1 L plastic drink bottles [B-2]
- empty 1 L plastic bottles [B-2]
- plastic cups [B-2]
- alum [B-2]
- small kitchen strainers [B-2]
- pieces of mesh screen / rubber bands [B-2]
- plastic spoons [B-2]
- bag of gravel [BUCKET]
- bag of coarse sand [BUCKET]
- bag of fine sand [BUCKET]
- Water Filtration Posters [B-2]

Additional Materials (NOT Included in Module):

- additional 1L plastic soft drink bottles w/ caps
- additional gravel and sand
- "swampwater"
- watch

ACADEMIC STANDARDS:

7th Grade

4.8.B Explain how people use natural resources.

- explain how natural resources and technological changes have affected the development of civilizations.

10th Grade

4.2.B Evaluate factors affecting availability of natural resources.

- describe natural occurrences that may affect the natural resources.
- analyze technologies that affect the use of our natural resources.

BACKGROUND:

You wouldn't drink lake or swamp water that was full of sticks, dirt, bacteria and other impurities that made it look and smell awful. But, in fact, this is how our drinking water looks before it is treated by municipal water treatment facilities. This is why municipal treatment plants are important. But how do water treatment facilities take dirty surface water and turn it into the clean water that comes into our homes?

First, we must clarify that these processes are relative to surface water treatment for municipal sources. This differs from municipalities who obtain their water from groundwater sources and private homeowner wells. The processes that we will discuss are used to treat only surface water. **Surface water** is the water that is found in rivers, streams, lakes, ponds, swamps, etc. In Pennsylvania 63% of households obtain their water from surface water sources. **Groundwater** is water that is found below the surface of the earth in the water table. Private wells are also supplied by the water table. Groundwater accounts for the other 37% of homes in Pennsylvania. (Nationally, 47% surface water to 53% groundwater.)

Municipal water treatments take in surface water from sources that offer a constant water supply throughout the year (large creeks, rivers, lakes, or man-made reservoirs). First they must strain the water to keep out large obstructions like logs, fish, plants, and leaves. **Aeration** is the next process used by some plants to rid water of trapped gases. The water is vigorously mixed to allow these gases to escape. The water is then treated in a flash mixer. Chemicals such as chlorine, fluorine, lime and alum are added to the water. These chemicals do a variety of things including kill harmful bacteria and trigger coagulation.

Coagulation is caused by alum, potassium aluminum sulfate, which helps settle out small particles that are suspended in the water. Alum causes the fine particles to clump together or coagulate and form floc. **Floc** is the name for these groups of particles.

During **flocculation** the large floc particles quickly sink to the bottom of the treatment tank and the remaining floc is still easier to filter out of the water than the uncoagulated particles would have been.

The next process is **sedimentation** where the water remains undisturbed. This allows remaining particles to settle to the bottom of the water tank. The longer the water is allowed to sit the longer the opportunity for sediment to form. Then, the clean water atop the sediment is drained out of the tank leaving the unwanted sediment behind. The collected sediment is usually disposed of in a landfill.

Filtration is the last attempt at removing any unwanted particles from the water. The water is filtered through a variety of substances that can range from rocks to sand to charcoal. Hopefully all the remaining particles will cling to the substrate and cleaner water will move on to the next process.

The last treatment step is **chlorination**. In this step chlorine is added again to kill off any remaining bacteria. After chlorination the water has completed the treatment process. It is stored in clear wells and storage tanks before it reaches your home.

Remember that not everyone’s water is treated in this manner. Groundwater requires less treatment than surface water. The Meadville Area Water Authority simply takes in groundwater, adds chlorine, and stores the water for public usage. Private wells also receive little to no treatment at all.

OVERVIEW: Students will make their own water filters and use them to filter dirty water by mimicking several processes used the municipal water treatment of surface water.

PROCEDURE:

Teacher Preparation: You will need to make some dirty water that will be filtered clean. To do this, add soil (especially clay and silt), rocks, leaves, sticks, and other things you might find in dirty stream water.

1. Cut a plastic soft drink bottle about 2/3 of the way from the top of the bottle. Cover the top with mesh screen and firmly secure with elastic. Then place the uncapped bottle top-down inside its bottom.

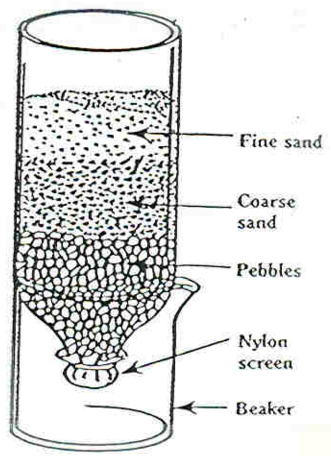
2. Pour roughly 1" of large gravel into the bottle, followed by 1" of small gravel, being careful not to mix them together too much. Then add 1.5" of coarse sand and finally 1.5" of fine grain sand, continuing to avoid mixing the components.

3. To flush the filter clean carefully pour an excess amount of clean tap water into the top, begin careful not to disturb the sand on top. It is best that the filter be held above a drain to allow the water to drain out.

4. Once most of the water has drained out the filter is ready to purify dirty water. (Pre-made water containing soil, silt, clay, rocks, leaves, sticks, and other particles.)

5. Fill a cup with dirty water. Into an empty cup, pour the dirty water through a strainer to keep large particles from passing. Observe the way the water looks and smells then take a spoon and stir and mix the water for at least 30 seconds like a blender. Pour the water into another cup, and then back and forth between the two a few times.

6. Next, add 1/2 tablespoon of alum. Stir the water for at least two minutes to dissolve the alum. Then allow the water to sit undisturbed for at least five minutes, preferably ten. The longer the water sits, the clearer the water will be at the end of the process.



7. After a large amount of sediment has settled to the bottom of the cup, carefully pour the top 2/3 of water into the sand/gravel filter. Make sure to be extra careful not to disturb the sediment at the bottom of the cup or mix up the sand in the top of the filter. Take your time!

8. After most of the water has filtered through the bottle, and collected in the cup below, observe the differences between the filtered water and the original water.

DISCUSSION:
Examine the filtered water of each student. Whose water looks the best? What could be some contributing factors to the differences in “clean” water?

Although this water is not crystal clear, stress the difference this simple activity has made in the quality of the water. Compare the original dirty water to the filtered water. Which would you rather drink? Imagine how much of a difference a real water authority facility makes.

Outline the similarities and differences between your filtration process and the actual method of water authorities. What steps in the municipal treatment process did you simulate? Which did you not simulate?

Have students complete the interactive Filtration Process Posters, on which they have to label the various steps of the filtration process.

Discuss why this water is still unsafe to drink. What could still be in this water? Discuss any further processes that would further purify the water.

EVALUATION:

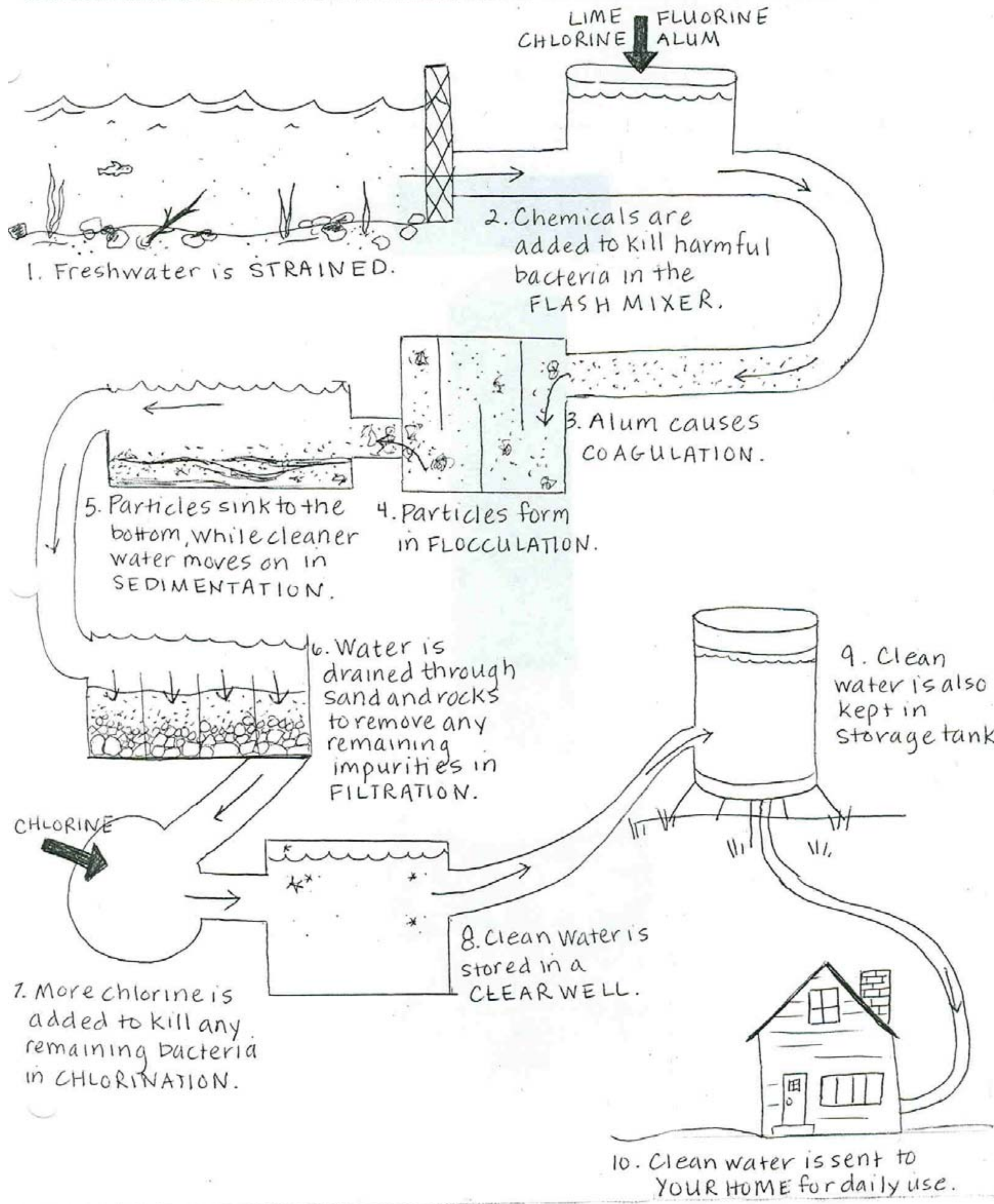
- What are the main processes of water filtration?
- How does the procedure you used compare to municipal water filtration in your area?

EXTENSIONS AND MODIFICATIONS:

- Visit your local municipal water authority for an informative tour.
- Use the interactive water filtration posters to test the students' knowledge before or after the experiment, or have students draw their own poster of the process.

NOTES (PLEASE WRITE ANY SUGGESTIONS YOU HAVE FOR TEACHERS USING THIS ACTIVITY IN THE FUTURE):

Water Filtration



Drinking Water Facts

Methods of Filtration

Before it is ever delivered to your house, drinking water goes through extensive filtration to remove any unwanted sediment, bacteria, protozoa, and harmful chemicals. Surface water is filtered as follows.

Surface Water Filtration

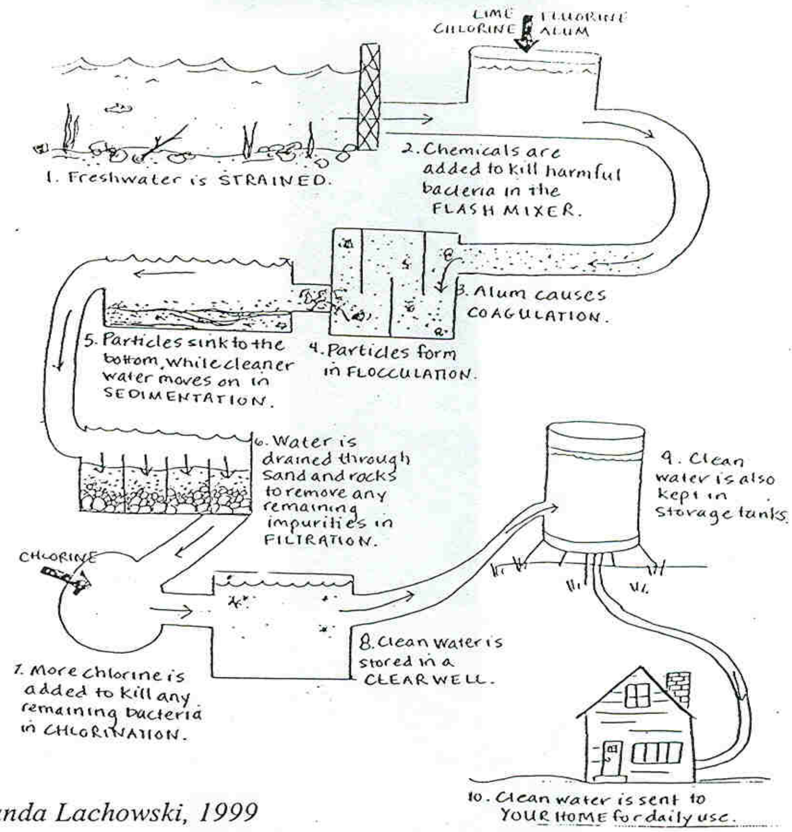
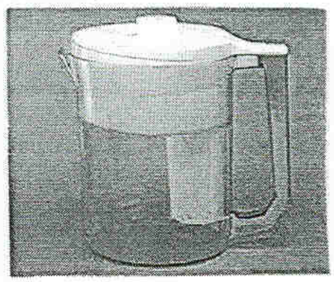


Illustration by Amanda Lachowski, 1999

In most municipal ground water systems, the water is only chlorinated. It never goes through all of the steps used for surface water. This is because groundwater has far less organic and particulate matter in it. Natural filtration through the ground makes the water safer to drink. Though only chlorination is actually implemented, constant testing ensures that no dangerous pollutants will enter the water unnoticed. If harmful organisms are found, as with surface water, the local authority may make a boil water order to remove them. With chemical pollutants, often the only solution is bottled water.

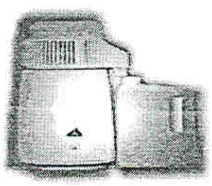
Still, some aspects of water quality are not strictly controlled by legislation. Most of these things involve aesthetic qualities of the water that do not affect health or nutritive value. For this reason, many people choose to filter their own water. Water filters exist in all forms and sizes, from Brita's filter in a sports bottle, to multi-thousand dollar hospital reverse osmosis systems.

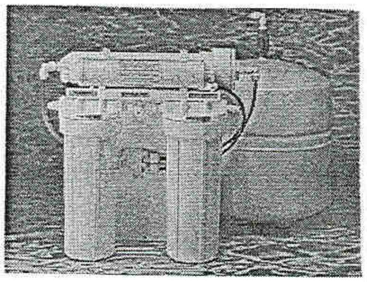
The most common types of home filtration system use activated carbon. Examples of commercial models include Brita, Pur, and Ametek. Water is forced through the carbon (either in a granulated or solid block form). Most particulate matter and pathogens such as cryptosporidium are blocked by the small size of the pores in the carbon. Also, because it is ionized ("activated") it removes some heavy metals and other ionized materials. (*)



Ion exchange systems (Water Softeners) are designed to reduce water hardness. The ionized calcium and magnesium which make water hard are exchanged with sodium or potassium. Ion exchangers perform no function other than softening water. They remove no other contaminants.

Distillation based systems heat the water to a boil, and then recondense it leaving behind contaminants. However, it is very expensive, and does not remove contaminants such as hormone disrupters. (**)





Reverse osmosis is generally considered to be one of the best filtration methods, especially in combination with activated carbon. In this method, water is forced through a semipermeable membrane at extremely high pressure leaving behind contaminants. This process cannot remove hormone disrupters, and pesticides. This method is often used in hospitals. (#)

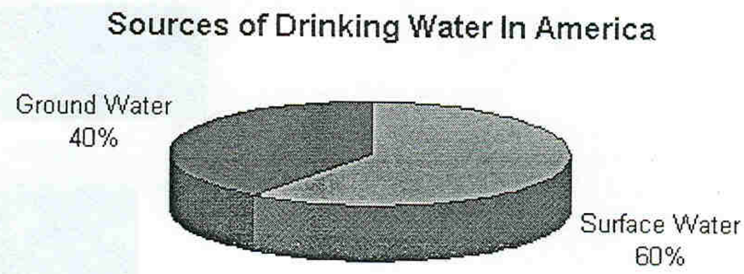
Ultraviolet treatment bombards the water with ultraviolet radiation. This kills most pathogens except cryptosporidium. Nonbiological contaminants are unaffected (hormone disrupters, asbestos, mercury, lead). (##)

** - Image from the Brita homepage. (http:://www.brita.com)*
*** - Image from Pure-Pro Water Distillers (http://www.pure-pro.com/distiller.htm)*
 # -Image from the Pure Water Company (http://www.goodwaterco.com/rounits.htm)
-Image from Safe Water Technologies (http://www.swtwater.com/)

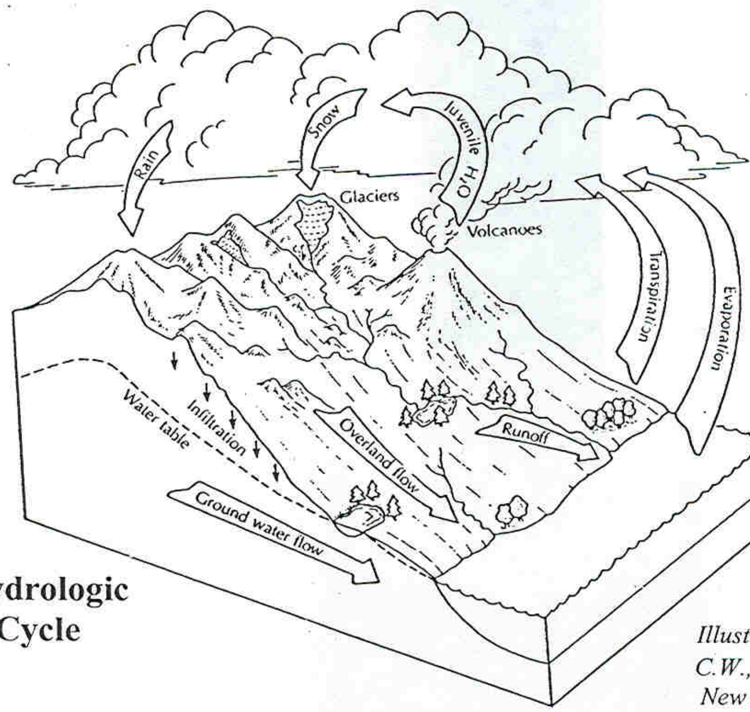
Drinking Water Facts

Sources of Drinking Water

Drinking water may be obtained from surface water, ground water, ice caps and glaciers, ocean water, and rain water. However, only the first two are used in this country. The other three are much more expensive (approximately 15 times) and are only used when other sources are either too contaminated or simply unavailable.



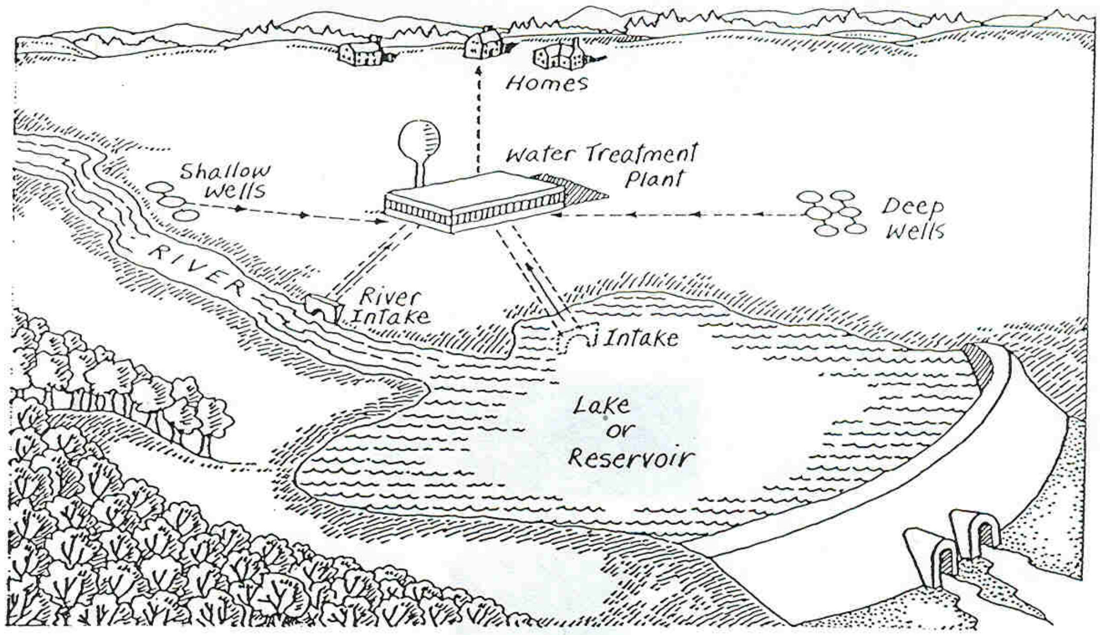
All of these sources are maintained by the hydrologic cycle (water cycle). Precipitation regulates the ground and surface water. Like surface water, groundwater eventually makes its way to a larger body of water (like the ocean) where it becomes surface water.



Hydrologic Cycle

Illustration courtesy of Fetter, C.W., 1994. Applied Hydrogeology: New Jersey: Prentice Hall.

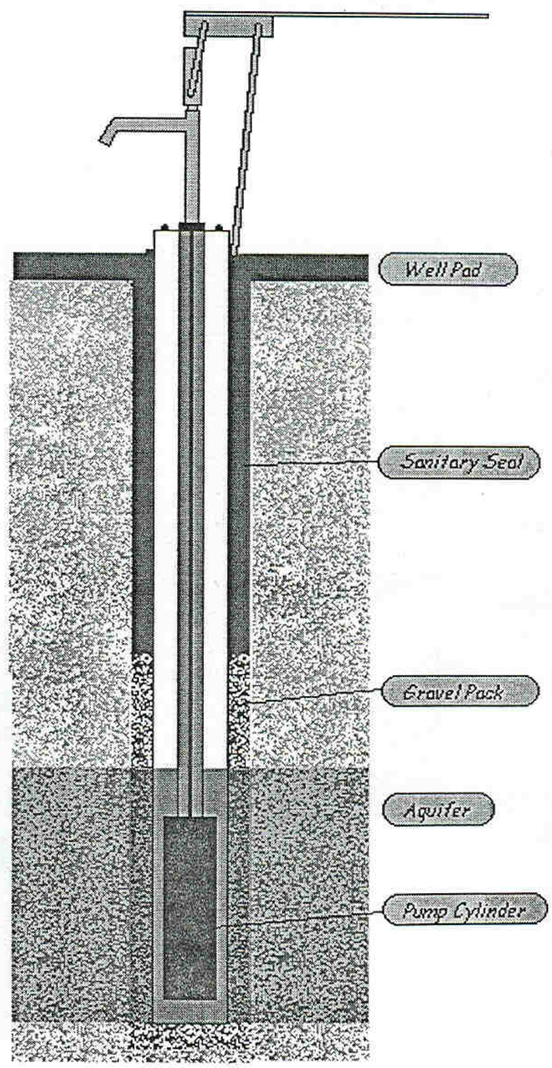
The French Creek Watershed (seen on the following page) is a natural water system of northwestern Pennsylvania and part of western New York. Various tributaries contribute to French Creek, which itself empties into the Allegheny River.

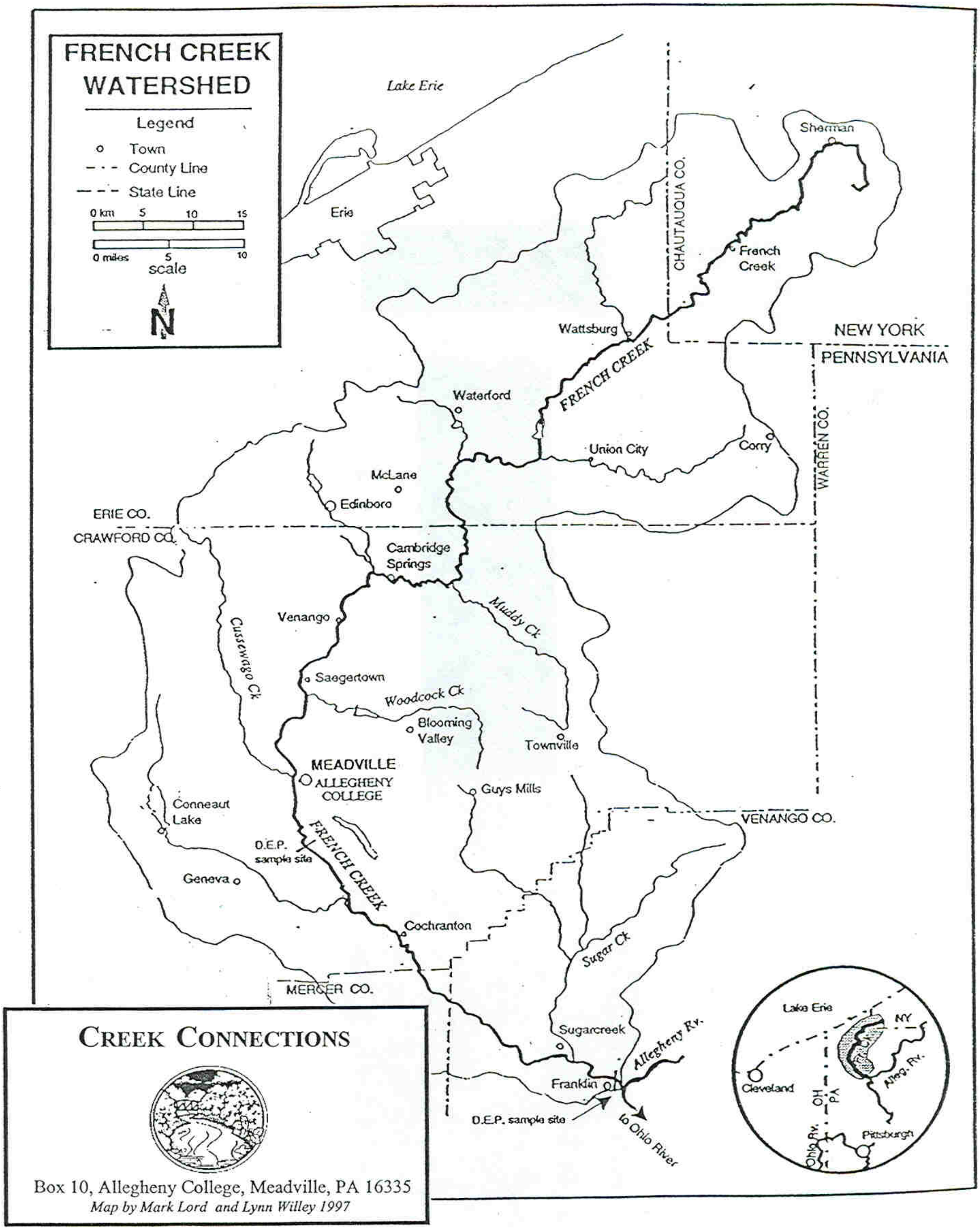


Surface water is drawn from lakes, rivers, springs and reservoirs through submerged intakes. Reservoirs help ensure that plenty of water is available even during times of drought. After treatment, surface water is pumped into homes.

Groundwater is pumped up through wells from areas of underground saturation known as aquifers. Many rural households have small private wells, but groundwater is also taken from larger municipal wells to supply small towns and cities.

This illustration shows a typical groundwater well. The well casing enters into the ground to retrieve the water and seal the well. The well casing is only permeable near the bottom, at the depth of the aquifer. This is to prevent unnecessary pollutants from entering the water. The permeable gravel pack helps filter the water that enters the well at the bottom.




FRENCH CREEK
WATERSHED
Legend
Town
County Line
State Line
0 km 5 10 15
0 miles 5 10
scale
N
Lake Erie
Erie
Sherman
CHAUTAUQUA CO.
French Creek
Wattsburg
NEW YORK
PENNSYLVANIA
FRENCH CREEK
Waterford
Union City
Corry
WARREN CO.
McLane
Edinboro
ERIE CO.
CRAWFORD CO.
Cambridge Springs
Muddy Ck
Venango
Cussewago Ck
Saegertown
Woodcock Ck
Blooming Valley
Townville
MEADVILLE
ALLEGHENY COLLEGE
Guys Mills
Conneaut Lake
VENANGO CO.
D.E.P. sample site
FRENCH CREEK
Geneva
Cochranton
Sugar Ck
MERCER CO.
Sugarcreek
Allegheny Rv.
Franklin
D.E.P. sample site
to Ohio River
Lake Erie
NY
Alleg. Rv.
Cleveland
OH
PA
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Map by Mark Lord and Lynn Willey 1997