Waterways
2 - 3
Teacher's Guide

California Content Standards
Grade Two: Science – 1c, 1d, 1e, 4a, 4b, 4g
Grade Three: Science – 1c, 1d, 5a, 5c, 5d

What's Going on?

The *WaterWays* exhibit demonstrates the power of water pressure to move, hold, and turn balls and wheels. A waterwheel caries balls from the platform to the ramps near the ceiling; water is directed and redirected through a maze of pipes; and a current pushes balls along a stream. The activities described in this guide help children understand how humans use water pressure to do work.

Before You Visit to CDM, explore how depth affects water pressure by creating milk carton fountains with holes at different depths. Because water is heavy and flows downward due to gravity, the deepest parts of any volume of water are under the most pressure. Thus, when there is more water above a hole, more pressure pushes it down and out of the hole. The closer a hole is to the bottom of the carton, the farther the stream will flow.

After Your Visit, explore one way that people harness water pressure to create energy by creating waterwheels. Waterwheels have been used throughout history to harness the power of water and put it to work. As water flows over or under the wheel, causing it to turn, the force of the wheel's spin turns a shaft. The shaft is usually attached to something else that works by turning, like a grinder or textile mill.

Pre-Visit Activity
Make a Water Fountain

Objective: Children will observe as water pressure pushes water out of a carton and into a tub.

What You'll Need:
For each pair of students –
1 nail
1 ruler or tape measure
Tub or basin
Pitcher of water

Other materials –
½ gallon milk cartons, at least one per child -- clean the milk cartons with warm water and detergent
Masking tape
Pencils
Student Recording Sheet A, 1 per student

What to Do:

1. Tell the children that they are going to make their own water fountains. Demonstrate the steps to making a fountain.
    a) Choose one side of the milk carton.
    b) Place the ruler in the center of that side. Measure ½ inch from the bottom of the carton and mark it with a pencil.
    c) Make a pencil mark ½ inch above the previous mark.
    d) Make a mark 1 inch above the other two.

e) Make a pencil mark 2 inches above the other three.
f) Use the nail to punch a hole at each of the pencil marks. Try to make each hole the same size.
g) When all of the holes are punched, use a strip of masking tape to cover them.

2. Pair the children and provide each pair with 1 milk carton, a nail, and a ruler. Give them time to make the holes and cover them.
3. Have children place their fountains in a tub. (Depending on how many tubs and pitchers you have, this step may be a whole class activity where each pair demonstrates in front of the class and a new variation is tried with each different pair's carton; a group activity with the group trying out the variations; or a paired activity where each pair comes to their own conclusions.)
4. Fill the carton with water, then remove the tape and watch the water flow out of the holes. Record the observations on the student recording sheet.
5. Retape the holes and fill the carton with water again. Now, remove the tape from just the bottom hole. Measure how far out the stream of water hits the tub.
6. Repeat step 5 with each of the other holes. Remove the tape one at a time, measure, and record.
7. Gather the class together to discuss the results of their experiments. Was there a difference in the streams of water that came out of each hole? *Assessment:*

Ask children to describe how water pressure creates the fountain streams.

Extensions:

- Repeat the above experiment, but instead of measuring distance, use a stop watch to time how fast the water drains from the carton. Which hole drains the fastest and has the fastest flow?
- Let each pair use the knowledge gained from the experiment to create their own fountains with holes of their choosing. Can they predict how fast and far each flow with travel? Does anything change if the holes are not all on the same side of the carton?

During the Visit Activity
Playing with Water Pressure

What You'll Need:
Hands, eyes, and brains

What to Do:
Challenge children to discover the many different uses of water pressure in the *WaterWays* exhibit as they play with the balls. You may want to use the following items as discussion starters.

Water pressure in the WaterWays exhibit:

- A waterwheel carries balls from the platform to the ramps near the ceiling. Is the waterwheel an undershot wheel (powered by water flowing under the wheel) or an overshot wheel (powered by water pouring onto the wheel from above)?
- Water is directed and redirected through a maze of pipes. How can you change the direction of the water flow?
- A water current pushes balls along a stream. Race some balls along the stream. Why can't a ball move against the current?
- Experiment with turning the wheel to make the water fountain bigger or smaller. What do you think is happening as you turn the wheel?

Post-Visit Activity
Creating a Waterwheel

Objective: Children will create a waterwheel and use it to lift a weight.

What You'll Need:
(Materials listed make one waterwheel. You will need one set per group of students.)
2 plastic coated paper plates
At least 6 plastic cups, all the same size
2 smaller plastic cups
Dowel or a rod, 3' long (maybe a broomstick)
Piece of string about 3' long
Duct tape
Pitcher of water
Weight, such as a washer or metal nut
Tub or basin
Student Recording Sheet B

What to Do:

1. Demonstrate the steps to create a waterwheel.
    a) To start making your waterwheel, poke holes in the center of the two paper plates (the hole should be big enough for the dowel to fit in) and then tape the two paper plates together, back to back.
    b) The 6 cups will become the paddles on your wheel. Tape the cups to the outside edge of your plates, equal distances from each other and facing the same direction.
    c) Poke dowel-sized holes in the center of the two smaller cups and tape those together, bottom to bottom also. Tape the string to the cups where they meet and wrap it around the cups. At the end of the string, attach your weight—the washer or metal nut. As your waterwheel turns, it should turn the shaft and the smaller cups, causing the string to wind up and lift the weight.
    d) Now, slide the dowel (or the shaft) through the center of the paper plate wheel and the smaller paper cups.
2. Divide the children into small groups of 3 or 4 and distribute the materials. Give the children time to build their waterwheels.
3. Take the groups outside. Have children hold their waterwheels over a tub. (Depending on how many tubs and pitchers you have, this step may be a whole class activity where each group demonstrates in front of the class and a new variation is tried with each different waterwheel or a group activity with the group trying out the variations.)
4. One group member holds the dowel lightly by resting it horizontally on the palm of his or her hand while the another person pours the water over the top of the waterwheel.
5. While the groups are working, circulate among the groups. Challenge them to explore some or all of the following questions:
    a) Pour water over the top of your waterwheel. Which direction does your waterwheel turn?
    b) How would you make it turn in the opposite direction?
    c) How can you make it turn faster?
    d) Pour water into the tub or basin. Hold the waterwheel so that it is in the water. (You may want to rest the dowel on the side of the tub.) Have one or two group members create a current by pushing down on the water at one end of the tub. What happens to your waterwheel?
    e) Which way makes the waterwheel turn faster – water flowing from above or below the waterwheel? *(An overshot wheel (where the water flows onto the wheel from above) is more efficient because it harnesses both the force of water and the force of gravity to turn the wheel.)*
    f) Place the waterwheel in the tub with the dowel pointing up. Create a current by pushing down on the water at one end of the tub. What happens to the waterwheel?
    g) Which method is the most efficient way to operate a waterwheel? Why?

6. Give children time to complete Student Sheet B.
7. Gather the class together as a group to discuss the results of their experiments.

Assessment:
Save Student Sheet B for documentation. Are children able to explain how the waterwheel works?

Extensions:
- Challenge children to find a way for their waterwheels to lift a heavier weight. How does the speed of water flow effect the way the waterwheel turns?
- Challenge children to determine a real life application for their waterwheel – not one that was used in the past, but one that would be useful to them today.

CDM Exhibit Page

Related CDM Lesson Plans:
Waterways: Waterwheels Work
Waterways: Whirling Waters
Waterworks: Under Pressure
Waterways: Ex-stream Pressure

Online activities:
http://www.energyquest.ca.gov/story/chapter12.html

Waterways
Student Recording Sheet A

Name _____

Measure the distance between the milk carton and the point where each stream hits the tub. How far does each stream land from the carton? Draw a picture to show the water flowing out of the carton and into the tub.

Waterways
Student Recording Sheet B

Draw and label a diagram showing the movement of your waterwheel. Be sure to show where the water comes from and how it is hitting the wheel.