APPENDIX A
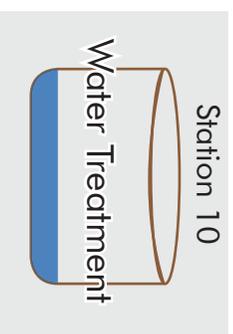
Diagram of Room Set-Up for Learning Stations

Station 6 — Reservoir

Station 5 — Groundwater

Station 10 — Water Treatment

Station 3 — Urban Runoff

Station 2 — Erosion

Station 1 — Cloud

Station 11 — Ocean

Station 7 — Residential

Station 8 — Industrial

Station 9 — Agricultural Irrigation

Station 4 — Agricultural Runoff
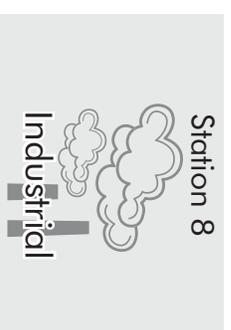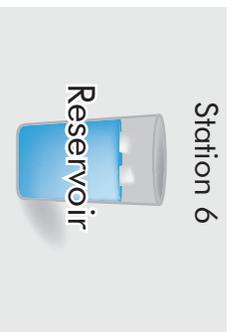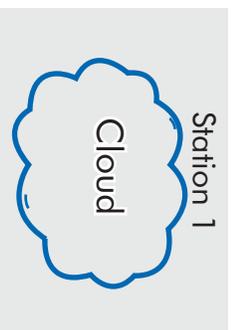
Learning Station I

Cloud

You are a raindrop falling from a cloud. Will you be used by nature, or will you be used by human activities?

Rain – Surface Runoff

Rain falls to the Earth and lands on a variety of objects: ground, trees, buildings, roads, lakes and streams. The path it takes will determine how it is used and the potential pollutants it will pick up along the way.

Directions

1. Role a die and follow the path according to the number you roll:

   a. **Roll 1**: You fall into a manmade reservoir.
   Proceed to the Reservoir Learning Station (#6)

   b. **Roll 2**: You fall onto the ground and seep into the Earth.
   Proceed to the Groundwater Learning Station (#5)

   c. **Roll 3**: You fall onto the ground and run over a hillside
   Proceed to the Erosion Runoff Learning Station (#2)

   d. **Roll 4**: You fall over a city.
   Proceed to the Urban Runoff Learning Station (#3)

   e. **Roll 5**: You fall over farmland.
   Proceed to the Agriculture Runoff Learning Station (#4)

   f. **Roll 6**: You are not heavy enough to fall out of a cloud yet.
   Stay in the cloud and return to the back of the line.

Learning Station 2 — Erosion

Your raindrop collects sediment, rock and soil as it runs down a hillside, in a process called **erosion**. Rapid erosion in an ecosystems can cause a decrease in **surface water quality** and **biodiversity**. It can also lead to mudslides and other natural disasters.

Directions

1. Add one tablespoon of soil to your water.

2. Roll the die.

   a. **Roll even:** Your raindrop runs into a reservoir. Proceed to the Reservoir (#6).

   b. **Roll odd:** Your raindrop runs into the ocean. Proceed to the Ocean (#11).

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Learning Station 3   Urban Runoff

Your raindrop lands in an urban area with many surfaces that do not allow water to effectively soak into the ground, such as asphalt and concrete. Common surface runoff pollutants that can occur in urban areas include lawn fertilizers, pesticides, automobile fluids, road deicing chemicals, household chemicals that are improperly disposed of, sediments, pathogens, fertilizers/nutrients, hydrocarbons, garbage, and metals.

Directions
1. Roll the die.

a. **Roll 1 or 2**: Your raindrop is polluted with automobile oil on a road and drains off into the surrounding soil.
Add 1 tablespoon of vegetable oil to your water to represent automobile oil.
Proceed to the Ocean (#11).

b. **Roll 3 or 4**: Your raindrop is polluted with automobile oil and runs into a storm drain and enters the sewer system.
Add 1 tablespoon of vegetable oil to your water to represent automobile oil.
Proceed to the Water Treatment Center (#10).

c. **Roll 5 or 6**: Runoff from your lawn reaches the street carrying fertilizers and pesticides and enters the storm drain and enters the sewer system.
Add a few drops of blue food dye.
Proceed to the Water Treatment Center (#10).

APPENDIX E

Agricultural Runoff

Your raindrop lands on active farmland. Agriculture can have adverse impacts on water quality.

Directions
1. Roll the die.

a. **Roll 1 or 2**: Your raindrop is polluted with a residue pesticide and/or herbicide. Add three drops of red food dye. Pesticides and herbicides are commonly used on crops in order to ensure adequate production; however, these chemicals can enter the environment and lead to environmental and health-related concerns.

b. **Roll 3 or 4**: Your raindrop is polluted with excess nitrogen causing an algal bloom. Add three drops of green food dye.
Excess nitrogen and phosphorous from fertilizers can cause a rapid increase in plant and algal growth. When the plants and algae decompose they reduce oxygen levels in the water. If oxygen levels decrease too low, they can create a hypoxic zone devoid of aquatic life.

c. **Roll 5**: Your raindrop is polluted with animal waste. Add a small handful of grass or other plant/straw matter. Animal agriculture produces large amounts of waste, including manure, bedding, spilled feed, and carcass disposal that must be managed properly in order to prevent or reduce adverse effects on the quality of water supplies.

d. **Roll 6**: Your raindrop falls onto organic farmland not using chemicals and is not polluted. Due to runoff, excess soil erodes into the surrounding surface water causing sediment pollution. Sedimentation clouds the water, reduces oxygen, and is detrimental to aquatic life. Add a small handful of soil to your raindrop.

2. Roll the die again.
a. **Roll even**: Your raindrop runs down a stream into the environment.
Proceed to the Ocean (#11).

b. **Roll odd**: Your raindrop runs down a stream into a reservoir.
Proceed to the Reservoir (#6).

Learning Station 5   Groundwater

Groundwater comes mainly from rain or snow that percolates into the ground by gravity, saturating soil and rock beneath the earth's surface. Groundwater contains the bulk of the world's freshwater supply and is commonly used for irrigation and industrial purposes. It connects bodies of water through discharge points such as springs and lakes and enters through recharge areas such as aquifers or permeable soils and rocks.

Directions

1. Roll the die.

   a. **Roll 1 or 2**: Your raindrop is polluted with salt. Add one teaspoon of salt to your raindrop. Saltwater intrusion can contaminate groundwater by mixing saltwater with freshwater and can adversely affect freshwater ecosystems.

   b. **Roll 3 or 4**: Your raindrop is polluted with human containments from leaking sewage pipes. Add one tablespoon of soy sauce to your raindrop. Human causes of groundwater contamination include underground sewage pipes and landfills. Because of its deep location beneath the Earth's surface, cleaning up contaminated groundwater is a difficult and expensive process.

   c. **Roll 5 or 6**: Your raindrop remains clean underground.

2. Select one card.

Learning Station 5 Cards

Card #1

An aquifer is a formation of soil and rocks that allow groundwater to be pumped out of the ground. Your raindrop is drawn up from the ground from a city's drinking well.

Proceed to the Residential Learning Station (#7)

Card #2

An aquifer is a formation of soil and rocks that allow groundwater to be pumped out of the ground. Your raindrop is drawn up from the ground to irrigate a local farmer's crop.

Proceed to the Agriculture Irrigation Learning Station (#9)

Card #3

An aquifer is a formation of soil and rocks that allow groundwater to be pumped out of the ground. Your raindrop is drawn up from the ground for industrial purposes.

Proceed to the Industrial Learning Station (#8)

Card #4

An aquifer is a formation of soil and rocks that allow groundwater to be pumped out of the ground. Through difference in pressure underground, your raindrop was formed through a spring and has reached the Ocean.

Proceed to the Ocean (#11)

Learning Station 6   Reservoir

A reservoir is an artificial lake used to store water. These man-made bodies of water are typically created by constructing a dam across a river. The water held in reservoirs are used for drinking water, irrigation, hydroelectric power, flood control, fire control, animal agriculture, and recreation. However, this construction of a dam changes the aquatic ecosystem and affects aquatic life upstream and downstream. Additionally, sediment that accumulates due to erosion limits the water storage capacity of the reservoir.

Directions
1. Select one card.

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Learning Station 6 Cards

Card #1

Reservoirs are commonly used to hold water for household uses and drinking water. Your raindrop has been pumped from the reservoir for household purposes.

Proceed to the Residential Learning Station (#7)

Card #2

Many reservoirs are used to store water to be used for agricultural purposes. Your raindrop has been pumped and transported for uses in a local farmer's crop.

Proceed to the Agriculture Irrigation Learning Station (#9)

Card #3

Reservoirs may store water for use in small or large industries. Many larger industries require a large amount of water. For example, nuclear power plants need a significant amount of water for cooling.

Proceed to the Industrial Learning Station (#8)

Card #4

A sudden heat wave causes your raindrop to evaporate back into the raincloud.

Proceed back to the Cloud (#1)

Learning Station 7   Residential

The average per capita water consumption in the United States exceeds 550 liters (250 gallons) per day, the most of any country. Activities that consume large amounts of water include flushing the toilet (26% of household indoor water use), laundry (22%), bathing (19%), and watering outdoor landscaping (averages vary by climate).

Throughout our daily activities, we accumulate numerous pollutants that enter our water cycle when flushed down the drain. Sewage, soap, food scraps, toilet paper, medicine, detergents, toothpaste, common household cleaners, and other chemicals are some examples of common residential pollutants that can enter the water cycle. Some of these pollutants can contribute to waterborne illnesses and can injure and kill aquatic life.

Directions
1. Roll the die.
   a. **Roll 1**: Your raindrop is polluted with phosphorous from the dishwashing detergent. Add one tablespoon of dishwashing detergent.

   b. **Roll 2**: Your raindrop is polluted with human waste. Add one teaspoon of chocolate sprinkles.

   c. **Roll 3**: Your raindrop is polluted with leftover medicine flushed. Add one tablespoon of maple syrup.

   d. **Roll 4**: Your raindrop is polluted with food wastes. Add one tablespoon of cereal/crackers.

   e. **Roll 5**: Your raindrop is polluted with other household waste. Add a square of toilet paper.

   f. **Roll 6**: The household uses phosphate-free laundry detergent. Your raindrop remains clean.

2. Roll the die again.
   a. **Roll 1, 2, 3 or 4**: Your raindrop is flushed and enters the sewer. Proceed to the Water Treatment Center (#10).

   b. **Roll 5 or 6**: Your raindrop runs down a storm drain into the environment Proceed to the Ocean (#11).

APPENDIX I

Learning Station 8 — Industrial

Industries, small and large, use large quantities of freshwater on an annual basis. **Effluents** (waste discharges) from manufacturing processes release pollutants that affect surface water sources and groundwater. Toxic chemicals and heavy metals that can build up in the tissue of plants and animals in increasing amounts through the food chain (a process called **bioaccumulation**).

Heat (**thermal pollution**), nutrients (increased nutrient loads can cause **eutrophication**, a process that depletes the **dissolved oxygen** supply). When **cooling water** is discharged back into surface waters its temperature is typically substantially higher than the water with which it is being mixed. The warmer water holds less dissolved oxygen and disrupts the natural aquatic ecosystem.

Directions
1. Roll the die.

a. **Roll 1 or 2**: Your raindrop is polluted with waste discharge from a manufacturing plant.
   Add 3 drops of blue food dye to represent chemicals.

b. **Roll 3 or 4**: Your raindrop was used in a power plant cooling process and polluted with thermal pollution.
   Add 3 drops of yellow food dye.
   This can cause a rapid increase in plant and algal growth. When the plants and algae decompose they reduce oxygen levels in the water. If oxygen levels decrease too low, they can create a hypoxic zone devoid of aquatic life because the oxygen levels are too low.

c. **Roll 5**: The hotel uses green detergent and other environmentally friendly practices. Your raindrop becomes part of the water supply for a hotel that uses green detergents. Some hotels are making a commitment to be environmentally sound.

d. **Roll 6**: The manufacturing plant treated their wastewater to remove chemicals. Your raindrop remains clean. Some industries have modified their manufacturing processes to minimize waste production or recycle their wastes, while many others use some type of **industrial wastewater treatment** technology in order to treat their wastewater.

2. Proceed to the Water Treatment Plant (#10).

Learning Station 9   Agricultural Irrigation

Agriculture in the United States accounts for 80 percent of the nation's consumptive water use. Where we choose to grow crops and raise market animals also has impacts on water consumption and water quality. Some **watersheds** may lack sufficient water supplies for suitable agricultural production; however, through human interventions such as **irrigation**, **diversions**, and **impoundments**, sufficient water supplies can be obtained.

Irrigation is a process whereby water is artificially applied to land for the purpose of assisting in crop production. This is accomplished by diverting water from one area to another, typically through pipes, canals, or ditches. Water impoundments, areas where water collects (e.g., reservoirs or ponds) that are the result of the construction of a dam or embankment, or by digging a large depression in the earth, often times facilitate irrigation. Furthermore, impoundments may serve as surface water sources for fish, and wildlife, aquaculture, recreation, and fire control.

Efficient irrigation methods conserve water and minimize water contamination. Efficiencies of three types of irrigation systems include:
◄ **Surface Systems (e.g. wild flood) - 30% efficient** - water is applied to the entire field and can run off the field.
◄ **Sprinkler System (e.g. traveling gun) - 65% efficient** - operated under pressure through perforated nozzles
◄ **Micro-Irrigation (e.g. microspray or mist) - 85% efficient** - low pressure systems that spray or sprinkle water over fields.

Directions
1. Choose the irrigation system you want to use.

2. Roll the die. The number rolled symbolizes the volume of water used to irrigate the crops.

3. Calculate the net water applied (cm3) using this formula:
Net Water Applied (cm3) = Number Rolled x 10 x % efficiency of the irrigations system chosen
Note: When multiplying by a percentage, convert the percentage to the appropriate decimal equivalent (65% = 0.65)

4. Proceed to the Learning Station based on your calculation:
   a. Net Water Applied >= 20 cm3 = Your raindrop reached the ground and drained into surrounding areas.
      Proceed to the Agricultural Runoff Learning Station (#4).

   b. Net Water Applied < 20 cm3 = Your raindrop has evaporated. Proceed to the Cloud (#1).

APPENDIX K

Learning Station 10   Water Treatment

Domestic **wastewater treatment (sewage treatment)** facilities address some issues associated with water quality. Wastewater needs to be treated because it may contain harmful **pathogens**, **toxins**, and **organic matter** that can have damaging effects on human health and the health of the local watershed.

Residential wastewater treatment is typically a four-step process:

1. In the **preliminary treatment** phase, large objects (e.g., sticks and other debris) are removed when the water passes through a large bar screen.

2. During **primary treatment**, impurities such as solid waste (which settles to the bottom) and oils (which rise to the top) are physically separated from the water.

3. The **secondary treatment** phase is where micro-organisms digest dissolved organic matter from the wastewater.

4. In the **final treatment** phase, any remaining harmful micro-organisms are killed using chlorine or ultra-violet disinfection. Prior to the treated water being returned to surface water sources, excess chorine is removed.

Directions
1. Pour your raindrop through the filter in the funnel.
   As the water filters through and is collected in the cup below, what observations can you make about the resulting effluent? Is there any residue left on the filter?

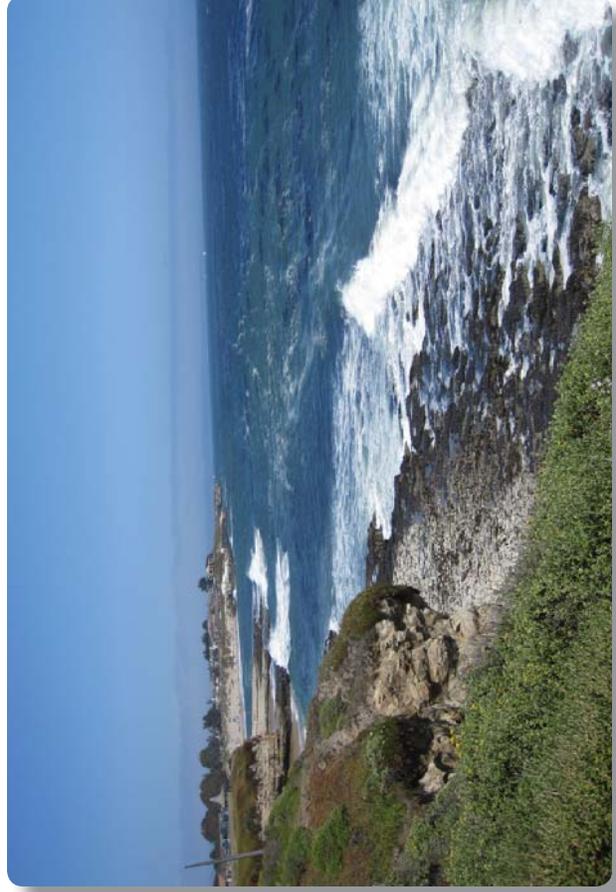2. After pouring your water through the filter, proceed back to the Cloud (#1).

Learning Station 11   *Ocean*

Water that enters the natural water cycle through rivers, streams, and surface runoff resulting from natural or human-induced activities can have numerous environmental effects. As water travels down to the lowest point, it may pick-up natural or human-created pollutants.

Directions

1. Pour your raindrop into the large bucket (using the funnel if needed). As the water filters through and is collected in the cup below, what observations can you make about the resulting mixture?

2. After pouring your water into the bucket, proceed back to the Cloud (#1).

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