Texas Water Development Board

School Water Audit

www.twdb.texas.gov

WATER IQ

Know your water.[SM]

INTRODUCTION

"For many of us, water simply flows from a faucet and we think little about it beyond it's immediate point of contact."
-Sandra Postel, director and founder of the Global Water Policy Project

"Never doubt that a small group of thoughtful, committed citizens can change the world. Indeed, it's the only thing that ever has."
-Margaret Mead, cultural anthropologist, explorer, writer, teacher

Water is our most precious natural resource. Without water nothing else is possible. This hands-on activity is part of the service learning project *Put Some Blue In Your Green School* that was developed to help schools become efficient water users and raise awareness about the need for good stewardship of water resources within the community. *Put Some Blue In Your Green School* correlates with the Texas Essential Knowledge and Skills, 112.37 Environmental Systems and 112.36 Earth and Space Science.

This activity is designed as a framework. It is expected that the activities will be adapted to serve the specific needs of your school and community partners.

In this project, you will:

- Analyze the indoor and outdoor water use at your school;
- Work with community partners to raise awareness about the need to conserve water; and
- Enact behavioral and structural changes in your school to conserve water.

The goals of this activity are to:

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

This activity includes seven components:

- Complete a preliminary investigation your school;
- Analyze your school's water bills;
- Read and analyze your school's water meter for two weeks;
- Measure indoor water consumption;
- Survey water use habits;
- Evaluate the school's irrigation system; and
- Report your findings and make recommendations.

In order to successfully complete this project, you will research water efficient technologies, determine how much water your school uses in a year, what type of water using fixtures are installed at your school, how many students and staff currently occupy your school, and how much water costs at your school.

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PRELIMINARY INVESTIGATION

Objective

In this investigation, you will explore your school to determine how water is used.

Background

In order to make recommendations on how your school can become water efficient, you must first know what practices your school currently implements and where water is used.

As you walk through your school, think about ways you can enact change whether by creating awareness at school or making recommendations to the community.

Materials

- Interior map of school
- Highlighter
- Writing utensil
- Camera (optional)
- Computer (optional)

Procedures

1. Obtain an interior map of the school (see page 4) from the front office. If you are unable to obtain a map from the front office, draw a detailed map as you walk through the school.

2. With map in hand, walk through the school and highlight the rooms and areas that use water. If you notice leaks during this activity, make a note of the location of the leak on your map and/or take a picture of the leak.

3. Draw a map of the exterior boundaries of your school, making sure to include sports fields and vegetated areas; or use the Internet to obtain a satellite image, see example on page 5. If possible, mark areas where sprinklers are located.

EXAMPLES OF WATER USE AT SCHOOL

<u>ACTIVITIES/CLASSES</u>

Animal husbandry
Art lab
Athletics
Bus washing
Cafeteria
Cooking class
Dance class
Drama
Greenhouse
Shop class
Nurse's office
Photo Lab
Printing lab
Science lab
Teacher's lounge

<u>FIXTURES</u>

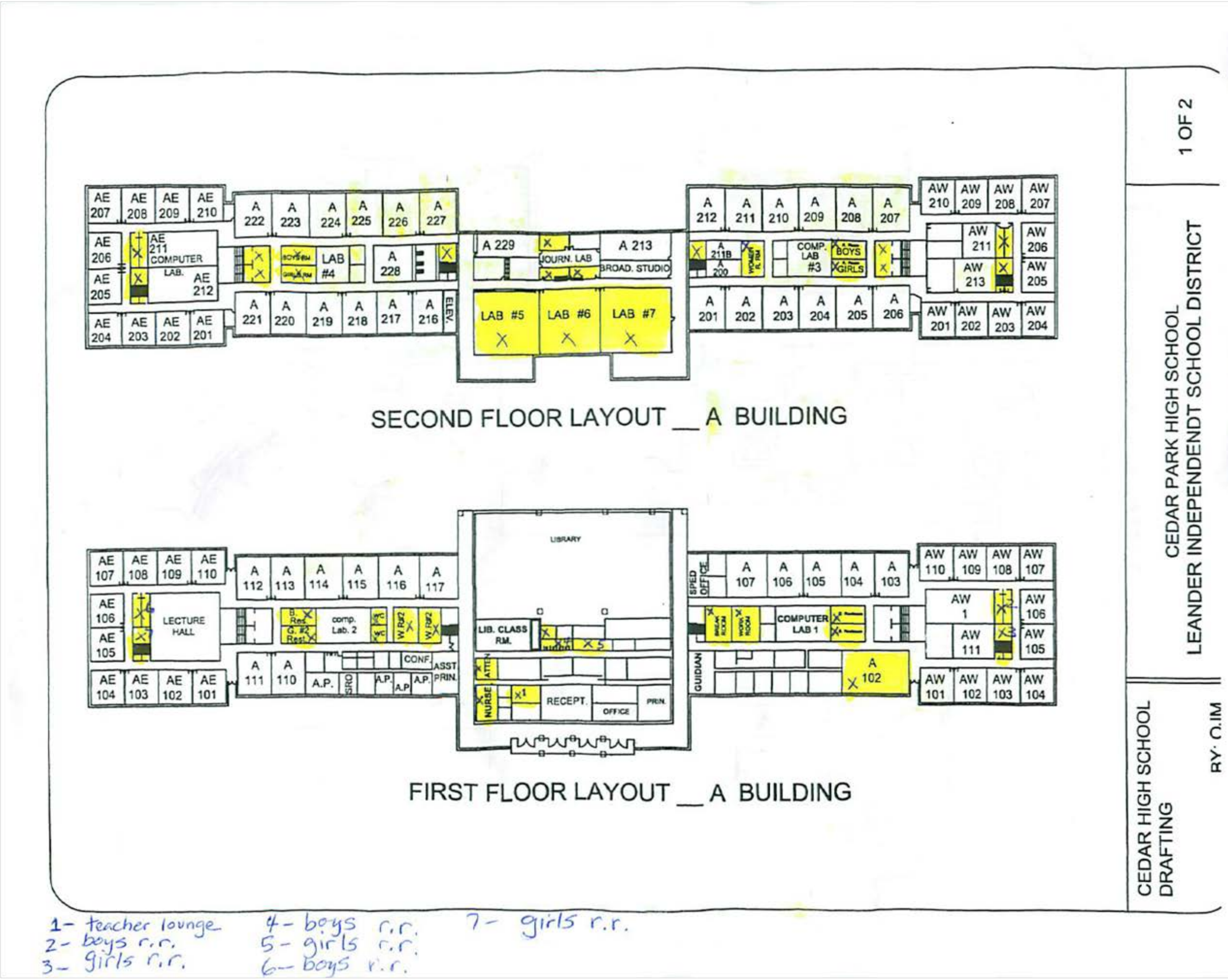
Animal watering trough
Clothes washer
Dishwasher
Food cookers
Garbage disposal
Ice machine
Printing machine
Photo processing
Showers
Steamer
Toilet
Urinal
Whirlpool tub
X-ray equipment

Questions

1. List the fixtures and areas of the school that use water. Were you surprised by what you discovered? Explain.

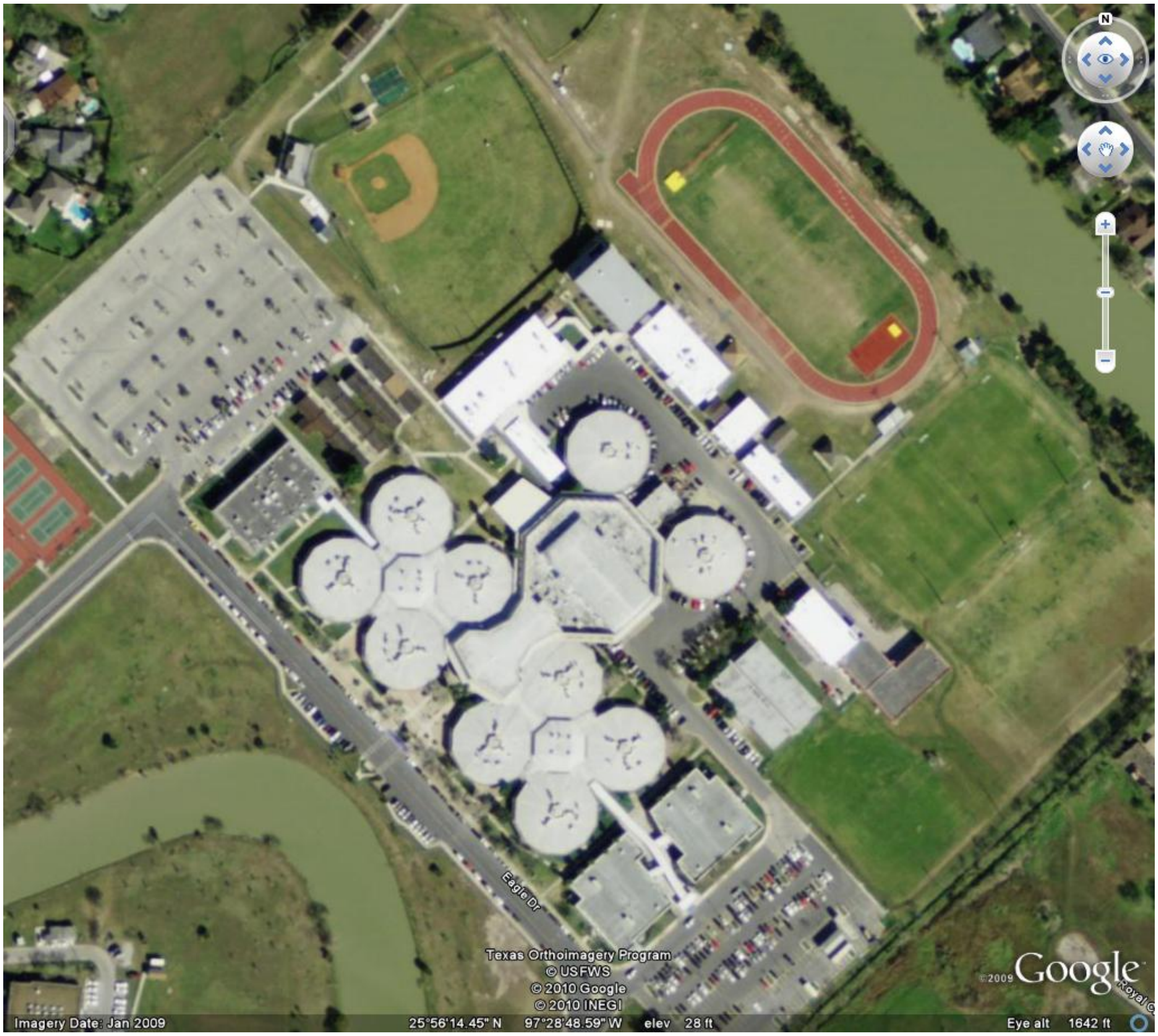
2. What did you learn about your school's water use while performing the preliminary investigation?

EXAMPLE OF SCHOOL INTERIOR MAP



Cedar Park High School, Leander ISD, Cedar Park, Texas

EXAMPLE OF SCHOOL SATELLITE IMAGE



Hanna High School, Brownsville ISD, Brownsville, Texas

ANALYZE WATER BILLS

Objective

In this activity, you will analyze your school's water bills for the previous year.

Background

Schools obtain their water either from a well, in which case a water bill may not be issued, or from a public water supplier that bills the school for its water use.

The public water supplier charges for water in a variety of ways (called a *rate structure*):

- Flat rate – one fee is charged, regardless of water use
- Decreasing block rate – the cost per unit of water decreases as the consumer's water use increases
- Increasing block tier – the cost per unit of water increases as the consumer's water use increases
- Seasonal rate – the cost per unit of water varies according to the season. Typically, summer rates will be higher than winter rates
- Monthly bill – a bill is sent out monthly
- Quarterly bill – a bill is sent out 4 times a year

Materials

- 12 months of school water bills
- Paper
- Writing utensil
- Computer (optional)

Procedures

1. Obtain the past 12 months of your school's water bills from your school district or water provider.
2. Create a graph that shows the amount of water used throughout the year on a monthly basis. You can either draw the graph or use a computer program such a Microsoft Excel.
3. Now, create a graph that shows the cost of water throughout the year on a monthly basis.
4. Analyze the graphs. Make note and examine inconsistencies in the graphs or trends in water use and cost.

Questions

1. What is the source of your school's water?
2. Which type of rate structure does your school fall under? Do the bills arrive monthly or quarterly?
3. Analyze *Brackett High School's Water Consumption and Cost of Water* graphs on page 8.
   a. Is there a relation between the cost of water and the use of water? Explain.
   b. During what part of the year does Brackett HS use the most water?
   c. What do you think is the cause for the unusually high use of water in the months of January and February?

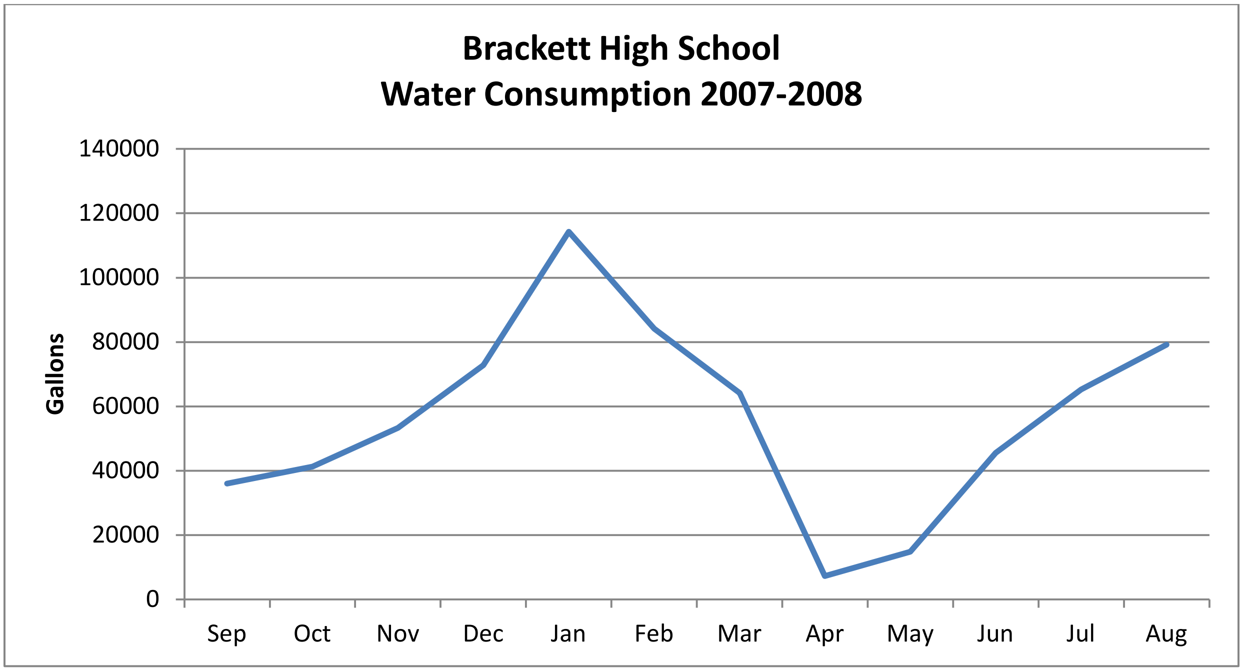
EXAMPLE OF A SCHOOL WATER BILL
(PAGE 1 OF 16 SHOWN)

2007-2008 CITY OF BRACKETTVILLE **ACCT.** **LOCATION** Home Ec./Cafeteria/Gym

	WATER						GAS				
	Present	Used	Charge	Sewer	Present	Used	Charge	SurCharge	Landfill	Total	Late Fee Applied to Past Due Accts.
SEPT.	1187400	36000	59.50	10.00	368885	11544	211.60	8.00	0	289.10	
OCT.	1228700	41300	67.45	11.60	381488	12603	184.39	8.00	0	271.44	
NOV.	1282000	53300	85.45	11.60	397566	16078	237.41	8.00	0	342.46	
DEC.	1354800	72800	114.70	11.60	441906	44340	645.00	8.00	0	779.30	
JAN.	1469100	114300	176.95	11.60	569300	127394	1734.53	8.00	0	1931.08	
FEB.	1553200	84100	131.65	11.60	617600	48300	689.30	8.00	0	840.55	
MAR.	1617300	64100	101.65	11.60	635400	17800	293.80	8.00	0	415.05	
APR.	168960	7230	113.95	11.60	649900	14500	259.10	8.00	0	392.65	
MAY	1837900	148.00	227.95	11.60	6659700	160700	2,687.98	8.00	0	2,935.53	
JUNE	1883500	45600	73.90	11.60	6717900	58200	1,103.79	8.00	0	1,197.29	
JULY	1948700	65200	103.30	11.60	6743000	25100	512.67	8.00	0	1,012.07	334.20 Sales Tax 42.30 Sales tax
AUG.	2027900	79200	124.30	11.60	6746500	3500	103.01	8.00	0	255.41	8.50 Sales Tax

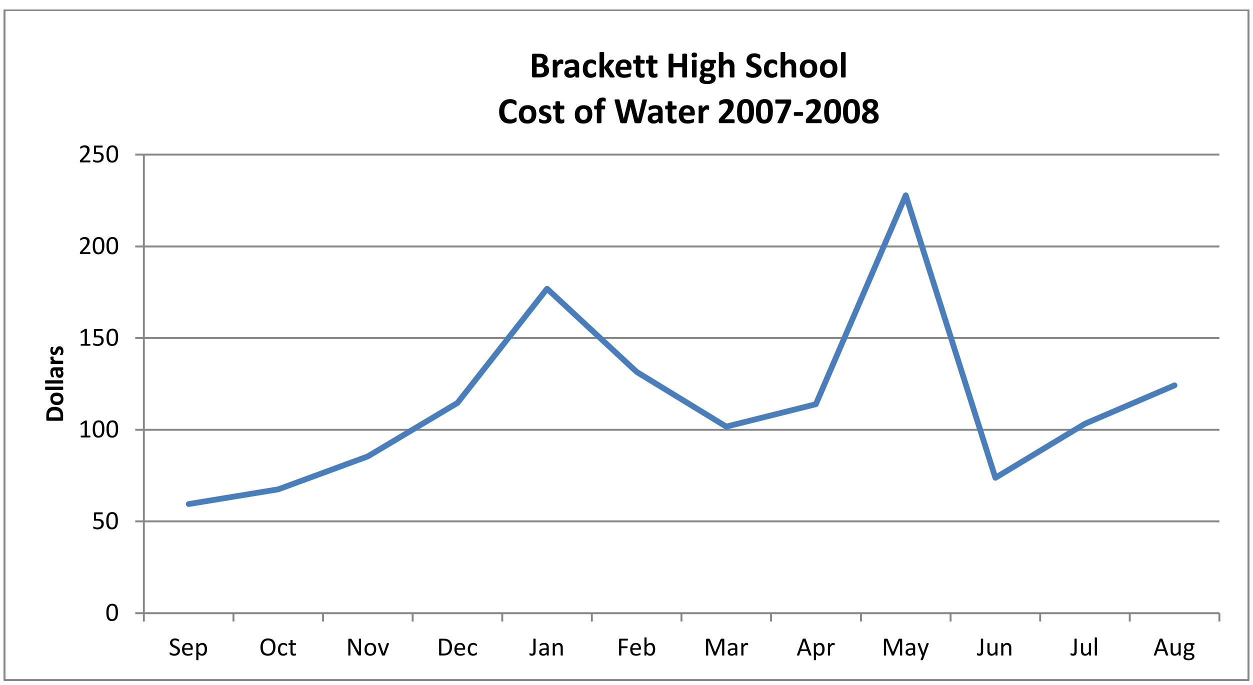
Brackett High School, Brackettville ISD, Brackettville, Texas

EXAMPLE GRAPH CREATED FROM BRACKETT H.S. WATER BILL



The water consumption graph was created by adding the totals in the "**Used**" column for all 16 pages of the bill and itemizing for each month. Included in the totals is consumption from the high school building, annex buildings, sports fields, and sports concessions.

EXAMPLE GRAPH CREATED FROM BRACKETT H.S. WATER BILL



The Cost of Water graph was created by adding the totals in the "**Charge**" column for all 16 pages of the bill and itemizing for each month. Included in the totals is consumption from the high school building, annex buildings, sports fields, and sports concessions.

READ THE WATER METER

Objective

In this activity, you will read the school's water meter(s) for two weeks. This activity requires you to get permission to access your school's water meter(s).

Skip this activity if you are unable to gain access to the water meter.

Background

There are three types of water meters; Circular-Reading Meter, Straight-Reading Meter, and Automatic Meter Reading (AMR) systems. Typically a public water supplier will either install a Straight-Reading Meter or an AMR system in a school.

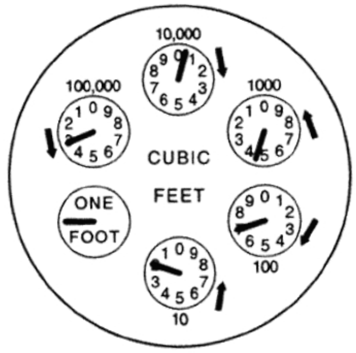
An AMR system does not have a visible dial, so you cannot read the meter. In order to obtain daily data from this type of meter, contact your public water supplier.

Straight-Reading Meters are easy to read. The number displayed on the dial is the number you record on the Meter Reading Log. In this example, the Straight-Reading Meter recorded 26 cubic feet of water.

STRAIGHT-READING METER

Some schools may have a Circular-Reading Meter installed. These types of meters use six dials to represent water usage.

Circular-Reading Meter



Current Reading

To read the Circular-Reading Meter, start with the dial that has the highest volume (100,000) and multiply by the number on the corresponding dial. Continue in descending order and sum the volumes from each dial. Record the "ONE FOOT" dial as a zero. If the hand on the dial is between two numbers, record the lowest number. In this example, the Circular-Reading Meter recorded 304,720 cubic feet of water (100,000*3 + 10,000*0 + 1,000*4 + and so on).

Meters record volumes of water usage in either gallons or in cubic feet. One cubic foot equals 7.48 gallons. If your school's water meter reads in cubic feet, you may want to convert your data to gallons so that when you present your findings, your data is relatable to the public.

Materials

- Meter Reading Log (page 11)
- Paper
- Writing utensil
- Computer (optional)

Procedures

1. Determine the number of water meters at your school. Some schools may have more than one water meter.

2. Determine a schedule for reading the water meter(s). Read the water meter at the same time every day for accurate data.

3. Record your data on the Meter Reading Log.

4. Create a graph that shows the amount of water used per day for the two week period. Draw the graph or create one using Microsoft Excel or a similar program.

5. Discuss and investigate reasons for fluctuations in the graph.

Questions

1. Approximately how many gallons of water did the Straight-Reading Meter record in the example provided? Hint: convert cubic feet to gallons.

2. Approximately how many gallons of water did the Circular-Reading Meter record in the example provided? Hint: convert cubic feet to gallons.

3. What trends in water use did you discover after performing this exercise?

4. Did a certain day of the week stand out as a heavy water use day? If so, discuss possible reasons for the excessive use.

Texas Water Development Board

SCHOOL WATER AUDIT

METER READING LOG

Today's Date	Today's Meter Reading	Minus	Previous Meter Reading	Equals	Cubic Feet Used	Times 7.48	Equals	Gallons Used	Divided By # of Days Between Readings	Equals	Average Gallons Used Per Day
		—		=		x 7.48	=		÷	=	
		—		=		x 7.48	=		÷	=	
		—		=		x 7.48	=		÷	=	
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MEASURE INDOOR WATER CONSUMPTION

Objective

In this activity, you will measure water consumption inside your school.

Background

In order to determine how much water is consumed inside your school, you will need to know how much water each fixture and appliance uses and how often it is used in a day. You will also need to know how many male and female students and staff are at your school and how many days a year your school is open.

There are two types of toilets typically installed in a school, residential and commercial grade. Residential toilets are those that are installed in houses. Residential toilets may be installed in areas of the school where the use is low, like the nurse's office or shop class. This type of toilet uses a tank that refills and stores water after every flush. It is most commonly known as a **tank-type** toilet.

Usually, tank-type toilets have a stamp behind the seat which indicates the flush rate. The most common flush rate is 1.6 gallons per flush. If you are unable to read the stamp, you can measure the flush rate from a tank-type toilet by doing the following:

1. Turn off the water to the toilet, this will prevent the tank from refilling after you flush. The toilet's water valve is located behind the toilet.
2. Carefully remove the lid to the tank.
3. With a wax pencil, draw a line at the current water level then flush the toilet once.
4. Using a container that measures in half gallons or quarts fill the tank with water until it reaches the line that was drawn. Record the amount of water you added. Convert the number to gallons, if applicable.
5. Carefully replace the tank lid and turn the water back on.

Worn flappers and tank parts can cause leaks. Tank-type toilet leaks account for huge amounts of water waste. You can test for leaks by dropping a dye tab, or a few drops of food coloring, into the tank. Wait five minutes, and then check the bowl. Since you did not flush, no water should have moved from the tank to the bowl. If you see color in the bowl, your toilet has a leak and school maintenance should be notified.

Commercial toilets do not have a tank. When the toilet is flushed, a flush valve is opened to let water in from a pipe in the wall. You can measure the flow rate from a commercial toilet by following the instructions in Procedure 6, on page 13.

Commercial toilet, Cedar Park High School, Leander ISD, Cedar Park, Texas

Measuring the rate of flow from a faucet

All data should be converted to gallons per minute (gpm) using a rate of flow formula. The rate of flow formula should be used for faucets, showers, bathtubs, and other water spigots. The **rate of flow** formula is as follows:

$$\frac{units\ measured}{seconds}\ x\ \frac{60\ seconds}{1\ minute}\ x\ \frac{1\ gallon}{units\ per\ gallon} = gpm$$

EXAMPLE: It took me 10 seconds to fill up a quart container from the faucet in the bathroom. Four quarts are equal to one gallon.

$$\frac{1\ quart}{10\ seconds}\ x\ \frac{60\ seconds}{1\ minute}\ x\ \frac{1\ gallon}{4\ quarts} = 1.5\ gpm$$

The rate of flow from the bathroom faucet is 1.5 gallons per minute (gpm).

Materials

- Stopwatch
- Container that measures fluid ounces
- Flowmeter bag (optional)
- Writing utensil
- Paper
- Interior school map (from preliminary investigation)
- Indoor Audit Worksheet (page 16)

Procedure

1. Revisit the areas of your school you highlighted as water using areas during your preliminary investigation.

2. Measure the water use from each fixture in the highlighted area and record your findings on the Indoor Audit Worksheet.

3. Make note of appliances that use water and include the model number on the Indoor Audit Worksheet.

4. If leaks are discovered, measure the amount of water coming from the leak by doing the following:

    a. Simultaneously place the container under the drip and start the stopwatch.

    b. Stop timing when the water level reaches one ounce.

    c. Calculate the total amount of water wasted from leaks in gallons per day (gpd) using the following formula:

$$\frac{1\ oz}{\#\ of\ seconds}\ x\ \frac{1\ gal}{128\ oz}\ x\ \frac{86{,}400\ seconds}{1\ day} = gpd$$

5. To measure the flow of water from a sink, do the following:

    a. Turn the water on to a normal flow.

    b. Simultaneously place the container under the flow of water and start timing.

    c. Let the water run until the container is filled or a pre-determined level is reached, then stop timing and turn off the water.

    d. Record the seconds and the water level. Use the rate of flow formula to determine the gallons per minute used by each fixture.

6. To measure the gallons flushed from a commercial toilet, do the following (see page 12 to measure the flush rate from a residential toilet):

    a. Flush the toilet and start the stopwatch.

    b. Stop timing when the flush is complete and the water begins to fill the bowl.

    c. Calculate gallons flushed by dividing the number of seconds it took to completely flush by 2. (This number has already been converted and is considered an industry standard.)

    d. Record your results.

7. To measure the gallons flushed from a urinal, do the following:

    a. Flush the urinal and start the stopwatch.

    b. Stop timing when the flush is complete and the water begins to fill the bowl.

    c. Calculate gallons flushed by dividing the number of seconds it took to completely flush by 5. (This number has already been converted and is considered an industry standard.)

    d. Record your results.

8. To measure the flow of water from a showerhead or bathtub, do the following:

    a. Place the flowmeter bag over the entire showerhead or tub faucet and hold tightly. If you are not using a flowmeter bag, place your container so that the showerhead or tub faucet is inside the container as much as possible.

    b. Simultaneously turn on the water to a full flow and start the stopwatch.

    c. If using a flowmeter bag, turn off the water when the stopwatch reaches 5 seconds and record the water level. If using another container, let the water run until the container is filled or a pre-determined level is reached and stop timing. Use the rate of flow formula to determine gallons per minute for each showerhead.

9. Calculate the amount of water consumed from all faucets, showers, tubs, and leaks in gallons per minute (gpm) using the rate of flow formula in the Background Section. Record your results on the Indoor Audit Worksheet. A sample Indoor Audit Worksheet is on page 17.

10. Calculate the gallons of water used per cycle for each appliance, like dishwashers, by referring to the specification sheet provided by the manufacturer and record your results on the Indoor Audit Worksheet.

Questions

1. While measuring water consumption, did you find broken or leaking pipes or fixtures? If so, describe.

2. Did loss of pressure come into play while you were measuring water consumption? If so, what could you have done differently to prevent the loss in pressure? Did the loss of pressure affect your data results?

3. Identify the independent variables.

4. Identify the dependent variables

5. Identify the controlled variables.

EXAMPLES OF WATER USING FIXTURES AND APPLIANCES

Athletics laundry, Pflugerville High School, Pflugerville ISD, Pflugerville, Texas

Ice machine, Cedar Park High School, Leander ISD, Cedar Park, Texas

Garbage disposal and pre-rinse spray valve, Pflugerville High School, Pflugerville ISD, Pflugerville, Texas

Physical therapy whirlpool tub, Cedar Park High School, Leander ISD, Cedar Park, Texas

Cafeteria dishwasher, Cedar Park High School, Leander ISD, Cedar Park, Texas

Photo lab, Cedar Park High School, Leander ISD, Cedar Park, Texas

SCHOOL WATER AUDIT

INDOOR AUDIT WORKSHEET

LOCATION:						
FIXTURE TYPE	CONTAINER MEASURED	SECONDS TO FILL CONTAINER	GALLONS MINUTE/ FLUSH/CYCLE	FIXTURE USE	GALLONS A DAY	NOTES
				Total		

SCHOOL WATER AUDIT

EXAMPLE OF AN INDOOR AUDIT WORKSHEET

LOCATION: Cafeteria, 6 female workers, 4 male workers

FIXTURE TYPE	CONTAINER MEASURED	SECONDS TO FILL CONTAINER	GALLONS MINUTE/ FLUSH/CYCLE	FIXTURE USE	GALLONS A DAY	NOTES
Hand sink #1	8 oz	3	1.25 gpm	(Avg gpm from sinks #1 and #2 = 1.25) 5 min, 5 times a day	1.25 gpm x 5 min x 5 uses a day = **31 gpd**	Supervisor said total run time for kitchen sink is about 5 min
Hand sink #2	8 oz	3	1.25 gpm			
Conveyor type dishwasher	n/a	n/a	0.66 gal/rack	50 racks a day	0.66 gal/rack x 50 racks/day = **33 gpd**	Meyer Diebel MD44
Pre-rinse spray valve	8 oz	1.5	2.5 gpm	Runs 10 min, 2 times a day	2.5 gpm x 10 min x 2 uses a day = **50 gpd**	
Garbage disposal	n/a	n/a	5 gpm	Runs 10 min, 2 times a day	5 gpm x 10 min x 2 uses a day = **100 gpd**	InSinkErator Model SS150
Restroom for cafeteria staff						
Toilet #1 (commercial)	n/a	3	1.5 gpf	(Avg gpf from toilets #1 and #2 = 1.75) 4 males x 1 times a day 6 females x 4 times a day	1.75 gpf x 4 men x 1 use a day = 7 gpd 1.75 gpf x 6 women x 4 usesa day = 42 gpd **42 gpd + 7 gpd = 49 gpd**	
Toilet #2 (commercial)	n/a	4	2 gpf			
Sink #1	8 oz	2	1.9 gpm	(Avg gpm from sinks #1, #2, and #3 = 1.3) 10 people, runs 1 min, 4 times a day	1.3 gpm x 10 people x 1 min x 4 uses a day = **52 gpd**	
Sink #2	8 oz	3	1.25 gpm			
Sink #3**	8 oz	5	0.75 gpm			Leaking
**Sink #3 leak	1 oz	230	$\frac{1\,oz}{230\,sec}\,x\,\frac{60\,sec}{1\,min}\,x\,\frac{1\,gal}{128\,oz}\,x\,\frac{60\,min}{1\,hr}\,x\,\frac{24\,hr}{1\,day} = \mathbf{2.9\,gpd}$			
Urinal #1	n/a	5	1.0 gpf	4 males x 3 times a day	1.0 gpf x 4 men x 3 uses a day = **12 gpd**	
				Total	**≈ 330 gpd**	

SURVEY WATER USE HABITS

Objective

In this activity, you will survey students and staff on their water use habits.

Background

In order to determine how much water is consumed at your school, you will need to know how much water each fixture and appliance uses in gallons per minute, how many minutes each fixture and appliance runs in a day, and how many times each fixture and appliance is used in a day. You will also need to know how many male and female students and staff are at your school and how many days a year your school is open.

Surveying people on their water use habits can give you real data and help you spot wasteful habits. Taking notes on these habits helps determine what kind of outreach, if any, is needed at your school.

For instance, say you are timing Sally washing her hands in the bathroom. There are two girls at another sink. You notice that they are talking to each other while putting on makeup and the water in the sink is running but they are not using it. After noting this behavior, you decide that you want to lead a public awareness campaign at your school about wasteful water habits. You decide to put posters up in and around the bathroom to make students aware of water wasting habits and how they can change their behavior to save water.

If you are unable to conduct a survey, you can use the estimates on the next page from the "1999 Water Research Foundation Study" (The Study).

To determine daily water consumption, input your survey results into the formulas below. Make sure you use the averages from the data you collected.

Faucets/Showers/Tubs:
average gpm x # minutes used x # uses per day

Toilets/Urinals:
average gpf x # uses per day x # of people

EXAMPLE: There are two toilets, four urinals, and four faucets in the boy's restroom. There are 200 male students and 10 male staff at the school. The school is open 210 days a year. The rate of flow was calculated from the previous exercise. See chart below.

BOY'S RESTROOM		
FIXTURE	RATE OF FLOW	AVERAGE RATE OF FLOW
Toilet	2.0 gpf	1.75 gpf
Toilet	1.5 gpf	
Urinal	1.0 gpf	1.0 gpf
Urinal	1.0 gpf	
Urinal	1.0 gpf	
Urinal	1.0 gpf	
Faucet	2.0 gpm	2.25 gpm
Faucet	2.0 gpm	
Faucet	2.5 gpm	
Faucet	2.5 gpm	

According to The Study on page 19, males use the toilet once a day, use the urinal 3 times a day, use the bathroom faucet 4 times a day, and wash their hands for one minute at school. Apply the data to the formulas below to determine the average water used in the restroom by all males for an entire year.

Faucets:
2.25 gpm x 1 min x 4 times a day x 210 males = 1,890 gpd

Toilets:
1.75 gpf x 1 time a day x 210 males = 367.5 gpd

Urinals:
1.0 gpf x 3 times a day x 210 males = 630 gpd

(1,890 + 367.5 + 630) gpd x 210 days = 606,375 gpy

The boy's bathroom uses 606,375 gallons of water in a year.

Materials

- Writing utensil
- Paper
- Indoor Audit Worksheet (page 16)

Procedure

1. Determine if you will randomly survey fellow students and staff on their water use habits or if you will use water use estimates as determined by The Study.

TO CONDUCT A SURVEY

- Select a random group of students and staff and survey their water use habits by asking them how many times they use the toilet or urinal, how many times they wash their hands, and how many times they use the shower facilities at school.

- Using the same random selection of students and staff, time how many minutes it takes to use the faucet and/or shower at school.

- For the cafeteria and other areas of the school that have large appliances, like dishwashers and clothes washers, ask the manager how many times each fixture is used and how many gallons of water is used per cycle.

THE STUDY'S WATER USE ESTIMATES

The Study's water use estimates for length of use at school is as follows:

- On average, people take 1 minute to wash their hands in the bathroom.

- On average, people take an 8 minute shower.

- On average, people use the kitchen faucet for 2 minutes.

The Study's water use estimates for the number of uses per day at school is as follows:

- On average, people use the bathroom faucet 4 times a day.

- On average, women use the toilet 4 times a day.

- On average, men use the toilet once a day.

- On average, men use the urinal 3 times a day.

Questions

1. What is the total number of students at your school? How many are female? How many are male?

2. What is the total number of staff at your school? How many are female? How many are male?

3. How many days a year is your school open?

4. Based on the data you collected, do you think your school would benefit from a water conservation outreach program?

EVALUATE THE IRRIGATION SYSTEM

Objective

In this activity, you will determine the efficiency of your school's irrigation system.

Skip this activity if you are unable to gain access to the irrigation controller or your school does not have an irrigation system. (Note: many public water suppliers will perform an irrigation audit for you.)

Materials

- 24 or more "catch cans" (small containers of the same size)
- Flag markers
- Anemometer
- Stopwatch or timer
- Graduated cylinder
- Soil probe
- Measuring wheel
- Pitot tube or pressure gauge
- Stopwatch
- Irrigation Audit Worksheet (page 27)
- Catch Can Worksheet (page 28)
- Outdoor map of school
- Writing utensil
- Paper

Background

Irrigation systems can be an efficient way to water landscapes, but if the system is not programmed properly, over-watering and excessive run-off can result. Such conditions can lead to high amounts of water waste. Properly evaluating the irrigation system can help save water, energy, and money.

An irrigation system's Distribution Uniformity (DU) measures how evenly the sprinklers apply water to the vegetation. No sprinkler system will distribute water with 100% uniformity, but a system that has a DU of 50% or less, wastes a lot of water and is not designed properly. A poor DU means that to apply the amount of water needed for proper plant growth, the sprinkler system needs to run longer and more frequently as compared to a system with a higher DU.

There are typically two types of sprinklers, fixed and rotary. Fixed sprinklers do not have rotating parts and are typically installed in flower beds and shrub beds. They are commonly known as pop-ups. Rotary sprinklers usually rotate in a circular or half-circular pattern and are typically installed in turf areas. Large rotaries are sometimes called cannons or guns.

Knowing the pressure of the irrigation system will allow you to determine if it is working efficiently. Too little pressure can cause brown spots in the vegetation because the water is unable to reach the entire area. Too much pressure can also cause brown spots because the water droplets break up early and reduce the radius of the spray pattern. Misting is an example of too much pressure.

The ideal pressure for fixed heads is 30 to 40 psi. The ideal pressure for rotary heads is 50 to 70 psi. To fix high pressure, install a pressure reducing valve. To fix low pressure, check the nozzle to make sure it is clear of debris and that it's the proper nozzle for the sprinkler.

In Texas, only a licensed irrigator can design, consult, install, maintain, alter, repair, or service an irrigation system. Do not attempt to fix your school's irrigation system or change the setting on the controller.

It is important to know the type of soil in each watering zone because different soils have different water holding capacities.

To determine what type of soil is in each watering zone, perform a "Mason jar test". You will need a Mason jar, the soil you want to test, and water. Fill the Mason jar half way with the soil you want to test and then add enough water to almost fill the jar. Close the lid tightly and shake the jar a few times. Let the jar sit overnight or until the particles settle. Calculate the percentage of large particles (sand), medium particles (silt), and small particles (clay) that have settled.

Mason jar test

From the image above, it is possible to calculate the percentage of each soil type. The ruler measures in eighths.

The total amount of soil in the Mason jar is 23 eighths. Sand is the heaviest and will sink to the bottom. The amount of sand in the jar measures 7 eighths, therefore the percentage of sand in the jar is about 30%. Silt is the second heaviest and is the middle soil. The amount of silt in the jar measures 11 eighths, therefore the percentage of silt in the jar is about 48%. Clay is the lightest soil and will remain suspended near the top. The amount of clay in the jar measures 5 eighths, therefore the percentage of clay in the jar is about 22%.

Use the Soil Texture Chart on page 25 to determine the soil type for 30% sand, 48% silt, and 22% clay. Draw a line through the triangle in the direction the arrow is pointing for the percentage of each soil texture. The intersection of the three lines indicates the soil type. In this case the type of soil is loam. Repeat this process for each of your soil samples.

Procedure

1. Referring to the outdoor map you created during the preliminary investigation, locate the irrigated areas of the school.

2. Determine which areas are watered with an irrigation system and ask the groundskeeper to show you the irrigation system controller. Note the current irrigation schedule. Ask the following questions:

    a. How many zones are irrigated with this controller?

    b. For how many minutes does each cycle run?

    c. How many cycles are run in a day?

    d. How many cycles are run in a week?

3. Draw a map and evaluate each zone separately, as follows, an example map is provided on page 26:

    a. Note the weather conditions. Measure the wind speed using an anemometer. If the wind speed is greater than 5 mph and/or if it is raining, postpone the evaluation.

    b. Using the measuring wheel, walk the perimeter of the watering zone and calculate the area. At the same time, have another person walk the area and make notes on the general conditions. Note the type of plant material in the watering zone, flag the sprinklers throughout the watering zone, make note of trees or hardscapes that may block the path of water from the sprinkler, and make note of soggy areas or areas where vegetation is lacking or is browner than in the rest of the watering zone. (You may need to turn on the water to determine the watering zone.)

    c. Once all of the sprinklers have been flagged, place "catch cans" throughout the watering zone. Place one container about a foot away from each sprinkler head and place another container halfway between each sprinkler. Make sure the containers are level.

    d. Turn on the water and wait (5 minutes for fixed heads and 10 minutes for rotary heads). Make note of broken, tilted, or dribbling sprinklers and inform maintenance.

e. While you are waiting, measure the pressure from a sprinkler head by using a Pitot tube.

f. Once the water is turned off, pour the water from each container into a graduated cylinder. Use the Catch Can Worksheet on page 28, to record your data.

g. Using a soil probe, measure the plant root depth in inches.

h. Determine the type of soil in the watering zone. If you are familiar with soil types, you can do this step at the same time you measure the plant root depth. If you are not familiar with soil types, refer to the background section for instruction.

i. Record your data on the Irrigation Audit Worksheet, located on page 27, in the Site Inspection Section.

4. Determine the Distribution Uniformity (**DU**) of each watering zone. To calculate DU, do the following:

   a. Using the Catch Can Worksheet, add up the total volume collected in the catch cans of one zone and divide that number by the number of catch cans used. That number is the total sample average, or CC_{avg}.

   b. To determine the catch can average of the lowest 25%, multiply the total number of catch cans used by 0.25. Now total the catch can volumes used by those cans in the bottom fourth, or lowest 25%.

   c. Divide the lowest 25% (Step b) by the total sample average (Step a) to get the Distribution Uniformity (DU).

$$DU = \text{lowest } 25\% \; CC_{avg} \div CC_{avg}$$

Example: In zone 2, I used 32 catch cans. The total volume collected was 591 ml. The average volume was 18.47 ml (591 ÷ 32 = 18.47). The lowest 25% includes 8 cans (32 x 0.25 = 8). The average of the lowest 8 readings was 14.13 ml. The DU of zone 2 was 0.77 (14.13 ÷ 18.47 = 0.77).

5. Determine the Reference Evapotranspiration (**RET**) for turf in your location by referring to the AgriLife Extension Website, your local weather station, or historic data.

6. Determine the Landscape Coefficient (**LC**) for each watering zone by using the Landscape Coefficient Tables on page 24 and entering your data into the following formula:

$$(LC_s) \times (LC_d) \times (LC_{mc}) \times (LC_q) = LC$$

7. Determine the Plant Watering Requirement (**PWR**) for each watering zone by entering your data into the following formula:

$$RET \times LC = PWR$$

8. Determine the Zone Precipitation Rate (**PR**) for each watering zone by entering your data into the following formula:

$$(CC_{avg} \times 3.66) \div (ZRT \times CC_A) = PR$$

   Where ZRT is the zone run time (the amount of time in minutes you kept the sprinklers on in the zone) and CC_A is the area of the catch can opening in square inches.

9. Determine the Irrigation Water Requirement (**IWR**) for each watering zone by entering your data into the following formula:

$$PWR \div DU = IWR$$

10. Determine the Run Time (**RT**) for each watering zone by entering your data into the following formula:

$$(IWR \div PR) \times 60 = RT$$

11. Determine the soil's Readily Available Water (**RAW**), Basic Intake Rate (**BIR**), and the Maximum Allowable Depletion (**MAD**) for each watering zone by using the Soil Property Chart on page 24.

12. Determine the Plant Available Water (**PAW**) for each watering zone by entering your data into the following formula:

    Plant root zone depth x RAW = PAW

13. Determine the Allowable Depletion (**AD**) for each watering zone by entering your data into the following formula:

    PWR x MAD = AD

14. Determine the number of Irrigation Days (**ID**) required for each watering zone by entering your data into the following formula:

    PWR ÷ AD = ID

15. Determine the Suggested Run Time (**SRT**) for each zone by entering your data into the following formula:

    (PAW ÷ PR) x 60 = SRT

16. Determine how many Minutes per Cycle (**MC**) each watering zone should run by entering your data into the following formula:

    (BIR ÷ PR) x 60 = MC

17. Determine how many Cycles per Day (**CD**) each watering zone should run by entering your data into the following formula:

    SRT ÷ MC = CD

18. Using your calculations from Steps 4-17, determine how many days the irrigation system should run in a month, how many cycles the irrigation system should run in a day, and how many minutes each cycle should run.

    According to the example Irrigation Audit Worksheet on page 29, the irrigation system only needs to run 13 days in May, with two cycles a day, at 12 minutes each cycle. After further consideration, I recommended that this system run twice a week, with two cycles at 12 minutes each.

Questions

1. What type of vegetation is the school irrigating?
2. What type of soil is the vegetation growing in?
3. How many irrigation system controllers does your school have?
4. How many zones does each irrigation controller have?
5. How many days a week does each irrigation controller currently run?
6. How many cycles are run in a day?
7. How many minutes does each cycle currently run?
8. What is the Distribution Uniformity of the school's irrigation system?
9. What type of irrigation system schedule changes, if any, did you recommend?

LANDSCAPE COEFFICIENT TABLES

SPECIES (LC_s)

VEGETATION TYPE	COEFFICIENT
Trees	0.5
Shrubs	0.5
Groundcover	0.5
Mixed	0.5
Turfgrass	0.7

DENSITY (LC_d)

VEGETATION TYPE	HIGH DENSITY	MEDIUM DENSITY	LOW DENSITY
Trees	1.3	1.0	0.5
Shrubs	1.1	1.0	0.5
Groundcover	1.1	1.0	0.5
Mixed	1.3	1.1	0.6
Turfgrass	1.0	1.0	0.6

MICROCLIMATE (LC_{mc})

VEGETATION TYPE	SURROUNDED BY IMPERVIOUS SURFACES	SMALL AMOUNT OF IMPERVIOUS SURFACES	NO IMPERVIOUS SURFACES
Trees	1.4	1.0	0.5
Shrubs	1.3	1.0	0.5
Groundcover	1.2	1.0	0.5
Mixed	1.4	1.0	0.5
Turfgrass	1.2	1.0	0.8

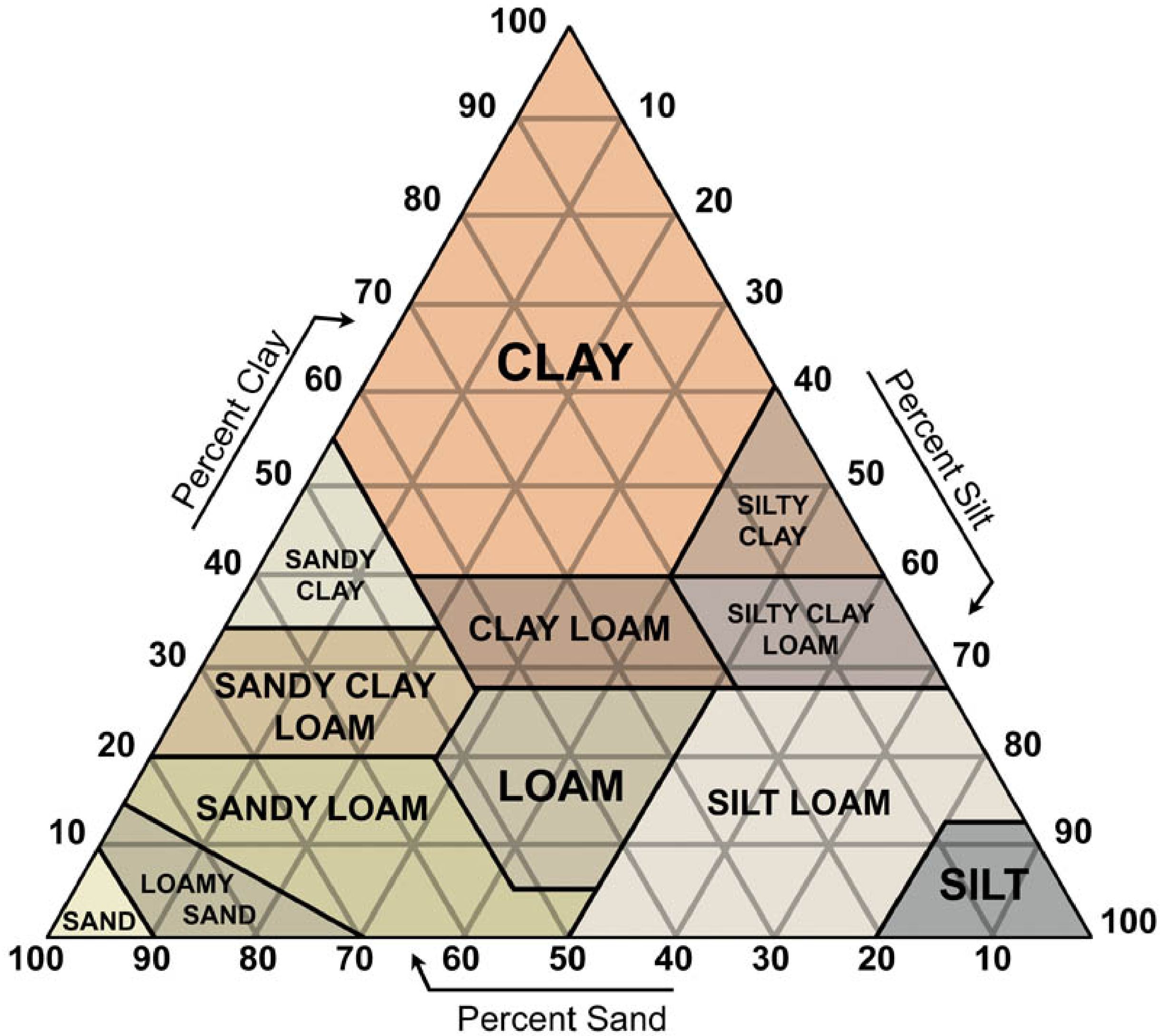
QUALITY FACTOR (LC_q)

VEGETATION TYPE	HIGH FOOT TRAFFIC	MEDIUM FOOT TRAFFIC	NO FOOT TRAFFIC
Turfgrass	1.2	1.0	0.8

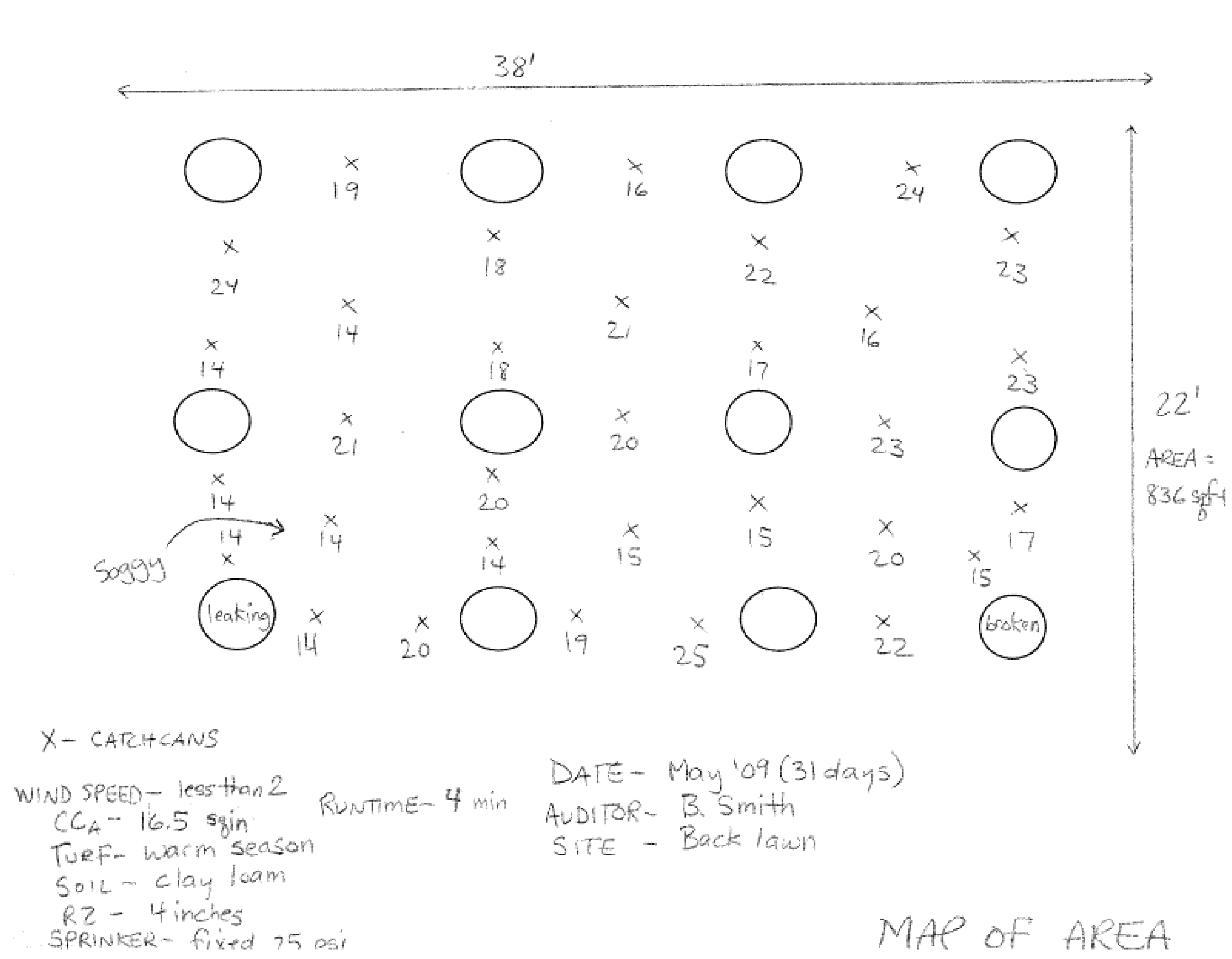
SOIL PROPERTY CHART

SOIL TYPE	READILY AVAILABLE WATER (RAW)	BASIC INTAKE RATE (BIR)	MAXIMUM ALLOWABLE DEPLETION (MAD)
Sand	0.09	0.90	0.60
Sandy Loam	0.14	0.40	0.50
Loam	0.17	0.30	0.50
Silty Clay	0.18	0.15	0.40
Clay Loam	0.20	0.20	0.40

SOIL TEXTURE CHART



EXAMPLE CATCH CAN MAP



IRRIGATION AUDIT WORKSHEET

Name of auditor:

Site name: Date plus the number of days in the month:

SITE INSPECTION

Zone	1	2	3	4	5
Sprinkler Type (Rotary or Fixed)					
Broken/Sunken Head					
Obstruction					
Clogged Head					
Visible Leak					
Pressure					
Soil Type					
Plant Type					
(RZ) Average Plant Root Depth					In inches

CALCULATIONS

Zone	1	2	3	4	5
(RET) Reference ET					In inches
(LC) Landscape Coefficient $LC = (LC_s) \times (LC_d) \times (LC_{mc}) \times (LC_q)$					
(PWR) Plant Water Requirement PWR = RET x LC					In inches
(PR) Zone Precipitation Rate $PR = (CC_{avg} \times 3.66) \div (ZRT \times CC_A)$					In/hr
(IWR) Irrigation Water Requirement IWR = PWR ÷ DU					In inches
(RT) Run Time RT = (IWR ÷ PR) x 60					In minutes
(RAW) Readily Available Water					
(PAW) Plant Available Water PAW = RZ x RAW					In inches
(AD) Allowable Depletion AD = PAW x MAD					
**(ID) Irrigation Days ID = PWR ÷ AD					
(SRT) Suggested Run Time SRT = RT ÷ ID					Min/day
**(MC) Minutes Per Cycle MC = (BIR ÷ PR) x 60					Min/cyc
**(CD) Cycles Per Day CD = SRT ÷ MPC					Cyc/day

**These boxes tell you how many days you need to water in the particular month, how many minutes you need to water, and how many cycles you need to run your irrigation system.

CATCH CAN WORKSHEET

Zone	1	2	3	4	5
Run Time					
(CC) Catch Can Volume in milliliters					
(DU) Distribution Uniformity DU = Lower 25% of CC_{avg} ÷ CC_{avg}					

EXAMPLE IRRIGATION AUDIT WORKSHEET

Name of auditor: B. Smith

Site name: Back lawn Date plus the number of days in the month: May '09 - 31 days

SITE INSPECTION

Zone	1	2	3	4	5
Sprinkler Type (Rotary or Fixed)	spray				
Broken/Sunken Head	one -broken				
Obstruction					
Clogged Head					
Visible Leak	one				
Pressure	25 psi				
Soil Type	clay loam				
Plant Type	warm season turf				
(RZ) Average Plant Root Depth	4 in				In inches

CALCULATIONS

Zone	1	2	3	4	5
(RET) Reference ET	6.5				In inches
(LC) Landscape Coefficient LC = $(LC_s) \times (LC_d) \times (LC_{mc}) \times (LC_q)$	0.6				
(PWR) Plant Water Requirement PWR = RET x LC	3.9				In inches
(PR) Zone Precipitation Rate PR = $(CC_{avg} \times 3.66) \div (ZRT \times CC_A)$	1.02				In/hr
(IWR) Irrigation Water Requirement IWR = PWR ÷ DU	5.13				In inches
(RT) Run Time RT = (IWR ÷ PR) x 60	302				In minutes
(RAW) Readily Available Water	0.20				
(PAW) Plant Available Water PAW = RZ x RAW	.08				In inches
(AD) Allowable Depletion AD = PAW x MAD	0.32				
**(ID) Irrigation Days ID = PWR ÷ AD	13				
(SRT) Suggested Run Time SRT = RT ÷ ID	24				Min/day
**(MC) Minutes Per Cycle MC = (BIR ÷ PR) x 60	12				Min/cyc
**(CD) Cycles Per Day CD = SRT ÷ MPC	2				Cyc/day

**These boxes tell you how many days you need to water in the particular month, how many minutes you need to water, and how many cycles you need to run your irrigation system.

EXAMPLE CATCH CAN WORKSHEET

Zone	1	2	3	4	5
Run Time	12 min				
(CC) Catch Can Volume in milliliters	24 19				
	18 16				
	22 24				
	23 $\boxed{14}$				
	$\boxed{14}$ 18				
	21 17				
	16 23				
	21 20				
	20 23				
	$\boxed{14}$ $\boxed{14}$				
	$\boxed{14}$ 15				
	$\boxed{15}$ 20				
	17 $\boxed{14}$				
	$\boxed{14}$ 20				
	19 25				
	22 15 =				
	591				
	Avg - 18.47				
(DU) Distribution Uniformity DU = Lower 25% of CC_{avg} ÷ CC_{avg}	14 14 14 14				
	14 14 14 15 =				
	113	DU = 14.125 ÷ 18.47 = 0.77			
	Avg - 14.125				

REPORT YOUR FINDINGS

Objective

In this activity, you will report your findings to the public.

Materials

- Writing utensil
- Paper
- Pictures taken during the audit
- Maps created during the audit
- Data collected during the audit

Background

In order to enact change, people need to be aware of what's going on in their community. By presenting your findings to the community, you are raising awareness about the need to conserve water.

Community partners are essential to the successful completion of this project. Since each school and community is unique, it is up to the instructor to act as the project manager to establish broad based goals, enlist support from school administration, and engage and guide the students through a successful learning experience. The outcome should culminate with the understanding about how to take action to conserve water.

To make an effective presentation, you should research new water efficient technologies and determine the cost effectiveness of such technologies. Providing a water balance in your report or presentation is the best way to reflect your school's water usage and potential savings. An example water balance is on page 33.

Procedure

1. Write a report that includes the following:

    a. The total amount of water your school uses in a year.

    b. The total amount of water wasted in a year due to leaks.

    c. The amount of money your school spends on water.

    d. The amount of water and money that can be saved if your school fixes all leaks.

    e. The amount of water and money that can be saved if people change their bad habits.

    f. The amount of water and money that can be saved by installing efficient fixtures.

    g. The amount of water and money that can be saved by changing the irrigation settings.

    h. Changes your school can implement to become more water efficient.

    i. Include a cost benefit analysis on upgrading fixtures and/or installing new water saving devices at your school, if possible.

2. Make a poster highlighting "the good, the bad, and the ugly" of your water audit. Include pictures, maps, and graphs.

3. Present your report and/or poster to school staff, school board officials, and/or members of the community.

4. Create awareness in your school by putting up posters or hosting a booth at a school fair that explains how students can change their habits and save water. Use data from your audit to emphasize your points.

Questions

1. What recommendations did you propose?

2. Did you notice bad habits while doing the preliminary walk-thru or while measuring water use? Describe.

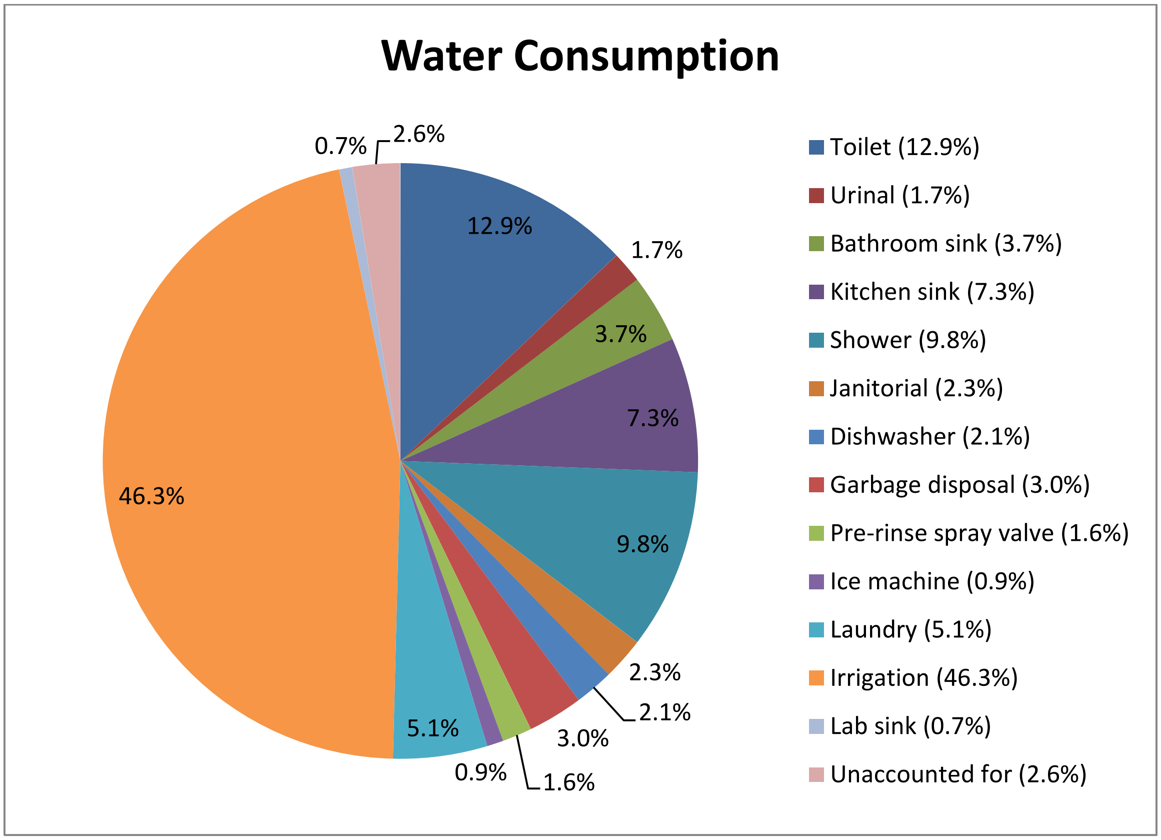
3. What kind of outreach or message can your class develop to help change the bad habits of others at your school?

4. During this process did you become aware about how you use or waste water? Describe.

EXAMPLE WATER BALANCE

FIXTURE TYPE	PERCENT OF TOTAL WATER CONSUMPTION	CURRENT CONSUMPTION (GALLONS)	UPGRADED FIXTURE SAVINGS (GALLONS)	UPGRADED FIXTURE SAVINGS (PERCENT)
Toilet	12.9%	2,120,631	1,334,506	63%
Urinal	1.7%	273,428	170,378	62%
Bathroom sink	3.7%	612,196	294,322	48%
Kitchen sink	7.3%	1,201,433	476,933	40%
Shower	9.8%	1,614,658	756,178	47%
Janitorial	2.3%	371,744	216,980	58%
Dish washer	2.1%	347,256	n/a	n/a
Garbage disposal	3.0%	496,080	140,400	28%
Pre-rinse spray valve	1.6%	269,568	89,856	33%
Ice machine	0.9%	142,093	n/a	n/a
Laundry	5.1%	839,948	n/a	n/a
Irrigation	46.3%	7,589,956	3,399,456	45%
Lab sink	0.7%	96,000	n/a	n/a
Unaccounted for	2.6%	425,807	n/a	n/a
TOTAL		16,400,798	6,879,009	41%

*n/a represents fixtures or appliances where an efficiency upgrade was not recommended



ANSWERS

PRELIMINARY INVESTIGATION

1. Students should list all fixtures they come across while on their investigation. Some students may be surprised to find that the school has a whirlpool tub, a green house, or that drama class has its own private bathroom.

2. Students should think about the type of water used, the amount of water used, and ways their school can become more water efficient.

ANALYZE WATER BILLS

1. Your school either gets water from a public water provider or from a well onsite.

2. If the school gets water from a well, there probably is no bill issued in which case this question would be "n/a". If a bill is issued, the answers will be either flat rate, decreasing block rate, or increasing rate tier. In addition to those three, a school may be billed a seasonal rate during the summer months. Bills may arrive quarterly or monthly.

3a. Yes, the cost of water directly reflects the use of water. Brackett HS is probably on an increasing block tier. However, there is a downward spike in the months of April and May for the consumption of water, but an upward spike in the cost of water. Upon further review of the bill, it was noticed that the school was over-charged. A billing error is the reason the cost of water doesn't match the use of water for those two months.

3b. Brackett HS used the most water in the winter months.

3c. The spike in increased water use in the months of January and February is most likely due to a leak.

READ THE WATER METER

1. The Straight-Reading Meter recorded 26 cubic feet of water, which is approximately 194 gallons. To convert cubic feet to gallons, multiply 26 by 7.48.

2. The Circular-Reading Meter recorded 304,720 cubic feet of water, which is approximately 2,279,306 gallons. To convert cubic feet to gallons, multiply 304,720 by 7.48.

3. Two examples of common trends are: a spike one day a week which may indicate the school's designated watering day or a huge increase in water use for a few days which may indicate a leak.

4. Sometimes an upward spike on the graph on the same day each week can indicate a heavy watering day. The most likely cause of this is watering restrictions.

MEASURE INDOOR WATER CONSUMPTION

1. The students should describe any leaks they found.

2. The students should make recommendations on how to do the experiment to avoid pressure differences and describe how the data was affected.

3. An independent variable is a variable whose variation does not depend on another. Example: If you decide to measure how long it takes to fill up a one quart container, the time will be the independent variable because its value does not depend on the amount of volume measured.

4. A dependent variable is a variable whose value depends on that of another. Example: Using the same scenario in question 3, the volume will be the dependent variable because its value depends on the time.

5. Controlled variables are those that are kept the same. Example: The same formula is used for each data set.

SURVEY WATER USE HABITS

1. – 3. Students should use the data collected from this exercise to answer the questions.

4. Students should describe any bad habits they noticed while performing the audit and recommend an outreach program, like hanging signs in the bathroom asking students to turn off the water when they are not using it.

5. Students should think about how they use water and what steps they can take to be more water wise in their daily life.

6. Students should collaborate on outreach projects they can do at school.

EVALUATE THE IRRIGATION SYSTEM

1. – 8. Students should use the data collected from this exercise to answer the questions.

9. Students should list any changes to the irrigation schedule they recommend to make the irrigation system more water efficient.

REPORT YOUR FINDINGS

1. Students should list the recommendations they suggested for the school.

2. Students should list bad habits they witnessed when walking through the school.

3. Students should explain the type of public awareness they recommended.

4. Students should make reflections on their own water use habits.

GLOSSARY

Allowable Depletion – The total amount of available water that can be depleted from the soil without adverse effects on plant growth and development.

Anemometer – An instrument that measures wind speed.

Basic Intake Rate – The rate at which water percolates into the soil after infiltration has decreased to a low and nearly constant value.

Catch Can – A container used to measure the amount of water an irrigation system applies.

Distribution Uniformity (DU) – The measurement of how uniform water is applied over the ground.

Evapotranspiration – A measurement of the total water needs of a plant including the water lost due to evaporation from the soil and transpiration from the plant.

Gpd – gallons per day

Gpf – gallons per flush

Gpm – gallons per minute

Gpy – gallons per year

Hardscape – An area or item in the landscape that provides a barrier to water.

Impervious surface – An artificial structure covered by impenetrable materials.

Managed Allowable Depletion (MAD) – The process of letting the soil dry out between irrigations to a pre-selected soil moisture content.

Readily Available Water (RAW) – The amount of water that can be stored in the soil and be available for growing plants.

Reference evapotranspiration – The rate of evapotranspiration from a hypothetical reference crop, typically turf.

Pitot tube – An instrument that measures fluid flow velocity (pressure).

Plant Available Water (PAW) – The amount of water in the soil, in inches, that is available for plant uptake.

Potable water – Water which is fit for consumption by humans and animals.

Public water supplier – A business that provides potable water for the public's use.

Zone precipitation rate – The measurement of how fast an irrigation system applies water to the landscape, in inches per hour, in a specific zone.