Go With the Flow

Albuquerque Bernalillo County
Water Utility Authority

Summary: Students learn how water is pumped uphill for storage in reservoirs, giving it potential energy. They experiment with different reservoir levels and measure the velocity or kinetic energy of the flowing water.

Grade: Eight

Subject Areas: Science, Math

Activity Materials for 8 groups:

- Eight water level setups (two containers linked with a tube and watertight seal)
- Worksheets (1 per student)
- Eight stopwatches
- Eight yard sticks or meter sticks
- 3-foot capped tube – 1.125 inch diameter (1 square inch of water on cap)
- One small bouncy ball that can roll in the tube
- 8 NEED Energy placemats
- Towels or paper towels to clean up the water that will be spilled

Posters

- Reservoir photo
- Reservoir/house diagram
- Setup diagram
- graphs

NexGen Science Standards

MS-PS3-2 Develop a model to describe that when the arrangement of objects interacting at a distance changes, different amounts of potential energy are stored in the system.

MS-PS3.A: Definitions of Energy

- Motion energy is properly called kinetic energy; it is proportional to the mass of the moving object and grows with the square of its speed. (MS-PS3-1)
- A system of objects may also contain stored (potential) energy, depending on their relative positions

Crosscutting Concepts

Systems and System Models
Models can be used to represent systems and their interactions – such as inputs, processes, and outputs – and energy and matter flows within systems. (MS-PS3-2)

Engineering Design
Develop a model to generate data to test ideas about designed systems, including those representing inputs and outputs (MS-ETS1-4)

Math
Analyze and interpret data to determine similarities and differences in findings (MS-ETS1-3)
Describe qualitatively the functional relationship between two quantities by analyzing a graph.

Go With the Flow

Talking Points:

- Societies change dramatically when people do not need to spend all their time carrying water from the source to their homes.
- Engineers can test ideas by building models.
- We can use graphs to answer our questions.
- We can analyze our data to find the relationship between the height of a column of water and the kinetic energy at the faucet.
- Kinetic Energy is energy of motion. Potential energy is stored energy.
- Energy can be transformed.
- When we waste shower water, we are wasting water, the electricity we used to pump it into the reservoir, and the heat it took to make the water hot. We need to be mindful of how we use all of our water, but especially our hot water.

Warm Up (10 minutes)

Tell students that we are going to investigate flow rates of water.

In the old days, people would carry buckets and containers of water from their water source to their homes for use. Water is heavy. This requires a lot of energy from people.

Nowadays, we have pipe that transport the water to our homes, but energy is still required to move this water. Energy comes in various forms. Potential energy is energy that is stored, waiting to be used. Kinetic energy is motion. If needed, demonstrate potential and kinetic energy with a bouncy ball.

- Hold a meter stick upright with one end on the desk.
- Bring a bouncy ball half way up the meter stick. Ask students to predict how high it will bounce. Drop the ball.
- Now bring the ball up to the top of the meter stick.
- Ask students if they think the ball will bounce higher, lower, or the same height.
- Drop the ball. It will bounce higher.
- Where did the ball get the energy to bounce higher? Answer – the ball got more potential energy when you raised it higher. It got the energy from your arm, lifting it up. We transformed the potential energy into kinetic energy when we dropped the ball.

Potential and kinetic energy can occur in different forms. And potential energy can transform to kinetic energy and visa versa. When I lifted the ball, the ball had potential energy. The kinetic energy used to raise the ball up came from my arm, my body which got its energy from potential energy stored in my

muscles. My muscles get their energy from the food I eat (chemical energy). The food grows with the energy it gets from the sun (radiant energy).

Review the various forms of energy (make a poster for this that includes pictures)

Forms of Potential Energy	**Forms of Kinetic Energy**
Chemical Energy -- energy *stored* in the bonds of atoms and molecules. Examples include petroleum, natural gas, and propane.	**Electrical Energy –** this is *movement* of electrons. An example is electrons *moving* through a wire in an electrical circuit.
Stored Mechanical Energy – energy *stored* in objects with an application of force. Examples include stretched rubber bands and compressed springs.	**Radiant Energy --** this is energy that *travels* in transverse waves such as light and xrays.
Gravitational Energy – this is the energy of place or position. An example is a rock resting at the top of a hill.	**Thermal Energy** – this is heat, created by the *movement and vibration* of atoms and molecules inside a substance.
Nuclear Energy – energy *stored* in the nucleus of an atom.	**Motion Energy** -- this is the *movement* of objects and substances from one place to another. An example is the wind

Show students the picture of the house and reservoir. **The water sitting in the reservoir has potential energy.** When you turn on the faucet, the water runs downhill. We don't pump it to you. **The water running out of your faucet has kinetic energy**. We measure it in gallons per minute.

Activity: (25 minutes)

Part 1. Flow Rate

Hand out one worksheet to each student. Have students sit in groups of 3-4 students per group. Pass out the lab equipment: towel, two containers with water in them connected by a tube, yardstick, and stopwatch.

Have the students experiment with the water in the containers. What happens when you lift one container? (The water flows to the lower container) How can you prevent the water from the full upper container from flowing into the empty lower container? (Lift the empty lower container above the full container) What happens if both containers are left on the table? (The water reaches equilibrium)

Explain to students that they will be investigating flow rates of 12 ounces of water at various heights. One container represents the reservoir and the other container represents a home. The container labeled reservoir has markings that say start and stop. The volume of water between the start and stop lines is 12 ounces. In this activity they will measure the time it takes the 12 ounces of water to flow from start to stop with the reservoir held at various heights.

Go over the worksheet and the data collection table. Demonstrate how to do the activity: One student holds the yard stick up from the table. One student holds the empty home container up high so no water

can flow into it. One student holds the full reservoir container at the height being measured (9, 18, 27 or 36 inches). The start line should be lined up with the measure on the yardstick. The student holding the empty home container puts it on the table, and water from the reservoir will start flowing into the home. As soon as the water reaches the start line on the container, the timer student begins timing and stops timing when the water reaches the stop line. This is repeated 3 times for each height.

What do you predict will happen as the reservoir gets higher and higher?

After they have collected their data and calculated their average, they will have data for 12ouces/___ seconds. This needs to be converted to gallons per minute, the flow rate used by the Water Authority. After they have calculated the gallons per minute, graph the height and gallons/minute data.

Use the graph to answer questions 1 and 2. Discuss their data and graph. What did their data reveal? When were potential energy and kinetic energy exhibited in the activity? Did the amount of potential energy change in the experiment? How did it change and what was the result?

Part 2. Energy (10 minutes)

Have students turn the worksheets over. Review potential and kinetic energy. Review the NEED coal flow diagram, showing the energy transformations to create electricity. (Make a modified version of this that shows electricity powering the pump to lift the water to the reservoir and then the water flowing from their to a faucet.) Have the students answer the first three questions on the worksheet.

If time is running out, this could be left to do later with the teacher. Move onto the section after the dashed line.

Discussion

Now that they have seen all the energy transformations that it takes to get their water, this would be a good time to talk about how important it is to save water – and when you do that, you save energy too!

In particular talk about showers. When we waste shower water, we are wasting water, electricity, and the heat it took to make the water hot. Give this example: Water flows from a shower faucet at a rate of 2 gallons per minute. If there are 500,000 people in Albuquerque and each one took a one minute shorter shower, how much water would Albuquerque save? Answer: 500,000 x 2 gallons/1 minute= 1,000,000 gallons.

This is also good opportunity to explain how to check the flow rates in their faucets at home. And explain there are aerators that can be installed on many faucets to alter the flow rate and save more water.

Questions? Contact
Erin Keck, ekeck@abcwua.org

Water Utility Authority

GO WITH THE FLOW Name: _____

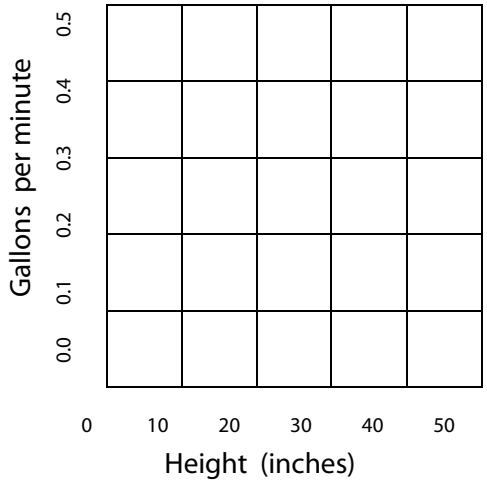
Part 1. Flow Rate

Measure the rate of flow of **12 ounces of water** at various heights, recording your data below:

12 oz. x $\frac{1 \text{ gallon}}{128 \text{ oz.}}$ = .93 gallons

Height (inches)	Time (seconds)				Convert Time from seconds to minutes	Divide gallons by time (minutes) to get:
	Trial 1	Trial 2	Trial 3	AVERAGE	AVERAGE x $\frac{1 \text{ minute}}{60 \text{ seconds}}$ =	Gallons / Minute
9						
18						
27						
36						

Graph the gallons/minute for each height on the graph below. Then using the graph answer the questions to the right.



1. At what height would you need to build your reservoir to deliver 0.25 gallons per minute?

_____

2. Approximately how fast would your water flow in gallons per minute if your reservoir level were 50 inches from the ground?

_____

_____

Metric Note: The Water Authority uses gallons to measure volume and inches and feet to measure distance. Most scientists use the metric system. Why do you think the Water Authority uses the English system and not the metric system?

Part 2. Energy

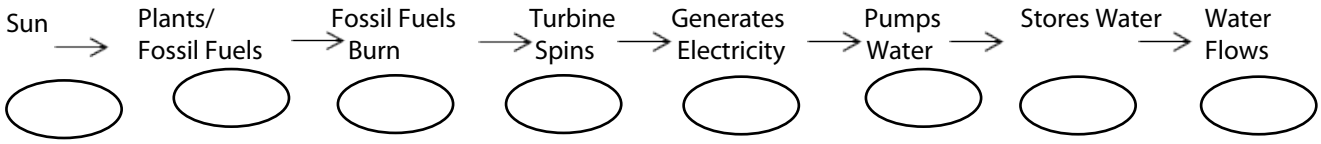
Potential Energy is stored energy. Circle the forms of Potential Energy below:

Gravitational Electrical Radiant Thermal Motion Stored Chemical Nuclear Mechanical

Kinetic Energy is energy of motion. Circle the forms of Kinetic Energy below:

Gravitational Electrical Radiant Thermal Motion Stored Chemical Nuclear Mechanical

Fill in the energy transformations that occur in a water supply system below:



When you pay your water bill, you pay for the energy it takes to get the water to you. The Water Authority gets its electricity from PNM and the Water Authority is PNM's biggest customer in Albuquerque. It takes a lot of energy to pump the water up to the storage tanks so it can flow to your home at the correct flow rate.

What is something you can do to reduce the amount of electricity used by the Water Authority?

_____

_____

List 3 ways you can save water:

1. _____

2. _____

3.

_____

Do you save energy when you do any of the 3 water saving methods you listed above? _____

Challenge Question: Residential water pressure is measured in pounds per square inch (psi), and ranges between 45 and 80 psi. The Water Authority aims for a water pressure of 100 psi as it leaves the reservoirs. The water loses enough pressure as it flows through the pipes that it is the proper pressure when it reaches your home. If 1 psi occurs at a height of 27 inches, how many *feet* high must a water tank be located for the water to have a psi of 100?

_____

ANSWER SHEET (This is an example. Answers may vary)

GO WITH THE FLOW

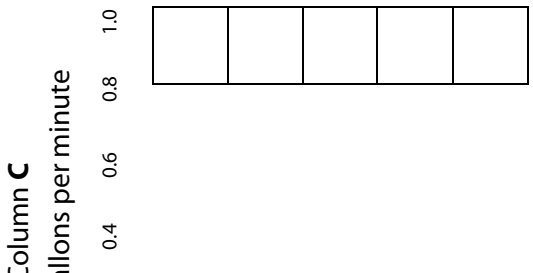
Name: _____

Part 1. Flow Rate

Measure the rate of flow of **12 ounces of water** at various heights, recording your data below:

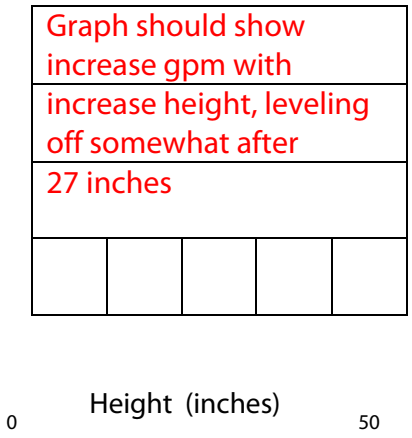
					Column **A**	Column **B**	Column **C**
Height (inches)	Time (seconds)				Convert Time from seconds to MINUTES	Convert Volume from ounces to GALLONS	Calculate gallons per minute
	Trial 1	Trial 2	Trial 3	AVERAGE	AVERAGE x 1 minute / 60 seconds =	12 ounces x 1 gallon / 128 ounces =	Column **B** / Column **A** =
9	23	22	22	22.33	0.37	0.09	.24
18	12	12	11	11.67	0.19	0.09	.47
27	10	10	9	9.67	0.16	0.09	.56
36	8	8	8	8	0.13	0.09	.69

Graph Column **C**, gallons/minute, for each height on the graph below. Put a dotted line showing how you think the water flow rate will continue if the reservoir was higher and higher. Then using the graph answer the questions to the right.



1. At what height would you need to build your reservoir to deliver 0.25 gallons per minute?

   Approximately 10 inches (Answers may vary)



2. Approximately how fast would your water flow in gallons per minute if your reservoir level were 50 inches from the ground?

Approximately .70 gallons per minute (Answers may vary)

Metric Note: The Water Authority uses gallons to measure volume and inches and feet to measure distance. Most scientists use the metric system. Why do you think the Water Authority uses the English system and not the metric system?

Part 2. Energy

Potential Energy is stored energy. Circle the forms of Potential Energy below:

Gravitational Electrical Radiant Thermal Motion Stored Mechanical Chemical Nuclear

Kinetic Energy is energy of motion. Circle the forms of Kinetic Energy below:

Gravitational Electrical Radiant Thermal Motion Stored Mechanical Chemical Nuclear

Using the types of kinetic and potential energy listed in the previous problem, fill in the energy transformations that occur in a water supply system below:

Sun → Plants/ Fossil Fuels → Fossil Fuels Burn → Turbine Spins → Generates Electricity → Pumps Water → Stores Water → Water Flows

K/Radiant P/Chemical K/Thermal K/Motion K/Electrical K/Motion P/Gravitational K/Motion

---

When you pay your water bill, you pay for the energy it takes to get the water to you. The Water Authority gets its electricity from PNM and the Water Authority is PNM's biggest customer in Albuquerque. It takes a lot of energy to pump the water up to the storage tanks so it can flow to your home at the correct flow rate.

What is something you can do to reduce the amount of electricity used by the Water Authority?

Use less water

List 3 ways you can save water:

1. Short (5 minute) shower
2. Turn the water off when brushing teeth, washing dishes, etc
3. Plant dry landscape plants, water during cool times of day

Do you save energy when you do any of the 3 water saving methods you listed above? Yes

Challenge Question:

Residential water pressure is measured in pounds per square inch (psi), and ranges between 45 and 80 psi.

	**Chemical Energy** -- energy *stored* in the bonds of atoms and molecules. Examples include petroleum, natural gas, and propane.
	**Stored Mechanical Energy** – energy *stored* in objects with an application of force. Examples include stretched rubber bands and compressed springs.
	**Gravitational Energy** – this is the energy of place or position. An example is a rock resting at the top of a hill.
	**Nuclear Energy** – energy *stored* in the nucleus of an atom.

	**Electrical Energy –** this is *movement* of electrons. An example is electrons *moving* through a wire in an electrical circuit.
	**Radiant Energy --** this is energy that *travels* in transverse waves such as light and x-rays.
	**Thermal Energy** – this is heat, created by the *movement and vibration* of atoms and molecules inside a substance.
	**Motion Energy** -- this is the *movement* of objects and substances from one place to another. An example is the wind

The Water Authority aims for a water pressure of 100 psi as it leaves the reservoirs. The water loses enough pressure as it flows through the pipes that it is the proper pressure when it reaches your home. If 1 psi occurs at a height of 27 inches, how many *feet* high must a water tank be located for the water to have a psi of

27 inches x 1 foot = 2.3 feet 1 psi = 2.3 feet

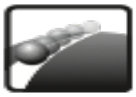
12 inches 100 psi = 230 feet

Forms of Energy

All forms of energy fall under two categories:

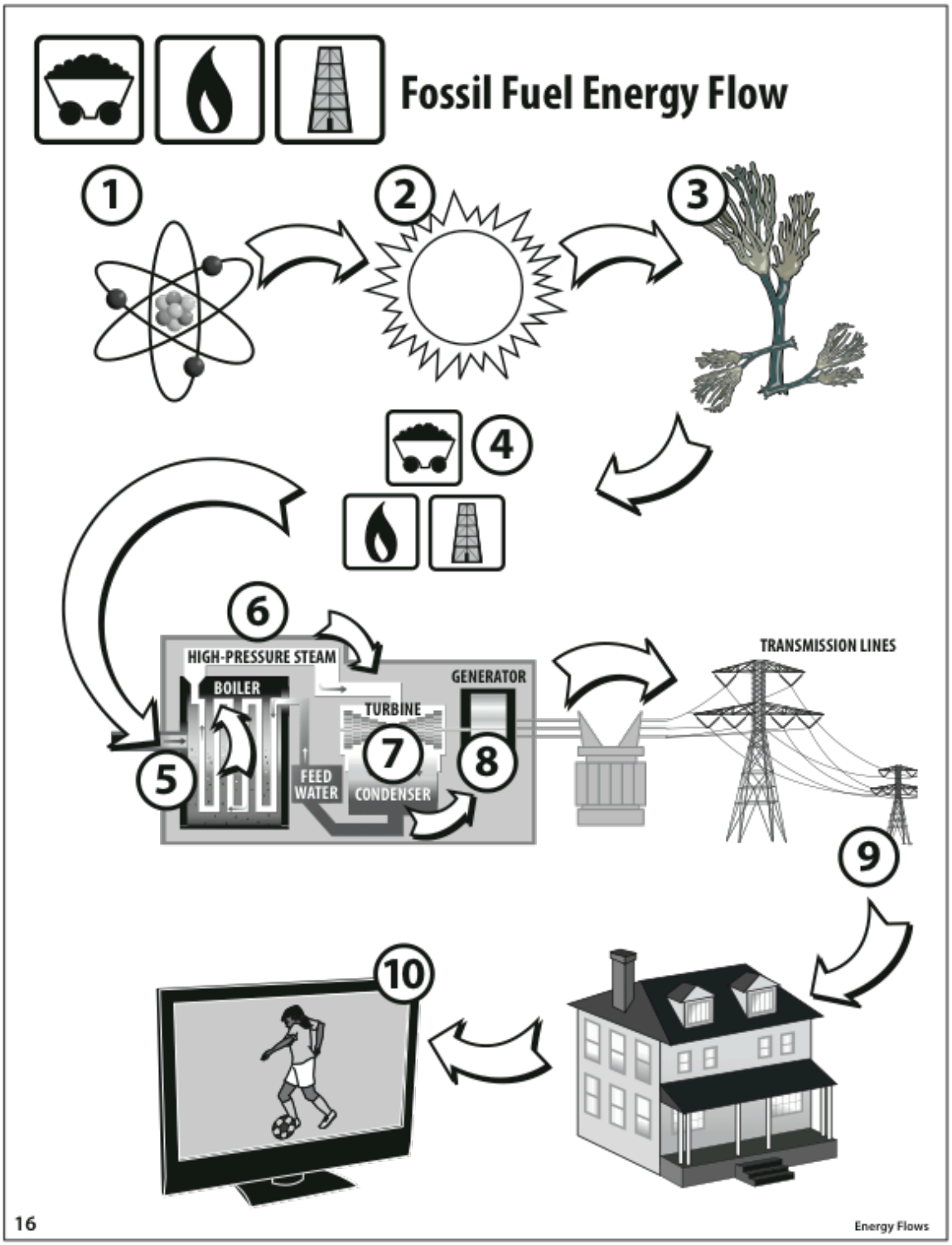
POTENTIAL

Stored energy and the energy of position (gravitational).



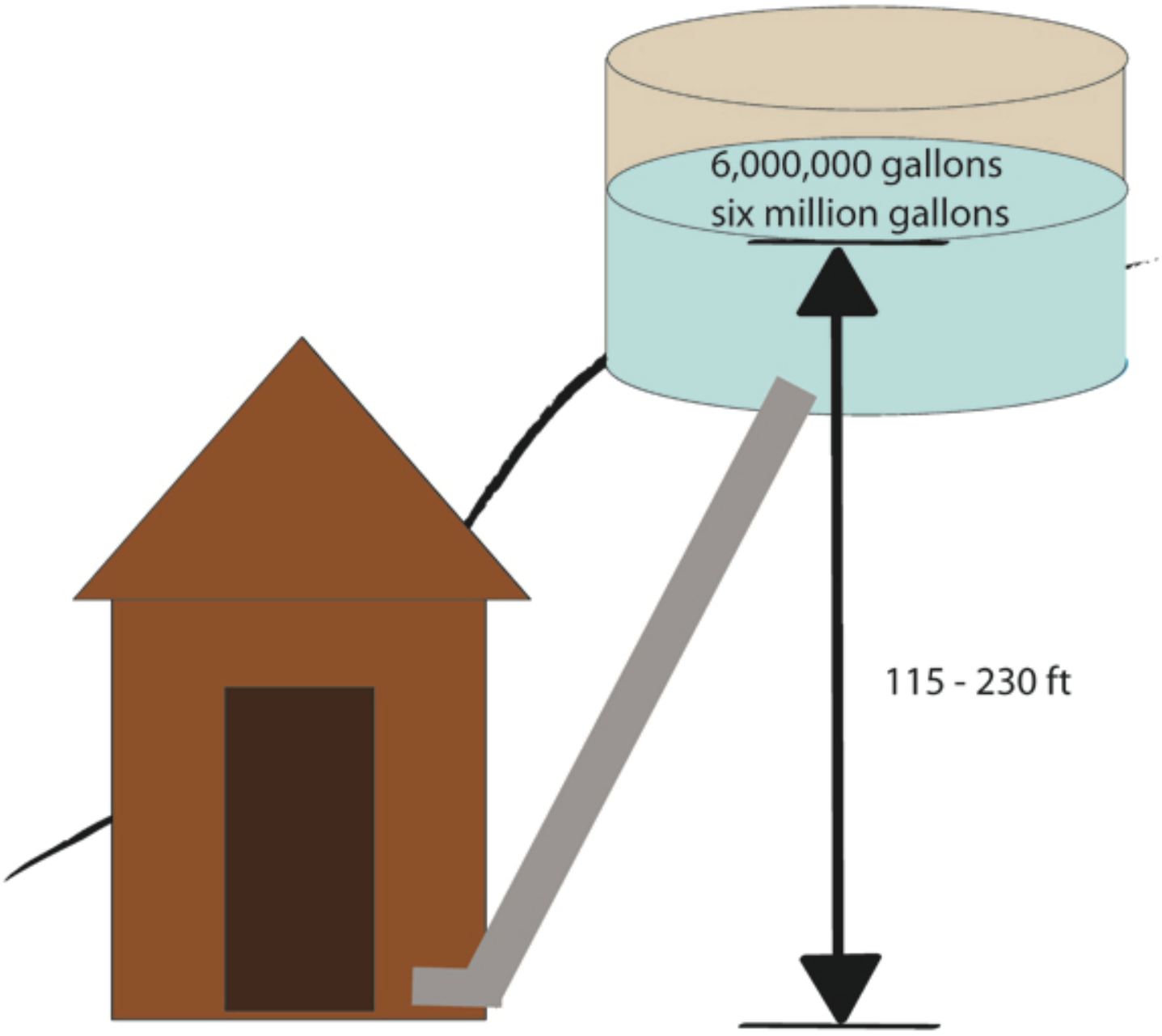
KINETIC

The motion of waves, electrons, atoms, molecules, and substances.


Fossil Fuel Energy Flow
1
2
3
4
6
HIGH-PRESSURE STEAM
BOILER
GENERATOR
TURBINE
TRANSMISSION LINES
5
7
8
FEED WATER
CONDENSER
9
10
16
Energy Flows

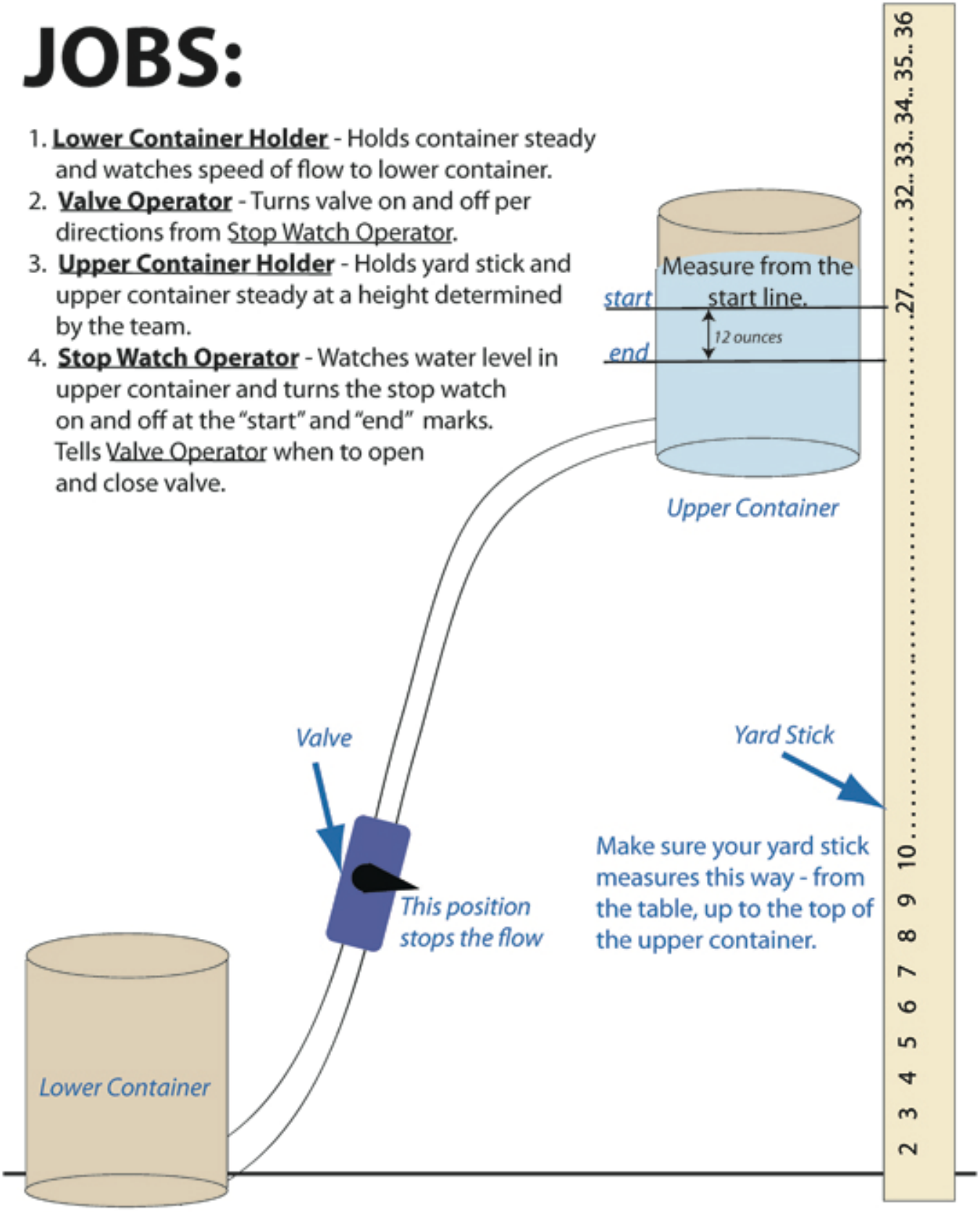
** Underground Water (wells pump water from aquifer)

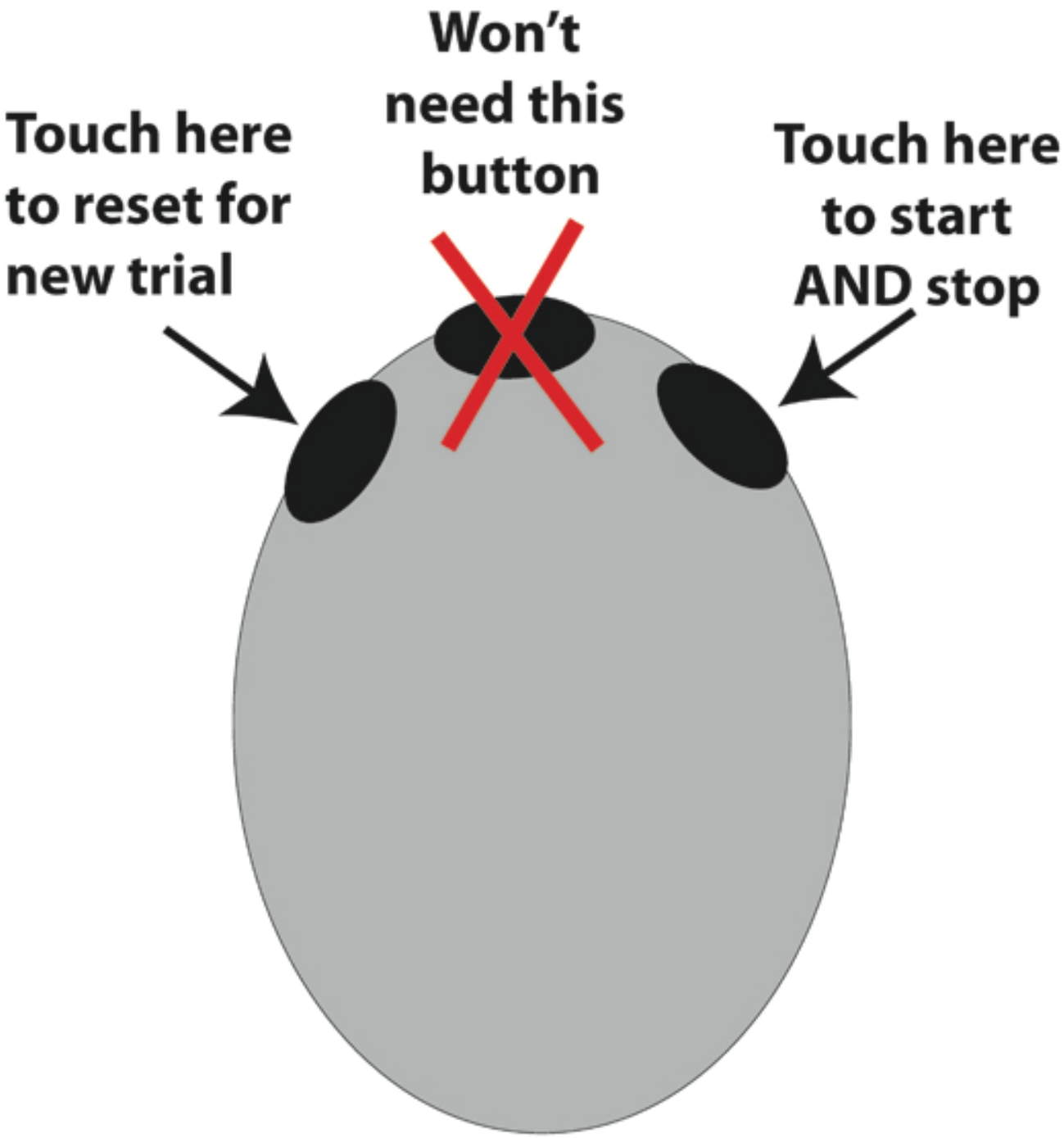
** River Water (cleaned and pumped to tanks)


6,000,000 gallons
six million gallons
115 - 230 ft

JOBS:

1. **Lower Container Holder** - Holds container steady and watches speed of flow to lower container.
2. **Valve Operator** - Turns valve on and off per directions from Stop Watch Operator.
3. **Upper Container Holder** - Holds yard stick and upper container steady at a height determined by the team.
4. **Stop Watch Operator** - Watches water level in upper container and turns the stop watch on and off at the "start" and "end" marks. Tells Valve Operator when to open and close valve.




Won't need this button
Touch here to reset for new trial
Touch here to start AND stop