Hydropower Science & Safety
Teacher's Guide

Introduction
Hydropower Science & Safety gives your students potentially life-saving information about staying safe around hydropower water facilities and when engaging in water sports, as well as important disaster preparedness information. The booklet also educates about water science and protection. Each page of the booklet is a self-contained teaching unit and may be taught in sequence with the other pages, or independently. This presentation guide provides discussion tips for each page, activity amplifications, and answers to puzzles.

Standards
The book supports multiple Science standards pertaining to energy resources, the role of water in the earth's surface processes, mapping the earth's features, and working with models. It also supports Health standards, including those pertaining to safety around water, refusal skills, and emergency preparedness.

Vocabulary
buoy – an anchored float used to show hazards for boats, or for mooring, p. 6
canal – a waterway built to convey water for irrigation, or to allow boats to go inland, pp. 5, 7-8, 15-16
condensation – when water changes state from vapor to liquid, as in clouds/rain, p. 3
dam – a barrier that holds back water and raises its level, forming a reservoir used to generate electricity or supply water, pp. 4-8
electron – a particle that travels around the nucleus of an atom, p. 4
electromagnet – a magnet in which a magnetic field is produced by a flow of electric current, consisting of a coil of copper wire wrapped around an iron core, p. 4
evaporation – when heat from the sun causes water in oceans and other bodies of water to rise into the air as vapor, p. 3
flume – a man-made channel conveying water, usually to transport logs, pp. 7, 16
percolate – soak into the earth, p. 3
pollutant – a substance that makes water dirty or toxic to life forms, pp. 14, 16
precipitation - water that falls to earth as rain, snow or hail, pp. 3, 12
reservoir – a natural or man-made lake used for storing water, pp. 3-6, 8, 10
runoff – precipitation that is not absorbed by soil, pp. 3, 12, 14-16
transpiration – the process of water evaporating from plants into the air, p. 3
watershed – an area or region of land that drains storm water into a river or other body of water, pp. 12-14, 16

Page 2: Water in Your World

Objective: To help students appreciate water as a vital natural resource and gain awareness of the limited amount of fresh water on the earth.

Background/Discussion: To drive home the concept of usable water's scarcity, introduce the famous line from Samuel Taylor Coleridge's poem, "The Rime of the Ancient Mariner:" "Water, water, everywhere, nor any drop to drink." This was the case for the thirsty seamen in the poem who were becalmed at sea without fresh water supplies. Explain that in our country we are so used to seeing water and having it in abundance, that grasping the need to conserve it can be difficult. While the booklet per se does not mention the need to conserve water, a good extension activity is to discuss the need for this, given how many things we do in life that require water, and that only 1% of the world's water supply is available for human use.

Water in Your Life Activity: Working in groups or pairs, have students create two lists: 1) ways they use water in daily life indoors, and 2) ways they use water outdoors or for fun. Then in the full class, ask groups to share what they found and record two lists on the board. Some possible answers:

- *Indoors:* baths, showers, toilets, cooking, washing clothes, washing dishes, mopping, watering plants, drinking (both humans and pets), fish tanks
- *Outdoors/for fun:* watering lawns and gardens, washing cars, swimming, boating, water play with balloons and high-pressure water soakers, water parks

When the lists are on the board, ask students which responses require *clean* water.

Page 3: The Water Cycle

Objective: To help students understand the water cycle.

Background/Discussion: The water cycle, also known as the hydrologic cycle, is a continuous natural system that keeps water always in motion. Explain that every molecule of water that was present when the earth was formed is still present today. The same water has moved from the oceans to the atmosphere, dropped down to the land, and eventually moved back to a body of water.

Review the phases of the water cycle. *Evaporation* occurs when the sun heats up water in rivers, lakes, or oceans and turns it into vapor or steam, which then rises up into the air. *Transpiration* also helps move water into the air when plants transpire (sweat) and lose water out of their leaves. Note that animals and humans too engage in the transpiration process when they sweat and breathe out—exhaled water vapor is a byproduct of cellular respiration. Ask students where the water that is part of animal and human bodies comes from. (*From food and liquids originating in the environment, making us all part of the water cycle.) Condensation* happens when the water vapor in the air gets cold and changes back into liquid, forming clouds. *Precipitation* occurs when so much water has condensed that the air cannot hold it anymore. The clouds get heavy and drop water back to the earth in the form of rain, hail, sleet, or snow. Once back on the land, water will either soak into the earth (*percolate*) or run over the soil as runoff. The sun's energy, in combination with the force of gravity, keeps the water moving without end.

Labeling Activity Answers:
1) evaporation; 2) transpiration; 3) condensation; 4) precipitation; 5) runoff; 6) percolates

Extension: Ask students to design their own water cycle diagrams, drawing and labeling the main concepts as listed above.

Page 4: The Power of Water

Objective: To teach students how hydropower works and to make them aware of the types of hydropower facilities that exist across the United States.

Background/Discussion: When flowing water is captured along the hydrologic cycle and used to generate electricity, it is called hydroelectric power, or hydropower. Electricity generated from the turbines in a hydropower facility is fed into the electrical grid, to be used in homes and businesses, and by industry.

Research Activity: Ask students to find the location of the hydropower dam that is nearest to where they live. **Extra Credit:** Identify the world's second largest renewable source of electricity, after hydropower. (Answer: *Wind power.*)

Megawatt Math: The Grand Coulee Dam produces 4729 more megawatts than the Hoover Dam. (6809 – 2080 = 4729). If available, show students on a map where the Grand Coulee Dam and the Hoover Dam are located.

Think About It: Many of the reservoirs in the Pacific Northwest are located in the high mountains for two reasons: 1) because higher areas get more rain/snowfall, and 2) so the water can flow downhill with the force of gravity to turn turbines that generate electricity. Snowmelt accounts for up to 75% of the accumulated precipitation of the US's western states.

Page 5: Energy and the Environment

Objective: To help students understand the benefits and environmental challenges posed by using various energy resources to create electricity.

Background/Discussion: Explain to students why understanding the differences between nonrenewable and renewable resources is important. Utilities have been transitioning toward generating more of their electricity from renewables in an effort to reduce CO_2 emissions. By knowing the advantages and challenges of various renewable energy resources, students will be better equipped to make informed energy decisions when they become voters and consumers. Learning about energy may also inspire career choices in this industry. Ask students if they know of anyone who is involved in any way in a green energy job.

Green Energy Research Amplification: Instead of individual research, consider asking students to research green energy resources in small groups, and then present their findings to the class. If any of the various green energy resources listed are used in your community, suggest that students find out local impacts that this resource has on the community, both positive and negative.

Extra Research Activity: Invite students to research green energy jobs. Have them develop a poster board presentation of a career or job that looks interesting to them. Their poster should include the following information: job title (and alternate names for it if there are any); education required; description of work involved; skills and abilities involved; why it appeals to them.

Page 6: Play it Safe in the Water

Objective: To provide students with safety guidelines for recreational water activities.

Background/Discussion: Many reservoirs in Central and Northern California have multiple uses, including electricity production (hydropower). Your students may live near a hydropower reservoir, or travel to one to enjoy water sports. In either case, it is important that students be aware of the function of these reservoirs, and practice basic water safety when enjoying their facilities. Ask students if they have ever gone swimming, boating, or camping near a hydropower reservoir. Ask them if they had known about the dangers of recreating near these (such as very cold or swiftly flowing water), and what types of precautions they or their family members took to stay safe.

Make a Water Safety Plan

1. The water sports listed on page 6 can be dangerous in a variety of ways, so students' answers will vary greatly.

2. Safety precautions may include the following: At all times wear the appropriate type of life jacket for your activity (check Coast Guard website for approved types for different situations); check the water before entering and don't go in if it is very cold or swiftly flowing; never enter the water alone/always go with a buddy; respect all signs and buoy markings; don't dive into water without first checking its depth.

Activity: Invite students to create a poster conveying important safety tips for play in and around water—whether a reservoir or any other body of water. If possible, invite another class to view them.

Pages 7 and 8: Dam and Canal Safety/River and Stream Safety

Objective: To teach students how to stay safe around hydropower dams, powerhouses and waterways.

Water Safety Discussion: Ask students to recall why it's unsafe to boat, swim, or play near hydropower powerhouses, canals, and flumes. (Answers include: *powerful underwater currents; icy cold water; sudden, swift water flows; slippery surfaces; submerged hazards*). Ask what can cause a slow stream to suddenly become a raging river in minutes. (Answers include*: Heavy rains, melting snows, or the sudden startup of electric hydropower generators.*) Ask students to recall signs of rising water levels in a river. (Answers include: *Louder sound of rushing water; previously exposed rocks, sticks, and brush suddenly covered with water; water flowing faster and/or deeper; more debris in the water; water now looks muddy when it didn't before; unexpected cold-water temperatures even on a warm day; sirens or flashing lights from a powerhouse.*) Ask students what they should do if any of those signs are present. (*Get out of the water and/or move far from the water's edge immediately.)*

Page 9: Water Emergency!

Objective: To teach students how to proceed in case they or someone they know is under threat of drowning or in some other sort of water emergency.

Water Emergency Discussion: Ask students for a recall of the procedures of how to respond if they are being swept along in rising/flowing waters, or if they witness someone else or a pet in this situation. (If they are swept along: *stay calm and control breathing; keep head above water; call loudly for help; remove shoes and drop anything else heavy; stay near the boat if there is one; if in a waterway, get to the side, cling to handles or branch, and wait for help; if in the middle of the water, float downstream on back with feet up, pointed downstream, moving diagonally across current until shore is reached, then roll onto dry land.* If they are witnessing someone else: *call loudly for help; tell the person to try to get to the side until help arrives; if they have a cell phone, call 911; do not try to rescue a pet, but call 911; stay there until help arrives.)*

Ask if anyone has ever been hiking or recreating around a stream or river when the water was raging strongly in a season when there had been no recent precipitation (meaning it was likely in the area of a hydropower facility). Have them describe it to the class. Ask if any student has ever witnessed or heard of someone they know drowning, or of someone getting trapped in rushing water and having trouble getting out.

Refuse a Dare Activity: Invite students to share their writings with the class. Ask for feedback on what it is that might make students say yes to a dare even if they know it's not the right thing to do. Why is it hard to say no?

Water Safety Presentation: Put students into groups, and have each group prepare a poster or Google slide set to present to the class about one of the aspects of water safety covered on pages 7-11, including 1) dam and canal, 2) river and stream, 3) water emergency, or 4) flood. Have each group be responsible for teaching the rest of the class the main ideas and tips about their area.

Pages 10 and 11: Is Your Family Prepared? Flood Safety Tips

Objective: To help students and their families prepare for a flood or other natural disasters, and to teach students how to avoid electrical hazards during a flood.

Discussion: Ask students if they have ever experienced a serious storm that involved flooding, a long-term power outage or an evacuation, or if they know someone who has. Have them share their stories with the class. Explain that being prepared ahead of time can make the stress of enduring such an event a lot easier and safer.

Ask students what precautions should be taken involving electricity during a flood. (*Do not touch electrical devices or appliances if they are wet or standing in water, and stay out of flooded basements since water conducts electricity; ask an adult to shut off electricity at the main breaker before evacuating; stay away from downed power lines, and report any to 911 and your local electric utility; if a line comes down on a vehicle you are in, call 911, stay inside until told to exit, and warn others to stay away.).*

Follow-up: Encourage students to share the tips about emergency kits, creating a contact list, family evacuation planning, and downed power line safety with parents/guardians and siblings. Have them report on their progress in assembling their emergency kits, exit maps, and lists.

Page 12: Everyone Lives in a Watershed

Objective: To help students understand that a watershed is any area of land that water flows across or through on its way toward a common body of water, such as a stream, river, lake, or ocean. Everyone lives in some type of watershed.

Background/Discussion: Watersheds can be big or small, but they have places of higher elevation as their upper boundaries. Watersheds capture water and eventually release it downhill. Ask students to think about whether the land where they live is steep or flat, and how that might affect the way the water runs off. *(Steep land will make the water flow into fast-moving creeks and rushing rivers. Flat land will allow the water to collect into lakes, ponds, and swamps.)* Explain that the runoff from smaller watersheds joins together to form larger watersheds. Examples of these are the Mississippi River and the Chesapeake Bay, which eventually drain into larger bodies of water and cover immense land areas. While looking at a map, discuss where the students see possible smaller watersheds that might flow into larger bodies of water.

Get students thinking about the impact that pavement and roofs have on a watershed. Tell them that a typical city block generates nine times more runoff than a forested area of the same size. Ask them why they think this is. *(Because a paved city block is an impervious surface that does not absorb runoff.)*

Word Game Answers:

runoff (first blank)	**watershed** (second blank)	**earth** (third blank)
soak (fourth blank)	**pavement** (fifth blank)	

Extension: Either individually or as a class, have students find out what type or types of storm water drainage occurs in your area. Have them find a storm drain near their home or your school. Ask them where they think the water flows from. What possible pollutants could get washed down into this drain? Some towns and cities label their storm drains with the names of the creeks or bodies of water they flow into. Have students find out if theirs does. For a further extension, have them draw their own storm drain logo. (Find examples on the Internet.)

Page 13: Create Your Own Watershed

Objective: To help students understand the basic properties of a watershed, how water flows from higher elevations to lower elevations, and how the placement of geographical features such as mountains, valleys, hills, rivers, and lakes can affect the path of water. Students will also gain an understanding of how contaminants and pollution can affect watersheds.

Procedures: After marking the plastic wrap in the places where students think the runoff will accumulate, it is not necessary to put the plastic wrap back on if it feels difficult to do. The act of marking it in the beginning serves to help students think about where they think the pools will occur.

Discussion: Ask students what direction the water flowed in and how it matched their predictions. What other features might affect the flow of watersheds? Students should notice that the water flowed to the lowest point, and that the contaminants collected in pools. To clean these pools, the water would need to be filtered. The model watershed resembles a real one in that it has various elevations and depressions, and the water flows down to create pools because of gravity. Pollution can also be very evident and extremely difficult to remove in both this and real watersheds. However, the model is different from a real watershed in that there are no trees or plants or soft surfaces to soak up the water. Ask students what ideas they have to reduce the impact of pollution on our watersheds and surrounding environment. (See suggestions for Page 15, below.)

Extension: Have students draw what they observed when they poured the water over their model watershed.

Page 14: Runoff and the Environment

Objective: To explain how polluted runoff can threaten our waterways and create "dead zones"—places where no plants, fish, or animals can live.

Background/Discussion: Ask students to think of all the pollutants that can be in runoff water in their neighborhoods. *(Some examples are yard debris, soaps, trash, motor oil, pool chemicals, animal waste, sediment, pesticides, fertilizers.)* Fertilizer is a big problem because it causes an overgrowth of algae when it reaches surface water. The algae consumes the oxygen in the water and blocks the sunlight needed by other plants and animals. Sediment (dirt, rust, or sand) from unplanted bare land also poses a problem. Sediment gets into runoff through the process of erosion, when storm water carries soil and gravel into the watershed. While not strictly pollution, excess sediment poses many problems in an estuary, threatening the lives of fish and other organisms that live there, as well as the animals the feed on them.

Extension Activities: Have students find out the actual size of the state of New Jersey, to understand just how big the Gulf of Mexico's dead zone is. And/or, have students conduct internet research about another "dead zone" that has been created by polluted runoff, and report back to the class. There are a few around the country now, such as off the coast of Oregon, in the Chesapeake Bay, and an estuary in the states of Maryland and Virginia. Efforts to revitalize the Chesapeake Bay dead zone have been under way since 2011, and it is now smaller than it once was, but it is still there.

Page 15: Protect Your Local Waterways

Objective: To teach students simple environmental monitoring and cleanup skills they can use to help protect their local watershed from harmful pollutants.

Background/Discussion: Discuss how important it is that everyone helps to keep our water clean. Keeping trash out of local waterways is one important way students and their families can protect our water. Discuss any other actions that students and their families currently take to keep water clean, or would like to start taking. (Possible actions to keep water clean: *Keep trash and chemicals out of toilets and drains; reduce use of chemical-based cleaning products and replace*

with nontoxic baking soda and vinegar; clean up after dogs and properly dispose of their waste in toilet or garbage; fix oil leaks from cars and properly recycle used motor oil; wash cars at a car wash to keep soap out of water sources; limit use of lawn fertilizers and yard pesticides; take leftover or used paint, pesticides, fuels, batteries, and used light bulbs to proper collections sites.) Ask students to share these ideas with their families.

Waterway Trash Cleanup Activity
Ideally, do this activity when current or recent rains have created a storm water flow along roadsides. If there's no rain, it's still fine to monitor trash and point out nearby storm drains. Procure disposable latex gloves to give students for trash collection.

Step 1: Explain that this initial "storm water" walk is to give students an overview of the area's runoff flow, where a storm drain is located (if there is one nearby), and if there is any trash in the area that might flow into the drain during rainstorms. If no trash has accumulated, locate a nearby storm drain and point it out, explaining that with heavy water flows, any trash on the ground may end up in this drain and be channeled into waterways. (Ideally, teacher should scout for storm drain in advance.)

Step 2: Have students share their findings from Step 1, and write on the board the locations that could use monitoring. NOTE: If there is no trash around the school, create a homework assignment for students to monitor an area by their home for trash, and record their daily findings in Row 1 of the chart on p. 15.

Step 5: If only home areas are monitored—not school—skip Steps 5 and 6. Instead, ask students to share how they feel being a "neighborhood trash monitor," and whether they would like to do it for another week or longer in order to protect the local watershed.

Step 6: If the amount of trash around school did not go down during week 3, ask students if they can think of why their poster campaign might not have made a difference. (Possible answers: *there was a special event during the week where the public came to campus and might have contributed to the litter; the school janitor had reduced work hours that week, or had other projects to focus on.*)

Extension: Spread the word about water protection at your school by having your class give a presentation to a younger grade or in a school assembly.

Back Cover: Get Water Wise!

Objective: To encourage students to review the important water concepts covered in the booklet.

Activity Answers: 1. glaciers; 2. vapor; 3. evaporates; 4. hydropower; 5. fish, swim, boat, raft; 6. canal, flume; 7. power line; 8. watershed; 9. pollutants; 10. protect