Water Quality Module
Kaizen: Continuous Improvement

Unit Length: 6 – 7 class periods
Lesson One:

Introduction: What are the EPA and its functions?

Background: The Environmental Protection Agency was created by Richard Nixon in 1970. Prior to that time, states and communities had developed separate environmental protection laws. The confusion and ineffectiveness amongst the many different forms of government led to a national response in the form of the creation of the EPA.

Website Sources:

- www.epa.gov
- http://www.epa.gov/watertrain/cwa/
- http://www.epa.gov/safewater/publicoutreach/pdfs/poster_landscape_11x17version.pdf
- http://www.epa.gov/adopt/
- http://cfpub.epa.gov/surf/locate/index.cfm
- http://www.epa.gov/owow/monitoring/volunteer/

Subject Area: Practical Living, Science, Social Studies

Kentucky Connection:

- Learner Goals: #1, #2, #4, #5, #6

- Academic Expectations**:** 1.1, 1.2, 1.5-1.9, 1.10, 1.16, 2.1, 2.3, 2.6, 2.8, 2.13, 2.20, 2.33, 4.2, 5.1, 5.5, 6.1, 6.3

- Core Content: AH-HS-1.4.2, RD-10-2.0.2, RD-10-2.0.7, SC-HS-4.6.1, SC-HS-4.7.2, WR-HS-1.1.0, WR-HS-3.6.0

Materials:

- Computer with internet access to each pair of students
- Or one computer with internet access and presenter
- Maps of Kentucky or Scott County
- Copies of charts
- Copies of poster

Length of Lesson: One class period

Vocabulary Words:

- Watershed - the area that drains to a common waterway, such as a stream, lake, estuary, wetland, aquifer, or even the ocean

- Impaired- a source of water that has been polluted or contaminated
- Organic waste – waste material which comes mainly from animal or plant sources
- Deforestation – deforestation is the long-term removal of trees from an area because of changes in land use

Essential Question: Why was the EPA created?

Guiding Questions/Outcomes:

- Students will be able to explain the history and role of the EPA.
- Students will be able to explain the need/s that led to the creation of the Clean Water Act.
- Students name and describe the three areas of concern as addressed by the Clean Water Act.
- Students locate how many EPA regulated facilities are in their community.
- Students determine the location of polluted waters in their community.
- Students describe the many factors that contribute to the pollution of their source of drinking water.

Skills Used:

- Research
- Observation
- Grouping

Activity:

- Students form pairs or small groups and go to the internet site http://www.epa.gov/watertrain/cwa/ . After reading the introduction, they should answer the following questions:

    - When was the clean water act passed?
    - When was the clean water act passed?
    - Why was the Clean Water Act created?
    - Name and describe the three areas of concern as addressed by the clean water act.

- Students then use provided maps and charts to determine the following:
    - How many EPA regulated facilities are there in my community?
    - Are there polluted rivers, streams, lakes, or ponds in my community? Name one impaired water near your home.
    - What are the major contaminants in Kentucky's rivers and streams?
    - Where do these contaminants come from?

- Students are given a copy of the Safe Drinking Water Act poster found at http://www.epa.gov/safewater/publicoutreach/pdfs/poster_landscape_11x17version.pdf. A teacher and/or group leaders lead a discussion in the many facets that must be considered in protecting our public health as it relates to clean water.

Assessment:

- Students prepare and deliver a short debate speech either supporting the EPA or suggesting it be dismantled. (Those against the EPA should provide alternative solutions.)

Extensions:

- Students develop a brochure to gain support from peers and begin an “Adopt a Watershed” volunteer program.

Kentucky Assessed Waters
Overall Water Quality Attainment for Rivers and Streams

Attainment Status	Miles
Good	4,902.40
Threatened	197.95
Impaired	4,671.22
Total Miles Assessed	9,771.57

Kentucky Top Causes of Impairments for Rivers and Streams

#	State Cause Name	Total Miles Impaired
1	MERCURY	37.00
2	PATHOGENS	34.55
3	SILTATION (SILTS)	28.60
4	IMPAIRMENT UNKNOWN	24.20
5	POLYCHLORINATED BIPHENYLS	6.50
6	HABITAT ALTERATIONS	5.70
7	EXOTIC SPECIES	5.00
8	SALINITY/TDS/CHLORIDES	2.80
9	ORGANIC ENRICHMENT (SEWAGE) BIOLOGICAL INDICATORS	1.90

Safe Drinking Water Act - Protecting America's Public Health
Deforestation / Soil Erosion
Local, State and National Public Health Protection Programs
Protected Watershed
Municipal Wastewater Treatment Plant
Concentrated Animal Feeding Operation
Landfill
Mining
Livestock Waste Lagoon
Pesticide / Fertilizer Application
Crop Dusting
Construction / Urban Sprawl
Fertilizer / Manure Spreading
Septic System
Local Land Use Decisions
Protected Wetlands
Water Table
Deep Injection Well
Industrial Releases To Air & Water
Saturated Zone
Industrial Wastewater Discharge
Spills
Shallow On-site System
Drinking Water Storage Tower
Future Source Of Drinking Water
Confining Layer
Private Drinking Water Well
Ground Water Treatment Plant
Ground Water Flow
Abandoned Well
Light Industry
Infrastructure Repair, Roads & Parking Lot Runoff
Source Water Protection Area
Gas Station / Underground Storage Tank
Fresh Water Aquifer
Vehicle Service Station
Sediment
Surface Water Treatment Plant
Boat Marina Debris
Drinking Water Intake
Storm Drain
MULTIPLE RISKS REQUIRE MULTIPLE BARRIERS
Safe drinking water is essential to the health of American citizens and the economic health of our communities. However, drinking water is vulnerable to contamination from many potential threats. There are programs and activities that when operated effectively form a protective web of multiple barriers to ensure the safety of our drinking water. The success of these barriers relies on the involvement and vigilance of local, state and federal officials, the private sector, public interest groups and individual citizens.
This poster identifies examples of
1. Surface and groundwater sources of drinking water (in blue),
2. Potential threats to those drinking water sources (in red), and
3. The multiple barriers that together protect our nation's public health (in green).
Safe Drinking Water Hotline – (800) 426-4791 Safewater Web Site – www.epa.gov/safewater
EPA

Lesson Two:

Introduction: Our Community's Water Sources

Background: This lesson introduces the significance and importance of Royal Spring to the city of Georgetown, Kentucky while investigating groundwater, karst areas, water quality, and carbonate aquifers. The main water source for Georgetown and Scott County is the largest Karst spring in Kentucky named Royal Spring. Royal Spring was a major factor in the founding of Georgetown and has been used as the main water source for over 200 years dating back to 1775. The spring discharges approximately 14 billion gallons of water each year. Other sources include the Elkhorn Creek, the Kentucky River and the Ohio River.

Website Sources:
- http://en.wikipedia.org/wiki/Georgetown,_Kentucky#History
- http://www.georgetownky.com/attrac.html
- http://www.rkci.org/library/kgs_kentucky_is_karst_country_ic04_12.pdf
- http://kygeonet.ky.gov/kyhydro/viewer.htm (zoom on Scott County)
- http://www.gmwss.com/
- http://nationalatlas.gov/natlas/Natlasstart.asp Click on water, then aquifers. Zoom into central Kentucky.
- http://waterdata.usgs.gov/nwis
- http://www.uky.edu/KGS/water/research/gw_quality.htm

Subject Area: Practical Living, Science, Social Studies

Kentucky Connection:
- Learner Goals: #1, #2, #4, #6
- Academic Expectations: AE1.1, AE1.10, AE1.11, AE2.3, AE2.6; AE2.19; AE5.3; AE6.1
- Core Content: PL-HS 2.33, SC-HS 2.19, SS-HS 4.11, SC-HS 1.1.8, SC-HS 4.7.1, SC-HS 4.7.2, SC-HS 4.7.5

Materials:

Copies of maps from website
Overhead presentor for use with computer
Two beakers
Hydrochloric or Muriatic acid
Small piece of limestone
Small piece of non-carbonate rock

Length of Lesson: Two Class Periods

Vocabulary Words:
- Karst: a landscape with sinkholes, sinking streams, caves, and springs.

- Watershed: an area of land that drains into a body of water.

- Carbonate rocks: sedimentary rocks composed mainly of calcium carbonate.

- Cave: a natural opening in rock large enough to be entered by man and extending to points where daylight does not penetrate.

- Dissolution (also called chemical solution): the process of chemical weathering of bedrock in which the combination of water and acid slowly removes mineral compounds from solid bedrock and carries them away in liquid solution.

- Sinkholes: a closed surface draining underground in karst landscapes. Sinkholes are often “bowl-shaped” and can be a few to many hundreds of meters in diameter.

Essential Question: Where does our water come from and how safe is it for consumption?

Guiding Questions/Outcomes:

- Students will be able to name the water sources used in Scott County.
- Students will be able to name Royal Spring as the main water source for Scott County and recognize it as the largest Karst spring in Kentucky.
- Students will define, locate and explain the significance of Karst areas.
- Students will use maps to compare the water quality of Georgetown with that of the rest of Kentucky.
- Students will explain how the limestone found in Kentucky acts as an aquifer or filter for groundwater.
- Students will recognize the essential role that groundwater plays in providing adequate water to our community and how rainfall amounts greatly contribute to that supply.

Skills Used:

- Research
- Observation
- Grouping
- Measuring
- Comparing

Activity:

- Provide basic information (location, how long it has been used as a water source, output capacity) about the Georgetown Municipal Water and Sewer found above or at http://www.gmwss.com/ Discuss the rarity of a spring being a main water source for a community.

- Define karst and the prevalence of karst areas in Kentucky. Go to http://kygeonet.ky.gov/kyhydro/viewer.htm and zoom several times on Scott County. Also, go to http://www.rkci.org/library/kgs_kentucky_is_karst_country_ic04_12.pdf pages 8 and 20. Locate and discuss karst area/s that flow into Royal Spring.

- Discuss how agricultural, community, and business chemicals/contaminants/pollution can travel through the karst area/s into the spring.
    - Go to: http://www.uky.edu/KGS/water/research/gw_quality.htm
    - Print the report and maps from each of the seven quality maps: Mercury, Cadmium, Selenium, Arsenic, pH, Nitrate-nitrogen, and Fluoride

    - Assign groups of students to each map. After time to research, students report to the class their findings on the substance, why it is important, and how our area compares to other areas in Kentucky.

- Commercial water softeners are very useful to Georgetown water customers. Have students arrive at their own reasoning as to the validity of the previous statement. Discuss and demonstrate the differences of several types of common rock with one being limestone (the most prevalent bedrock in Kentucky). The water in Kentucky is mostly filtered by carbonate aquifers. You can view a map of aquifers at http://nationalatlas.gov/natlas/Natlasstart.asp. The following experiment will demonstrate why the limestone in our area contributes to the "hardness" of our water.
    - Materials:
      2 beakers
      20% solution of hydrochloric acid (also known as muriatic acid)
      A sample of limestone
      A sample of non-carbonate rock
    - Procedure:
      Partially fill two beakers with the acid.
      Weigh and measure each rock.
      Place them in separate beakers and watch what happens. The limestone will fizz and the non-carbonate rock will not react.
      Check the beakers every 10 minutes. (The dissolving action will stop if either the acid or the calcite is no longer available to react. If this happens, either add more acid or break the limestone to expose more calcite.) In about one hour the limestone sample will be noticeably smaller.
      After drying, the samples can be weighed and measured again to determine the changes.
- Once students have determined that limestone is a major factor of the "hardness" in our water, have them name and discuss the negative and positive effects of "hard" water. (Examples: effects on cleaning capability, water pipes, facets, ice-makers, and the nutrition aspects.)

Assessment: Assessment is given in the form of student involvement in class discussion, group research, and observation.

Open Response:
Considering all our class has discussed, name and describe the source, quality, and availability of your water. Explain the significance of that source to the history and quality of life in Georgetown, Kentucky.

Scoring Rubric:

Score:	Conditions:
Novice	Names and locates the source of water. Explains that Royal Spring has served as a main water source since the founding of Georgetown.
Apprentice	Names and locates the source of water. Explains how groundwater moves into and forms the Royal Spring. Explains that the Royal Spring played a large role in the development of Georgetown by providing a reliable water source.
Proficient	Names and locates the source of water. Explains how groundwater moves into and forms the Royal Spring. Demonstrates an understanding of karst areas. Compares the quality of water with the rest of Kentucky **or** explains the process of limestone as an aquifer. Explains that the Royal Spring played a large role in the development of Georgetown by providing a reliable water source.
Distinguished	Names and locates the source of water. Explains how groundwater moves into and forms the Royal Spring. Demonstrates an understanding of karst areas. Compares the quality of water with the rest of Kentucky **and** explains the process of limestone as an aquifer. Explains that the Royal Spring played a large role in the development of Georgetown by providing a reliable water source.

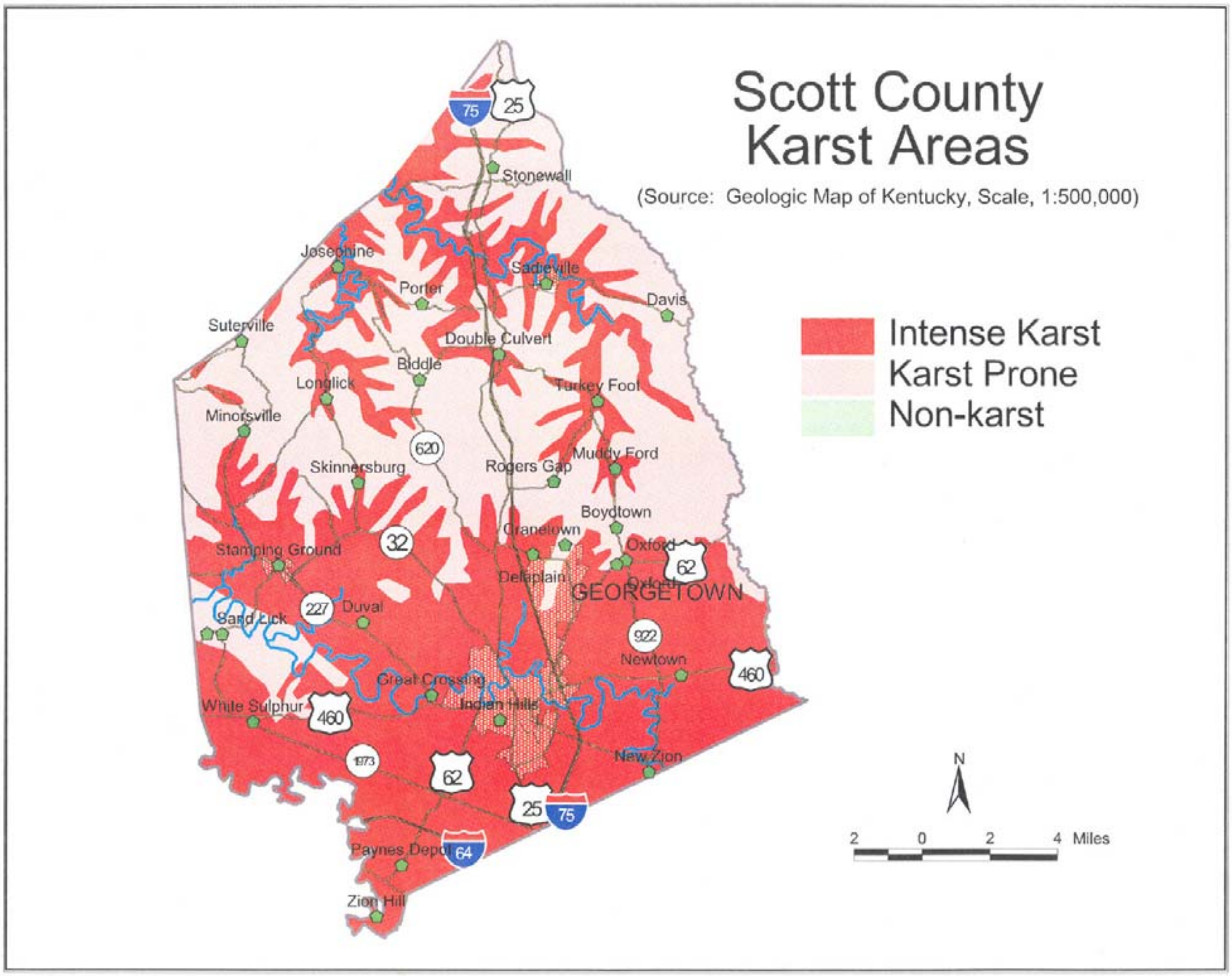
Extensions:

- Research the founding of Georgetown, Kentucky and Rev. Elijah Craig. Then visit the Royal Spring Park, information following.
- Kentucky bourbon whiskey was first produced in Georgetown Kentucky. Royal Spring, still visible today at Royal Spring Park on West Main Street, provided the water for Baptist minister Rev. Elijah Craig's new mixture in 1789. It is Kentucky's largest spring-based public water system, serving some 7,000 customers. Also at the park is an authentic 1874 log cabin built by former slave Milton Leach. It is a mini-museum for local history. Call 502-863-6201

- Invite Georgetown drama professor George McGhee to visit class and perform his portrayal of Elijah Craig.

- Research proposals that are being considered for alternate and additional water supply; i.e. Kentucky American and Louisville Water Company. Discuss the pros and cons of the proposed pipeline from the Ohio River.

- Research dates of drought in Georgetown. Compare those date using data on water levels from www.usgs.gov/water .



Scott County
Karst Areas
(Source: Geologic Map of Kentucky, Scale, 1:500,000)
Intense Karst
Karst Prone
Non-karst
Stonewall
Josephine
Sadieville
Porter
Davis
Suterville
Double Culvert
Biddle
Longlick
Turkey Foot
Minorsville
Muddy Ford
Skinnersburg
Rogers Gap
Boydtown
Cranetown
Stamping Ground
Oxford
Delaplain
GEORGETOWN
Sand Lick
Duval
Newtown
Great Crossing
White Sulphur
Indian Hills
New Zion
Paynes Depot
Zion Hill
75
25
620
32
62
227
922
460
1973
64
N
2 0 2 4 Miles

Lesson Three:

Introduction: "Splish, Splash, Every Drop Counts"
Activity adapted from Kentucky Wonderful Commonwealth water unit
http://keec.ky.gov/WonderfulCommwealthHS.pdf

Background: Water is a scarce natural resource. Water pollution is an issue of continuing concern as we look to the future for our sources of drinking water. The average American uses 100 gallons (approximately 400 liters) of water each day. Sources of pollution range from naturally occurring pollutants from animals to pollutants caused directly by human development.

Website Sources:

- http://peacecore.gov/wws/educators/enrichment/africa/about/index.html
- http://www.popact.org/why_pop/water/water-table8.htm
- http://ga.water.usgs.gov/edu

Subject Area: Science, Mathematics, Social Studies

Kentucky Connection:

- Learner Goals: #2, #4
- Academic Expectations: 2.1, 2.3, 2.6, 2.8, 2.16, 2.19
- Core Content: SC-HS-4.7.1; SC-HS-4.7.2; SC-HS-4.7.3; SC-HS-4.7.5; MA-HS-4.1.2; SS-HS-4.4.2; SS-HS-4.4.3

Materials:

- Student handout: daily water usage log
- Script "Who dirties the water? Not me, dude."
- Large jar or aquarium with clean water
- Large spoon/stirring utensil
- Film canisters labeled on the outside with the underlined word below, containing the substance/pollutant listed below.

Beaver: wood chips
Runoff: charcoal
Shellfish: crushed shell
Settlers: organic garbage
Farmers: potting soil
Straight pipes: toilet paper
Sunbathers 1: suntan lotion
Sunbathers 2: newspaper
Sunbathers 3: plastic pieces
Laundromats: dish detergent
River: sand
Wetlands: dry grass
Aquarians: shells
Carpenters: nails
Fishermen: nylon line
Boaters: Styrofoam
Homeowners: fertilizer
Factories: molasses
People: baking soda
Patients: artificial sweetener tablets

Length of Lesson: One class period.

Vocabulary Words:

<u>Pollutant</u>—a liquid, gas, dust, or solid material that causes contamination of air, water, earth and living organisms.

Essential Question: How do my daily actions impact our water supply?

Guiding Questions/Outcomes:

- Students will be able to analyze their personal daily water usage and analyze their results
- Students will be able to describe how water has become polluted

Skills Used:

- Data collection
- Graphing
- Analysis
- Group collaboration
- Observation

Activity:

- Previous Instruction:
    - At the close of class the day before this lesson, introduce today's lesson and distribute the student handout (daily water usage log) for students to complete for homework.
- Ask students how much water they think the average student uses each day (the average American uses 100 gallons/400 liters per day). Transition students into analysis of their water usage logs.
- Students will get into groups of 4 to compute their group's average water consumption. Each group will prepare a bar graph of their consumption to be presented to the class.
- "Who Dirties The Water? Not me, Dude." *Adapted from Kentucky Wonderful Commonwealth water unit,* <u>http://keec.ky.gov/WonderfulCommonwealthHS.pdf</u>
    - 20 students will receive a film canister containing a foreign substance (see materials list) to begin the activity.
    - As the teacher reads the "Who Dirties the Water? Not me, dude" script, students who have canisters will come up to the front of the room as the word on the outside of their canister is read and pour in their substance when the script calls for it. The teacher will pause in the reading while the student adds his/her substance and the student will tell the class who they are and what they think their substance is.
    - A designated student will stir in the substances as they are poured in (and occasionally show the students the spoon as the water becomes murky).
    - As each substance is added, students will complete their data table (Student Data Sheet 1).
    - When the script has been read completely, students will respond to 3 final questions:
        - Who dirtied the water?
        - Who is responsible for cleaning it?
        - Why do you think it is important to keep our water supply pollutant-free?

Assessment:

- Students will complete a daily water usage log and make individual conclusions/analysis of their data
- Students will complete a bar graph of their water consumption in groups
- Students will individually complete a data sheet and concluding questions accompanying "Who Dirties the water? Not me, Dude."

Extensions:

- Have students complete a week-long water pollution log. At the end of the week, combine student data in the form of a bar graph to see the impact one class can have on water quality.
- Have students keep a water log for one week and compare their findings to their one day log. How did their usage vary? Then, students should research water usage in Africa and compare to their own usage. Students should be encouraged to try to limit their water usage for one day to simulate the life of those who have a more limited access to clean water. They will then write a reflection on their experience. Access to the power point and Africa diaries extension can be found at http://its.guilford.k12.nc.us/act/grade7/act7/asp?ID=660

PERSONAL DAILY WATER USAGE LOG

Keep track of the amount of water you and your household use in one day. You will probably be surprised how much water you use! The average person living in sub-Saharan Africa uses 10-20 liters of water per day. How do you compare??

ACTION	# TIMES in 1 DAY	AVERAGE WATER USAGE (in liters)	TOTAL
FLUSHING THE TOILET		X 20 L	
WASHING YOUR HANDS		X 8-20 L per minute (tap running)	
WASHING YOUR FACE		X 8-20 L per minute (tap running)	
SHOWERING & BATHING		X 100 L	
BRUSHING YOUR TEETH		X 20 L per minute (tap running)	
SHAVING		X 8-20 L per minute (tap running)	
COOKING		X 20 L	
HAND WASHING DISHES		X 35 L	
DISHWASHER		X 40 L	
GARBAGE DISPOSAL		X 20 L	
CLEANING THE HOUSE		X 32 L	
WASHING THE CAR		X 400 L	
WATERING THE LAWN/PLANTS		X 35 L per minute	
WASHING CLOTHES		X 80 L (low setting) X 120 L (high setting)	
DRINKING WATER (tap water, tea, coffee)		X 1 L	
TOTAL			

Conclusion:

Using your data, how can you conserve water?

- Think about small daily changes you can make in your household to decrease your personal water use and misuse. Write at least 5 changes you can make and how you think they can impact the "water footprint" you leave behind.

WHO DIRTIES THE WATER?
Student Data Table

WHO IS ADDING?	WHAT IS ADDED?

WHO DIRTIES THE WATER?
NOT ME, DUDE.
Script

The Story:
Once upon a time there was a beautiful piece of land. It was almost an island, since it was connected to the mainland by a narrow land bridge and surrounded on three sides by a lake. The lake was filled with clear water and was dotted with a few small green islands (*Point to the jar*). Fish and other aquatic life thrived in the water. The land was covered with trees and the lake teemed with wildlife.

Chorus: ***recited by entire class***
Would you want to swim in this lake?
Would you eat fish caught in this water?
Would you like to go boating in this lake?

Animal life flourished along a nearby river and the **BEAVER** were plentiful. A **RIVER** ran along one side of the land, carrying sediment with it as it flowed into the lake.

WETLANDS bordered the edges of the lake. Grasses from the wetlands sometimes washed into the lake and became food for the fish.

In the shallow water, clams and other **SHELLFISH** thrived.

A small group of people lived on this land, which they called Aquarian. The people were called the **AQUARIANS.** The Aquarians fished for food and shellfish in the lake. They dumped some of their garbage near the lake. We still find the piles of shells they left.

Chorus: ***recited by entire class***
Would you want to swim in this lake?
Would you eat fish caught in this water?
Would you like to go boating in this lake?

After many years, **SETTLERS** from Europe came to live in the area. The settlers built a town much larger than the Aquarian villages. Some of the town's garbage was dumped into the lake. **CARPENTERS** built houses, farms, and stores that filled the Aquarian valley.

As the town grew, the settlers filled the wetlands to provide more land on which to build. **FARMERS** cut down trees to clear their fields. Without trees and wetlands to hold the soil, rain carried soil into the lake.

Chorus: ***recited by entire class***
Would you want to swim in this lake?
Would you eat fish caught in this water?
Would you like to go boating in this lake?

More and more houses and shops were built, and the town of Aquarian grew into a city. Sewer pipes were constructed to remove the waste from houses and bathrooms. Some houses sent their sewage into the rivers and lake without going into the sewage system. These were called **STRAIGHT PIPES**.

Since the wetlands had been filled in, **RUNOFF** water washed pollution from the streets directly into the lake.

FISHERMEN found that nets made of plastic were stronger than those made of rope. Sometimes these nets got lost in the water.

Fishermen and **BOATERS** sometimes threw their rubbish overboard.

Chorus: *recited by entire class*
Would you want to swim in this lake?
Would you eat fish caught in this water?
Would you like to go boating in this lake?

The city built **LAUNDROMATS** where people could wash their clothes. The detergents went down the pipes with the sewage into the lake.

People cleaned their houses. The **PEOPLE** used poisonous tile and drain cleaners, which flowed into the sewage system.

Even swimmers and **SUNBATHERS** going to enjoy the lake sometimes left garbage on its beaches.

As the city grew, **HOMEOWNERS** fertilized their lawns. The excess fertilizer poured into the lake.

Some of the **FACTORIES** built along the water's edge dumped their toxic wastes and chemicals into the water.

PATIENTS took medicines and tiny amounts of the medicines showed up in the water.

Chorus: *recited by entire class*
Would you want to swim in this lake?
Would you eat fish caught in this water?
Would you like to go boating in this lake?

Who dirties the water? WE ALL DO.
Who is responsible for cleaning it up? WE ALL ARE.

Daily Water Usage in Lesotho, Africa

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by **Peter Yurich**, Ha Khayensti, Lesotho
There isn't much water available because we had a very dry winter and no rain this spring. I usually try to use only one to one and a half liters of water a day. This includes bathing, cooking, and cleaning dishes. Once a week I wash clothes, but try to use as little water as possible.
My day starts by boiling two liters of water. I use less than one liter to bath, drink two cups of coffee and save the rest for cooking and cleaning dishes. If the tap is working I may indulge myself by using a little more for bathing.
My host family uses a little more than I do because there are more people in the family. They use a wheelbarrow to carry two 10-liter buckets of water. Right now they use more water because they are making dung smear for the floor and walls of a new building. The building was constructed from rock and held together with a mud mixture that dried and became hard.

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by **Cynthia Holahan**, Ha Nkoka, Thaba-Tseka District, Lesotho
On average, I fill a twenty-liter bucket of water every two to three days for daily use. This varies, of course, according to how often I bathe and wash my hair (Sorry Mom!). In the evenings I boil about two liters for the next day's drinking. I began boiling after a long bout of giardiasis, and infection of the small intenstine. At first I found it tedious and "un-Peace Corps-like" to boil, but having a routine of boiling to get rid of giardia is actually not a problem at all. I bathe indoors using a basin. It's truly amazing how little water is actually required to bathe! I use roughly three liters to bathe and three to wash my hair. During the dry season, when the river is nothing more than a series of stagnant puddles, I also use tap water to wash my clothes, as do others in the village. The Basotho are very particular about washing themselves, their clothes, bedding and dishes on a daily basis so their dependence on the village water system, particularly during the dry season is great.
I don't even know how I can compare my use of water in Peace Corps to that in the United States. My life here depends on the availability of water, rain, and the weather in general as it never did growing up in a big city. I am so completely conscious now of how every drop is used, of how to use water more efficiently, and of the fact that I never known when or if water will not be available.

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by **Becki Krieg**, Qacha’s Nek, Lesotho
My water comes from various sources, and sometimes the water from these different sources gets mixed together. So to be safe, I boil all water I use for drinking, especially my favorite drink, Kool Aid sent from the States!
There is no running water at my house. I store water in two large buckets inside my house. I need to scoop the water out of the buckets to use for cooking, cleaning or bathing. But Lesotho can be very cold. It even snows in the wintertime. So I certainly don't want to pour that cold water over myself for bathing. That means taking the extra time to heat some water before taking a bath. A bath means a few inches of water in a bucket. I certainly can't cover my whole body in hot water. Winter baths are cold!
Because water is so difficult to get, I have learned to conserve and recycle water. I usually have only 60 liters of water for an entire week for all my needs. I can recycle water when washing clothes. The water used to rinse one load of laundry is used to wash the next load (all washed by

hand of course). I have also learned how to get clean by bathing in a bucket with only four liters of water. That's only two 2-liter Coke bottles of water for an entire bath!

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by **JeanMarie Mitchell**, Ha Tebelo, Lesotho

My day begins with a knock at my door at dawn from a neighbor. She knocks to tell me to come to the well and fetch my water. Each night A'Me comes and takes my bucket to ensure I am the first to receive water.

I have never valued something as much as I value water now. Honestly, I never thought twice about the water I used or how much or where it came from. Now, only receiving 5 liters a day, I save every drop I can! I recycle dirty water for use in my garden and my family also uses rainwater catchments. People here wait all day to get water and travel long distances to fetch it. The Rural Water Supply (government water works) has been promising for over a year now that it will come to my village and deep-drill a borehole, but they still have not arrived. Will they ever? I only hope.

http://its.guilford.k12.nc.us/act/grade7/gr7_files/holcombe_africa/diary.doc

Water in Africa

This spring box is in the Village Chief's compound. People share the water from this tap with the chickens and other animals.

by Peter Yurich
Ha Ntlale, Lesotho (1999)

Half a rubber tire was used to make a water hole for the chickens. Ducks also play and drink in water holes like these.

by MaryAnn Camp
Ha Rantuba, Lesotho (1999)

Ma Maroesi, age 57, is washing clothes. The women and children begin very early in the morning getting water for bathing and cooking. Most of the time it is carried on the heads of the women, while the children bring wheelbarrows to carry the 20 liter plastic jugs.

by MaryAnn Camp
Ha Rantuba, Lesotho (1999)

These women walked down a mountain to get water from a stream, and now, with the water in the buckets on their heads, they have to go back up to get to their homes!
by JeanMarie Mitchell
Ha Tebelo, Lesotho (1999)

Students at Pope John XXIII School on Christ the King Mission walk the half-kilometer home every day with their books and their water for the next day. Students are always excited to see the camera, but many have run away. They don't like photos that show their struggling.
by Claire Hilger
Christ the King Mission Qacha's Nek, Lesotho (1999)

Moohko, age 6, is getting a bath. Her mother is wearing the typical Basotho dress with Kabo and straw hat.

by MaryAnn Camp
Ha Rantuba, Lesotho (1999)

The children of Ha Sekhohola Primary School gather around the ‘citibeng' or bore hole to fetch water between classes.

by Cynthia Holahan
Ha Nkokana, Thaba-Tseka District, Lesotho (1999)

A young girl scoops one liter of water at a time to fill a bucket. This will be all the water her family has for the day. Many buckets are lined up as their owners wait their turns to draw water and fill them.

by Becki Krieg
Lesotho (1999)

Lesson Four:

Introduction: Water: The Necessary Nutrient

Background: (Activity adapted from http://keec.ky.gov/WonderfulCommonwealthHS.pdf) Students will learn the properties of water. They will learn the types of water contaminants and standards for pollutants. They will also learn how to clean up the water.

Subject Area: Math, Science, Practical Living

Kentucky Connection:

- Learner Goals: #2, #3, #6
- Academic Expectations: 2.1, 3.4, 6.1, 6.3
- Core Content: SC-H-3.5.1, SC-H-3.5.5, PL-H-3.3.2, PL-H-3.3.3

Materials:

Day 1

Determining pH:

- pH paper (1-14)
- lemon juice
- white vinegar
- all purpose cleaner (example: 409)
- liquid detergent
- carbonated soft drink
- ammonia cleaner
- water

Salinity:

- salt
- funnel
- two bottles (need to hold 3 cups of water)
- food coloring

Temperature Lab:

- 1 flat pan
- 1 funnel
- 1 plastic spoon
- 2 ice cubes
- food coloring
- cold water
- measuring cups
- hot tap water

Buoyancy:
- 1 pan
- 2 pieces of clay
- 1 paper towel

Day 2
- Access to computers, telephone and library materials for research
- List of local resource people to contact about local water
- Local watershed maps (at least 4 to be shared by groups of students)
- Bucket containing 5 liters of “swamp water” (or add 2 ½ cups of dirt or mud to 5 liters of water)
- Three 2-liter plastic soda bottles, two with the cap and one without
- One 1.5 liter (or larger) beaker or another soft drink bottle bottom
- 2 tablespoons alum (potassium aluminum sulfate), found at a pharmacy
- Fine sand (about 800 milliliters in volume)
- Coarse sand (about 400 milliliters in volume)
- Small pebbles (about 400 milliliters in volume)
- Larger beaker or jar (500 milliliters or larger)
- Small piece of flexible nylon screen (approximately 5 cm X 5 cm)
- One tablespoon
- One rubber band
- One stopwatch

Length of Lesson:
Two class periods

Vocabulary Words:
- <u>Clean Water Act –</u> the Federal Water Pollution Control Act of 1972, Public Law 92-500, is a law passed by the United States Congress in 1972 that creates guidelines for states to follow concerning water quality.
- <u>EPA Standards</u> – national standards for a variety of environmental programs that have been researched and set by the Environmental Protection Agency (EPA), which was established by the United States Congress in 1970 in an effort to control pollution of air, land and water.
- <u>Wastewater treatment plant</u> - a large facility that treats wastewater from homes and industry to a point where it can be safely discharge into the environment.
- <u>Watershed</u> – region draining in to a river, river system, or body of water
- <u>Water treatment Plant</u> – a facility that cleans and purifies water pumped from wells, river, and streams prior to distributing the water to customers.

Essential Question:
What are some properties of water? How can I tell if my water is clean?

Guiding Questions/Outcomes:

- Students will be able to list some properties of water.
- Students will be able to identify where we get our drinking water.
- Students describe what happens to drinking water before it gets to our homes.
- Students will define water shed.

Skills Used:

- Observation
- Speculation
- Research
- Investigation
- Organization
- Discussion
- Comparison
- Communication

Activity:

Day One: Properties of Water

pH Lab :

- Label the seven containers with the appropriate materials listed in the materials list.
- Test the pH of the solutions by briefly dipping the pH paper in the solution and immediately checking the color against the pH scale. pH paper changes to different colors depending on the pH of the solution being tested. What type of liquid is each?
- Fill out the data table

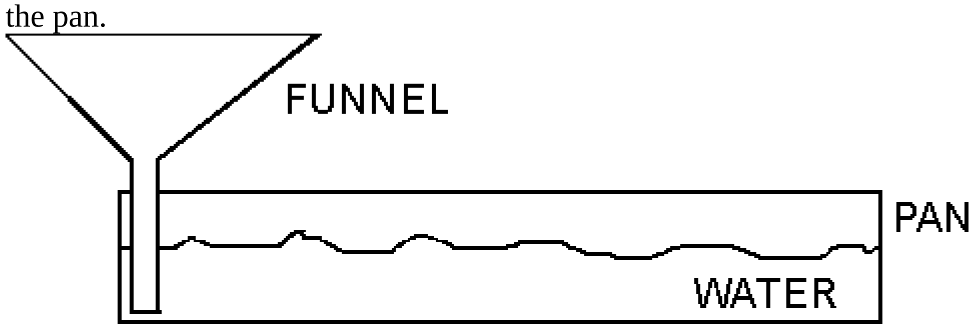
Solution	pH
#1	
#2	
#3	
#4	
#5	
#6	
#7	

- Ask the following questions:
  - What are the pH values of the acids?
  - Which items were acids?
  - What are the pH values of the bases?
  - Which items were bases?
  - Which items are used for cleaning, acids or bases?
  - Which items are used in foods, acids or bases?
  - Why is the pH of water neutral?

Salinity Lab:

- Put one cup of water in each container.
- Add ½ teaspoon of salt and 2-3 drops of food color to one of the containers and mix.
- Add 1/3 cup of salt to another container.
- Put the funnel all the way to the bottom of the first container and slowly pour 1/3 cup of fresh water into the funnel. What happens?
- Put the funnel all the way to the bottom of the second container and slowly pour 1/3 cup of fresh water into the funnel. What happens?
- Ask the following questions:
    - Salinity is a measure of how much salt is dissolved in water: the saltier the water, the greater its salinity. How do you think salinity affects the weight of water?
    - Explain what happened in containers 1 and 2.
    - Design you own experiment to test if water gets heavier as it gets saltier. Write your procedure and then try it.

Temperature Lab:

- Have students formulate a hypothesis for the following:
  What happens if you dump a pan of blue-colored water into a pan of red-colored water? They will mix and make purple-colored water. What if the blue water is cold and the red water is hot? What might happen if, instead of dumping the two together, you gently and slowly pour them together?
- Follow this procedure:
    - Fill the pan halfway with hot tap water. Let the water settle down and be careful not to bump the pan or the desk.
    - Put 1/3 cup of cold water, 6 drops of blue food color, and the ice cubes in the largest cup. Stir for a few minutes so the water gets very cold.
    - Put the funnel in one corner of the pan so the tip of the funnel touches the bottom of the pan.
    - 

    - Slowly drip the cold water into the funnel and have students describe what happens.
    - After the water has reached a steady state (nothing appears to be changing), describe the contents of the pan using words and/or a sketch.
    - Ask students: Could temperature changes affect currents in rivers and ponds?

Buoyancy Lab:

- Background information: Buoyancy is the ability of an object to float in a liquid, such as water. This concept helps to explain why some things float while other objects sink. If an object weighs more than the weight of the water it displaces, it will sink. If the object weighs less, it will float. This helps explain why a heavy ship can easily float in the water, while a much smaller and lighter brick will sink quickly. It isn't the size or shape of an object that primarily determines buoyancy, but the relation between the weight of an object compared to the weight of the water the object displaces.

- Ask students to formulate a hypothesis to the question, “What will happen if you drop a chunk of clay in water?”
- Procedure:
  - Fill the pan ¾ of the way with tap water.
  - Have each team member use one piece of clay.
  - Squish the clay into a ball and drop it into the water.
  - Students describe what happened.
  - Take the clay out of the water and dry if off (dry if off to keep it from getting too gooey). Students continue forming the clay into different shapes to see if they can find a way to make it float.
  - Ask students: “What was important about the shape for the clay to float?”

Day Two: Tapping Into Our Local Water System

- Begin this activity by asking students where water originates. Depending on student responses, if necessary, review the hydrological cycle and the amount of water found on earth.
- Show students a Kentucky watershed map. Explain that watersheds are areas of land which drain into a stream, river, lake, or another body of water. Explain that within a single watershed, all of the precipitation drains to a given point in the same body of water, and that the elevation of the land determines the area of the watershed, with the highest ground forming the boundaries. Tell students that they are part of the largest watershed in the United States – the Mississippi River watershed – but that they are also located in much smaller watersheds that would include the closest ditch that water drains into after a large rain.
- Pass out the watershed maps and have students move into smaller groups so they can locate their school on the map. Have students name the closest stream to their school. Next, ask students to follow the small stream to the next largest stream. Continue this until they arrive at a large lake, or the largest river on the watershed map.
- Explain to students that there are water quality guidelines that set the standards for local water companies to follow. Explain that these standards were developed by the Environmental Protection Agency and state agencies to keep our water safe for human consumption.
- Pour about 1.5 liters of “swamp water” into a 2-liter bottle. Have students describe the appearance and smell of the water. Tell students that, as a class, they will simulate what the local water companies must do to filter impurities out of the water and disinfect it so it is safe for us to drink when it reaches our homes.
- **AERATION:**
  Place the cap on the bottle of “swamp water” and shake the water vigorously for 30 seconds. Continue the aeration process by pouring the water into either one of the cutoff bottles, then pouring the water back and forth between the cutoff bottles 10 times. Ask students to describe any changes they observe. Pour the aerated water into a bottle with its top cut off. Explain that this process allows gases trapped in the water to escape and adds oxygen to the water.
- **COAGULATION:**

Add approximately 2 tablespoons of alum (aluminum potassium sulfate) to the water. Slowly stir the mixture for 6 minutes. Explain that particles suspended in the water will clump together with the alum to produce floc.

- **SEDIMENTATION**
  Allow the water to stand undisturbed in the bottle. Have students observe the water at 5-minute intervals for a total of 20 minutes and write their observations with respect to changes in the water's appearance. The floc should settle to the bottom.
  - NOTE: This would be a good time for students to begin locating information about the local drinking water supply. The local water company should have an Internet web site or a local telephone number so students might contact someone to find out where local water comes from, where it is stored, and where the local drinking water treatment and wastewater treatment plants can be found.
  - Have students write down the information they have found from their local water company.

- **FILTRATION**
  While the floc is settling, construct a filter from the bottle with its bottom cut off:
  - Attach the nylon screen to the outside neck of the bottle with a rubber band. Turn the bottle upside down and pour a layer of pebbles into the bottle - the screen will prevent the pebbles from falling out of the neck of the bottle.
  - Pour the course sand on top of the pebbles.
  - Pour the fine sand on top of the course sand.
  - Clean the filter by slowly and carefully pouring through 5 liters (or more) of the clean tap water. Try not to disturb the top layer of sand as you pour the water.

After a large amount of the floc has settled, carefully – and 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) "swamp water" into the collection bucket. Compare the treated and untreated water. Ask students whether treatment has changed to appearance and smell of the water.

- **DISINFECTION:**

Inform students that a water treatment plant would, as a final step, disinfect the water (e.g., would add a disinfectant such as chlorine) to kill any remaining disease-causing organisms prior to distributing the water to homes. Therefore, the demonstration water is not safe to drink.

- Ask students the following questions to trigger discussion of what they observed:
  - What was the appearance of the original "swamp water"?
  - Did the aeration process change the appearance or smell of the water? (If the original sample was smelly, the water should have fewer odors. Pouring the water back and forth allowed some of the foul-smelling gases to escape to the air of the room.)

- How did sedimentation change the water's appearance? Did the appearance of the water vary at each 5-minute interval? (The rate of sedimentation depends on the water being used and the size of alum crystals added. Large particles will settle almost as soon as stirring stops. Even if the water contains very fine clay particles, visible clumps of floc should form and begin to settle out by the end of the 20-minute observation period.)
- How does the treated water (following filtration) differ from the untreated "swamp water"? (The treated water should look much clearer and have very little odor.)

- After the experiment has been concluded, have students use a computer and access the site named "The story of drinking water": http://www.drinktap.org/kidsdnn/Portals/5/story_of_water/html/clean.htm At the opening screen click on the box, See a treatment plant in action. Have students draw, label and explain the steps used to obtain clean drinking water.

Assessment:

Day 1:

Completion of lab including data table and questions of #1 Lab – pH
Completion of lab and questions of #2 Lab – Salinity
Completion of lab and questions of #3 Lab – Temperature
Completion of lab and questions of #4 Lab – Buoyancy

Day 2:

Students produce a written explanation detailing information about the local drinking water supply.
Students construct a detailed drawing that shows the steps performed in a water treatment plant. The drawing is labeled and contains a description of each step.

Toyota Connection

- TMMK has an on-site waste water treatment plant for treating industrial wastewater before it is released to the Georgetown Municipal Water and Sewer Service, Wastewater Plant #2. Treatment consists of coagulation with lime to remove the heavy metals followed by sedimentation, and finally filtration.

- TMMK recycles some of the water used in manufacturing processes and some rainwater. The water flows through a self-cleaning Ultra Filtration System and then a Reverse Osmosis System. It can then be recycled and used in the boiler and cooling tower systems. The amount of water recycled would be enough for 400 households with a family of four for an entire year! This process and others like it help TMMK support preservation of the natural resources in the area.

- Wastewater from TMMK is treated by primarily biological treatment, followed by a new system of carbon and resin filtration before a final effluent disinfection with ultra-violet light. The carbon strips the wastewater of organic compounds while the resin focuses on metals removal. This treatment plan has been very effective in treating the wastewater before releasing to Georgetown Municipal Waste and Sewer System and then is discharged to Lane’s Run Stream.

- All chemicals used at TMMK are piped above ground to prevent leaks from contaminating ground water and surface water.

- Storm water run-off from parking lots and rooftops drain into one of four retention ponds for control of flow. The outfall pipe provides a perfect point to sample and test the storm water once a month during a rain event. In the event of a leak or spill to the storm water system, the ponds can provide containment. The water can be treated on the spot or pumped out and treated in the wastewater treatment plant.

Data tables for reproducing

Solution	pH
#1	
#2	
#3	
#4	
#5	
#6	
#7	

Solution	pH
#1	
#2	
#3	
#4	
#5	
#6	
#7	

Solution	pH
#1	
#2	
#3	
#4	
#5	
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#7	

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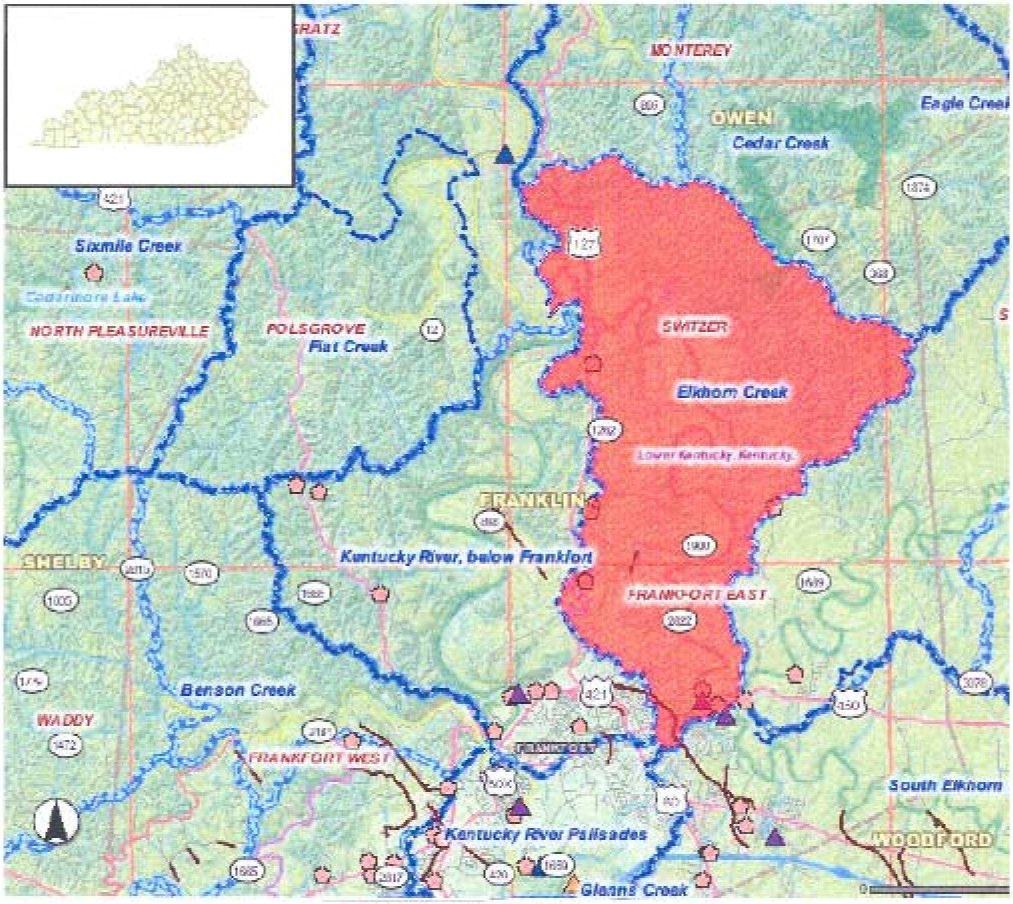
#5	
#6	
#7	



- KPDES Permitted Facilities
- Public Water Source - Groundwater
- Public Water Source - Surfacewater
- Industrial/Commercial Withdrawal

Combined Materials list for Ordering, Gathering, and Shopping

Specialty:
pH paper (1-14)
2 funnels
2 pieces clay
1.5 liter beaker
500 milliliter or larger beaker or jar
2 Tablespoons alum (potassium aluminum sulfate)
Fine sand (800 milliliters in volume)
Coarse sand (400 milliliters in volume)
Small pebbles (400 milliliters in volume)
Small piece of flexible nylon screen

Department or Grocery Store:
Lemon juice
White vinegar
All purpose cleaner
Liquid detergent
Carbonated soft drink
Ammonia cleaner
Salt
Red Food Coloring
Blue Food Coloring

At Home or School:
2 ice cubes
Cold water
Water
Hot Tap Water
Plastic spoon
Measuring cups
2 bottles (hold 3 cups each)
Flat pan
Pan to test buoyancy
Paper towels
Research tools: computer, telephone, library materials
List of local people to contact about local water
Local watershed maps (at least 4)
Bucket with 5 liters of “swamp water”
Three empty 2-liter bottles (2 with caps)
1 Tablespoon
1 rubber band
1 stopwatch
Copies of local watershed maps
Copies of 2 separate handouts