



GRADE

TEACHER RESOURCE GUIDE

HUMAN IMPACT IN THE SAN FRANCISCO BAY WATERSHED

THEME:

The San Francisco Bay is an important part of a watershed where rivers and other freshwater sources flow and shape the land on their way to the ocean. People who live within the watershed impact it in many ways.

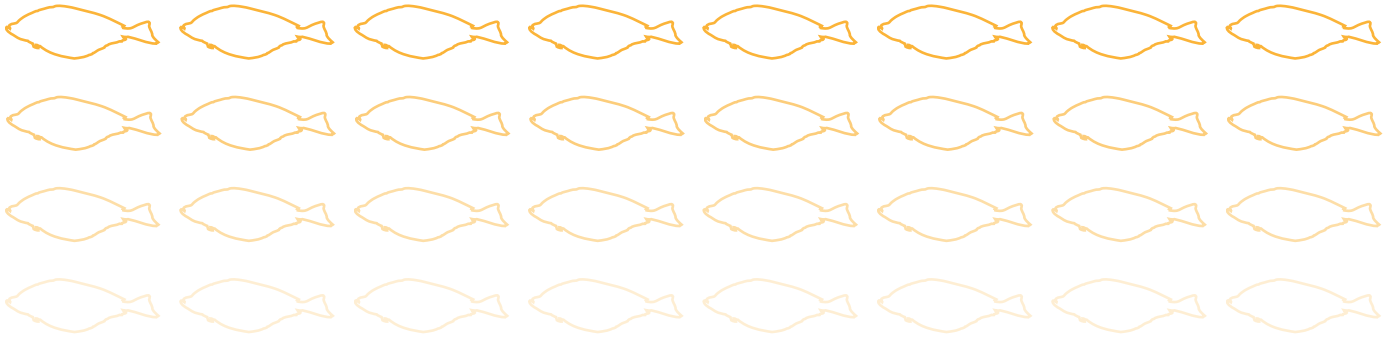
CRITICAL ISSUE:

Freshwater Flows

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SUMMARY:

The San Francisco Bay is an important part of a watershed where rivers and other freshwater sources flow and shape the land on their way to the ocean. People who live within the watershed impact it in many ways, including diverting water for drinking, building hydroelectric power plants, and using land for agriculture. Analyzing the costs and benefits of these impacts helps people make responsible choices that minimize the negative impacts they have on Earth.

In this resource guide you will find four lesson plans linked by the common theme of the natural processes of the San Francisco Bay Watershed and the impacts humans have on this environment. While the lessons may be used separately or together, the final two (Humans and the Watershed and Human Impact Analysis) can be used as a mini project for students to analyze the costs and benefits of changing our environment.

MISSION STATEMENT:

Aquarium of the Bay's Education and Conservation Department's mission is to promote literacy in ocean and watershed health, climate change issues, and science career development through the lens of critical issues such as sustainable seafood, marine protected areas, marine debris and plastics, climate change and fresh water flows.

ACKNOWLEDGEMENTS:

Aquarium of the Bay thanks the S.D. Bechtel, Jr. Foundation for their generous support for our K-12 programs and development of this Teacher Resource Guide.



SHAPING OUR LAND

LESSON 1

Enduring Understanding: The San Francisco Bay is an important part of a watershed where water shapes the landscape. A watershed connects all the organisms that live within it. The health of the watershed depends on the actions of humans living there.

Materials

- Paint trays (one per group)



- Sand/soil (about 1/2 lb. for each tray)
- Cups (two per group) or spray bottles
- Water
- 2-ft. piece of aluminum foil (one per group)
- Wide wooden sticks (one per group) (Plant labels, popsicle sticks, or tongue depressors would work.)

SETUP:

1. Assemble the following for each group:
 - 1 paint tray
 - 1 piece of aluminum foil
 - Sand/soil
 - Cup of water
 - 1 wooden stick
2. Students can put together the trays.
 - Crinkle and fold aluminum foil to form “mountains” along upper edge of the paint tray.



- Add sand or soil so the trays look like this:



PROGRAM OUTLINE:

Introduction

- Students observe a photograph of the San Joaquin River. They should notice the shape and color and what is surrounding the river. This picture shows the river with a very low flow. The reason this part of the San Joaquin River is low is because much of the water has been diverted for drinking.

Explore

- Students use the materials to create a model of a river. Students should have limited directions so that they have space to explore what happens and try different scenarios with their model.
 - Students receive the materials (tray, foil, sand, and water in cups) and are told that they'll make a model of a river to see how it is formed, how it changes in different situations, and how people change rivers with dams.
 - o Dams are barriers built in rivers to hold back water and control the release of water to generate electricity.
 - Have students set up the tray with mountains, a sloping area of land, and a bay.
 - Make it "rain" in the mountains and observe the river. Students pour water in the mountains and then draw and describe what happens.
 - o Also direct students to see what happens when the placement or amount of rain is changed. They can record what happens when there is a heavy rainstorm or it rains on top of a river. Let students experiment with different scenarios and record all their data on the student handout.



- Students also build a "dam" and observe how runoff is affected by human activity.



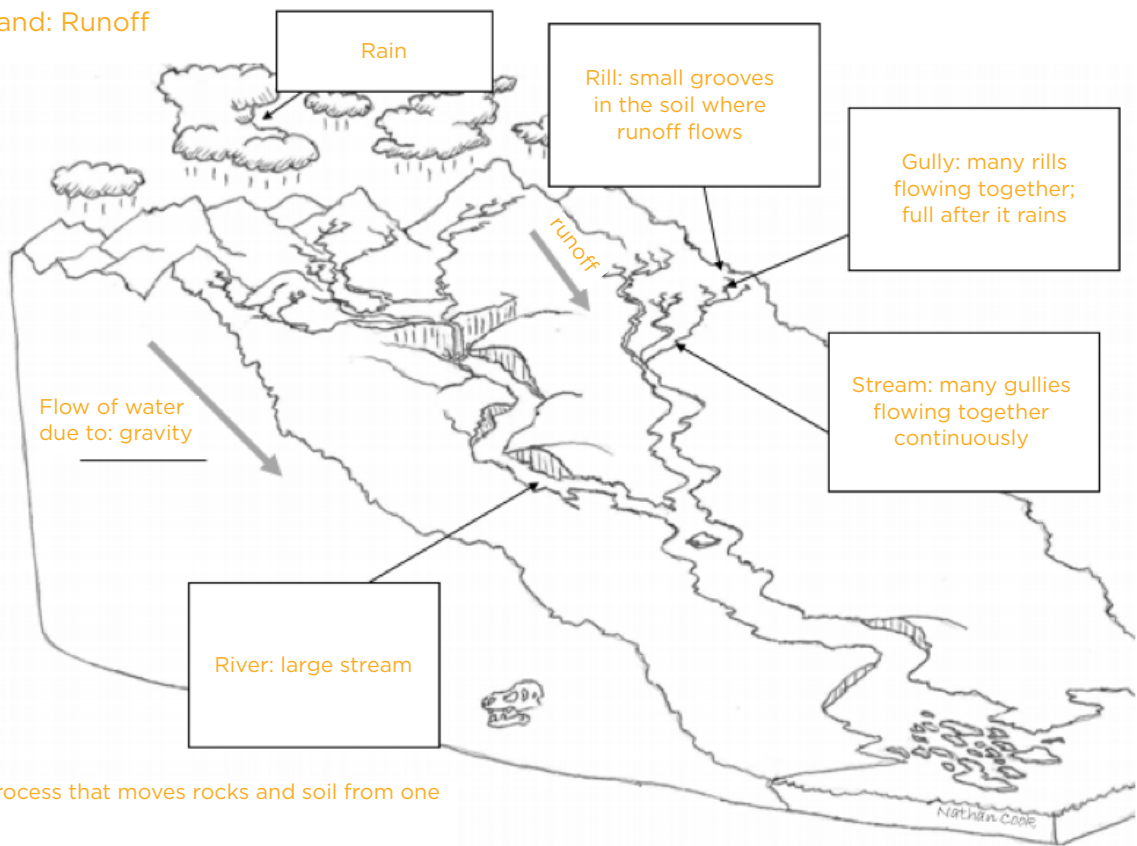
PROGRAM OUTLINE CONTINUED:

- o Specifically observe the water that has traveled to the mouth of the river (at the “bay”). Students discuss their observations with their group and determine how natural and human processes affect water flow. They will answer the questions on their papers, which can be used as notes for a larger class discussion on what situations they tried and what happened.

Group discussion and notes

- Erosion is a process where natural forces move rocks and soil from one place to another. One important cause of erosion that helps shape Earth’s surface is runoff.
- Runoff is water moving over the surface of the earth. Runoff is affected by the
 - amount of rain
 - amount of vegetation
 - type of soil
 - shape of the land
 - how people use the land
- Runoff moves downhill due to gravity and forms rills, small grooves in the soil.
 - Rills flow together to form gullies, which are often only full after it rains, and are made larger through erosion.
 - Gullies flow together to form streams, which are continuously flowing down a slope. A stream or river flows continuously from the mountains to the ocean.
 - Rivers are constantly changing and shaping the land around them through erosion and deposition. Deposition happens when soil that is carried by the river settles to the bottom.

Shaping Our Land: Runoff



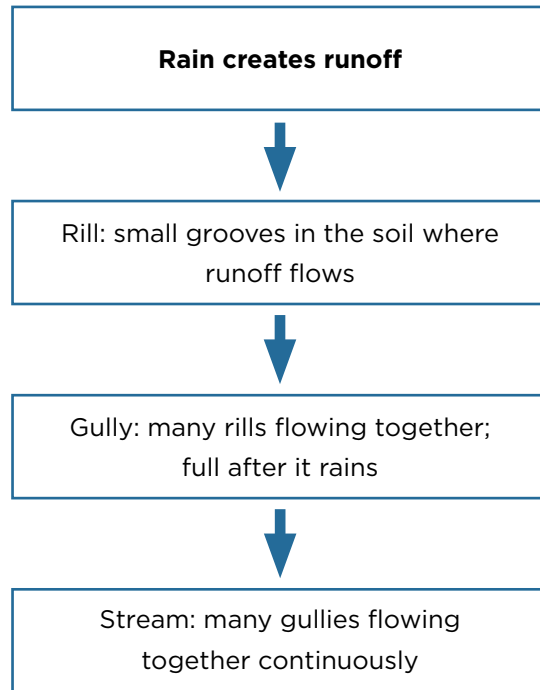
Erosion: Natural process that moves rocks and soil from one place to another

Deposition: Natural process that happens when soil carried by water settles to the bottom

PROGRAM OUTLINE CONTINUED:

Practice

- Students can complete the flow chart with a partner or individually as practice or to check for understanding.



Conclusion

- Students can share their ideas about why freshwater flowing through a watershed is important and how to conserve water.
 - Water flowing and shaping our land is important because people and all the other animals and plants need freshwater to survive and space to live. Because of these needs, it is important for us to protect our freshwater supplies by
 - o keeping pollution out of rivers (placing waste in the proper places, recycling oil, etc.).
 - o maintaining the flow of rivers (diverting less water for drinking and agriculture, taking down dams, etc.).
 - Being aware of human use of rivers (diverting water for drinking, agriculture, building dams to generate electricity) is important so we can protect our water resources and have them for the future.



TEACHER BACKGROUND:

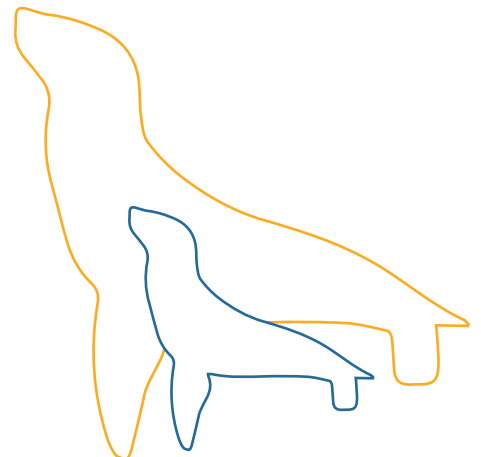
The land around us is constantly changing due to Earth's natural processes, as well as human actions. One important process that shapes our landscape is the movement of sediment through **erosion** and **deposition**. Water is an essential and dynamic part of creating habitats for plants, animals, and humans. People depend on water not just for basic needs like drinking or farming but also for generating electricity, transportation, and recreation. Because we are so dependent on our water resources, it is important to understand the processes that move and shape Earth's surface. In understanding how water erodes and deposits materials, we can better protect our resources and use them in a sustainable way so we will have them in the future.

Water erosion is an important natural process that shapes Earth's surface, moves sediment from one place to another, and provides habitats for living things. One cause of erosion is **runoff**, which is water flowing over Earth's surface. Water erosion begins with rain. Some rainwater soaks into the ground, evaporates, or is absorbed by plants, but some water flows along the surface of the land (runoff). Runoff flows downhill, due to gravity, and carries loosened soil particles or other materials as it moves. The water flowing over the ground creates tiny channels in the soil called **rills**. The rills continue to flow and converge into larger **gullies**. Gullies are generally only full of water after a rainstorm. Gullies widen due to erosion and come together to form larger channels called **streams**. A stream is differentiated from a gully not only because of its size but also because it is continuously flowing down a slope. A stream is rarely dry due to natural processes. A **river** is a large stream.

As streams and rivers flow through an area, they change the land around them. The energy in the moving water chips and grinds the rocks and sediment surrounding the water, creating wider and deeper channels. The process of water erosion creates valleys, waterfalls, floodplains, lakes, and other shapes in the land. These geographical features create important habitats for plants and animals, as well as humans.

Runoff is affected by many different factors, including the amount of rainfall, amount and types of vegetation, type of soil, shape of the land, and the ways in which people use the land. For example, deserts with low rainfall will still have a lot of runoff because there is little vegetation to stop it. Also, when people build on top of soil, water cannot soak into the soil, and surface runoff is increased. This can increase the chances of flooding in certain areas. The runoff from urban areas can contain pollutants that may be harmful to areas downstream.

Humans also have an impact on the process of water erosion and the formation of streams and rivers. Humans are constantly modifying the world around them to meet their needs. All the actions we take have an effect on the living and non-living things around us, even if we don't realize it. We can help protect these habitats and ensure that we have the resources we want for the future. Conserving water is an important action that we can all take to protect our rivers and all the living things that rely on freshwater. Helping to reverse negative human impacts, such as dams and water diversion, can help rivers continue to take their natural course.



GLOSSARY:

Deposition: Process of sediment created by weathering and erosion being laid down in a new place, changing the shape of Earth's surface

Erosion: Process whereby natural forces move rocks and soil from one place to another

Gully: Large channel in soil that carries runoff after it rains; created by the convergence of many smaller rills

Rill: Small channel in soil that is created by runoff

River: Large stream of continuously flowing water

Runoff: Water moving over the surface of the earth

Stream: Small bodies of water that are continuously flowing down a slope; created by the convergence of many smaller gullies

6TH GRADE STANDARDS:

California Science Content Standards

- 2.a. Students know water running downhill is the dominant process in shaping the landscape, including California's landscape.
- 2.b. Students know rivers and streams are dynamic systems that erode, transport sediment, change course, and flood their banks in natural and recurring patterns.

California Next Generation Science Standards

- MS-ESS2.C. The Roles of Water in Earth's Surface Processes
 - MS-ESS2-4. Water continually cycles among land, ocean, and atmosphere via transpiration, evaporation, condensation and crystallization, and precipitation, as well as downhill flows on land.

Science and Engineering Practices

- MS-ESS2-6. Develop and use a model to describe phenomena.

California Common Core Standards

ELA/Literacy

- WHST.6-8.2. Write informative/explanatory texts to examine a topic and convey ideas, concepts, and information through the selection, organization, and analysis of relevant information.

Mathematics

- MP.2. Reason abstractly and quantitatively.

Name: _____

Date: _____

EXPLORING THE RIVER PART II



<p>Try different situations (more rain, raining downstream—be creative!) Record your data below.</p>	<p>Build a dam to block the flow of your river. Make it rain again in the mountains and observe what happens to your river.</p>
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Answer the following questions about your river model:

1. What happened when it rained in the mountains? Cite evidence from your model.

2. How did the water change the land in your model?

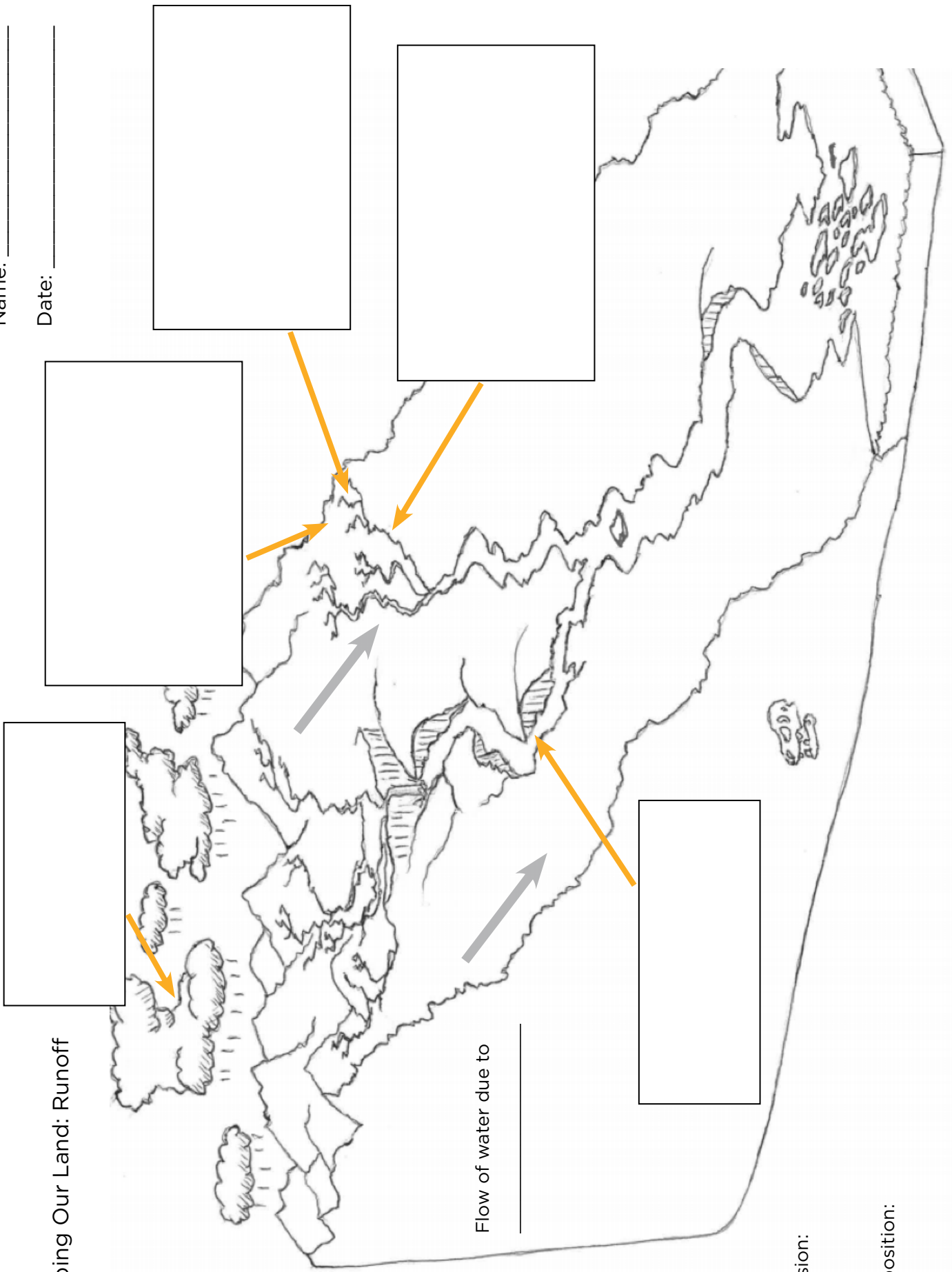
3. Observe the water that has formed a lake at the bottom of the tray. How is this water similar to and different from when it came down as rain in the mountains?

4. What happened when people built a dam blocking your river? Cite evidence from your model.

5. Why do you think rivers are important to the environment?

Name: _____

Date: _____



Shaping Our Land: Runoff

Flow of water due to

Erosion:

Deposition:

Name: _____

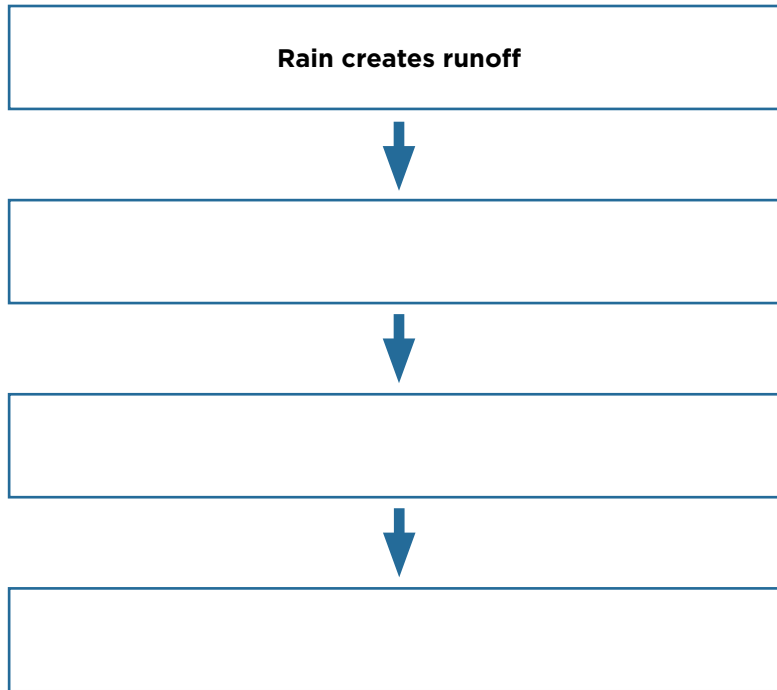
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EXPLORING THE RIVER PART III



DIRECTIONS: Complete the following flow chart with the following words and their definitions.

Stream, Rill, Gully



How Can I Help?

1. How did humans affect the rivers?

2. Streams and rivers provide important habitats for plants and animals living in and around them. List at least three actions that you can take to protect rivers and the habitats they provide.

1. _____

2. _____

3. _____

LESSON 2

A WONDERFUL WATERSHED

Enduring Understanding: The San Francisco Bay is an important part of a watershed where water shapes the landscape. A watershed connects all the organisms that live within it. The health of the watershed depends on the actions of humans living there.

Materials

- Watershed model
 - Paint tray
 - Aluminum foil mountains
 - Sand
- Cups
- Water



or pictures (see Student Materials)

- “The San Francisco Bay Delta Watershed” text
- “Watershed Connections” game cards
- Paper (one color for event cards and one color for organism cards)

SETUP:

1. Set up one watershed model, if you’re using it. Crumple aluminum foil near the top of the paint tray to form mountains; place sand about an inch deep along the inclined portion of the paint tray.



2. Make copies of “The San Francisco Bay Delta Watershed” text.
3. Copy one set of the “Watershed Connection” game cards (one color for event cards and one color for organism cards).

PROGRAM OUTLINE:

Introduction

- Demonstrate deposition and what a watershed is.
 - A **watershed** is the entire area where all the water flows into one location. This includes precipitation, surface, and groundwater. This can be done using the foil and sand model created in Lesson 1 or using the images shown in the Student Materials.
- Students will be asked to observe the color and consistency of the water in the “bay” and compare it to the water that was used to make the rain in the mountains (clean tap water). The entire model represents a watershed, and the water in the bay will have sediment that has been transported through the

PROGRAM OUTLINE CONTINUED:

watershed and then settled to the bottom.

- This can lead to a discussion of water transporting materials that have been eroded, with specific examples of the San Francisco Bay Watershed and its features.
- The San Francisco Bay Watershed includes almost half of California and includes mountains, valleys, the San Joaquin and Sacramento Rivers, the Sacramento San Joaquin River Delta, and the San Francisco Bay.
 - o A **delta** is a landform where one or two rivers flow into a body of water. It is formed by the deposition of sediment carried by the river as it flows out of the mouth of the river.



- When rivers flow downhill, they carry sediment with them and lay it down in another place. This is called deposition.
- A lot of **deposition** happens in the Sacramento-San Joaquin River Delta, where the water slows down and sediment settles out of the water.
 - o The San Francisco Bay gets sediment from rivers flowing into it, which brings in nutrients and makes it a sandy bottom habitat. Because the San Francisco Bay is also open to the ocean, saltwater comes into the bay and mixes with the freshwater from rivers. This mix of freshwater and saltwater is called brackish water. It is what makes the San Francisco Bay an **estuary**.

Have students read “The San Francisco Bay Delta Watershed” text as a whole group, in partners, or individually.

- Students will continue to explore the features of the watershed and why it is an important concept.

Interconnected Game: Students will continue to explore the importance of watersheds.

- A watershed is important because
 - it provides freshwater and habitats for living organisms.
 - it connects all living and non-living things in the watershed. Any actions taken within the watershed affect the rest of the watershed.
- Students stand in two concentric circles, facing each other. This can also be done in lines or in

PROGRAM OUTLINE CONTINUED:

- smaller groups, but students need at least three different partners during the course of the game.
- Students in the outer circle have event cards. Students in the inner circle have organism cards. The goal is to work with a partner to determine how the action/event affects that organism.
 - After a set amount of time, students rotate to the left until told to stop so they have a new partner (time this with music, a stopwatch, a certain number of students, etc.).
 - Continue changing partners and determining the interconnected nature of everything in a watershed!

Discussion of how both human and natural events affect the entire system in which the events occur.

- How do humans specifically affect the watershed? How do the non-living processes (like freshwater flows) affect the living organisms in the watershed? What actions should we take to make sure the watershed stays healthy for everyone?
- Natural events, such as storms or floods, change the physical habitat and resources available for the organisms living there.
- Humans can impact the watershed positively by restoring habitats or conserving water, or negatively by building dams, diverting water, polluting, etc.
- Every action, whether natural or caused by humans, has an impact on the rest of the watershed. Everything is interdependent.
- As informed, responsible people, we need to restore habitats, conserve water, and work to prevent habitat destruction and pollution. If we are responsible citizens, we will have the resources we need for the future!



TEACHER BACKGROUND:

The Importance of Watersheds

A **watershed** is important because it connects all the living things within it. A watershed is all the land where the water from precipitation, surface water, and groundwater flows into one location. Because all the water flowing within a watershed ends up in one place, the condition of the ending body of water is dependent on the condition of the rest of the watershed. Debris, plastics, or pollutants that enter the freshwater flow through surface or groundwater become a hazard for all the ecosystems downstream, and they are even more concentrated at the terminal point.

Humans use freshwater for a variety of needs and processes, and they all have a larger effect on the watershed. We need freshwater to survive, and humans have historically used water as a very important natural resource. Water is diverted for drinking, landscaping, and agriculture. Rivers are dammed to generate electricity. Humans use freshwater for transportation, recreation, and in the production of goods. Flowing water is a dynamic system, and humans introduce even more change to the environment. The effects of our actions are not always immediately apparent, but it is important to understand the watershed as an interdependent system of living and non-living things that is constantly changing.

The San Francisco Bay Delta Watershed

The San Francisco Bay Delta Watershed is a large watershed, spanning more than 40 percent of the area of California. The two major rivers in the San Francisco Bay Delta Watershed are the Sacramento River and the San Joaquin River. The San Joaquin River is the second longest river in California. It has been greatly affected by human development. The San Joaquin River runs near many very important agricultural areas. Urban runoff, chemical fertilizers, pesticides, and other pollutants have damaged the water quality of the river. Also, up to 95 percent of the water in the San Joaquin River has been diverted for uses in cities, as well as for agriculture. The Sacramento River includes some urban and agricultural lands, but the water quality is better than that of the San Joaquin River, and there is not as much water diverted from it.

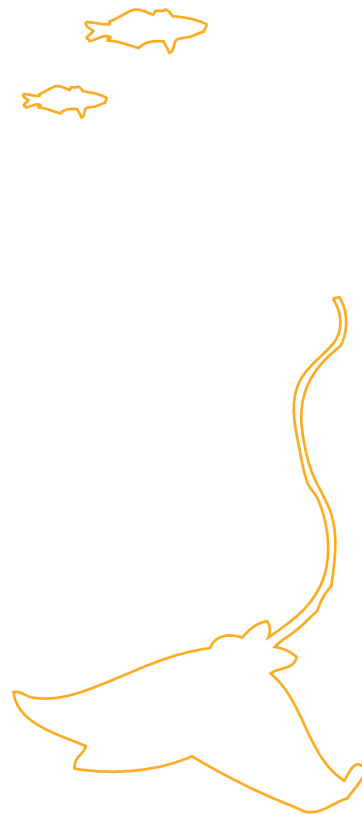
These two rivers converge before flowing into the San Francisco Bay. This inland convergence of rivers is called an inverted delta. It is an important part of the watershed. The Sacramento-San Joaquin River Delta provides valuable habitat for many different animals and fertile farmland for humans. The Sacramento-San Joaquin River Delta drains into the San Francisco Bay and then out to the Pacific Ocean through the Golden Gate.



[US Environmental Protection Agency](#)

TEACHER BACKGROUND CONTINUED:

The San Francisco Bay is an important habitat largely because of the watershed. The freshwater flowing down through the rivers meets the ocean water flowing in through the Golden Gate from the Pacific Ocean. The water mixes in the bay to create **brackish** water. These special conditions in the San Francisco Bay and delta create the largest **estuary** on the west coast of the Americas. Estuaries are highly productive ecosystems. The San Francisco Bay and delta are home to around 750 species of animals. The high productivity of this ecosystem is partly due to the high levels of nutrients that flow through the rivers. Sediment that is carried by rivers through the watershed is deposited on the substrate when the water flow slows down at the delta and the body of water into which it flows. This creates a habitat able to support a high number and diversity of species.



GLOSSARY:

Brackish: Water that is a mix of saltwater and freshwater

Delta: Landform built up where one or two rivers flows into a lake or ocean and sediment settles out of the water; shapes of sediment deposits include fan, cuspate, and bird's foot; The Sacramento-San Joaquin River Delta has a fan shape, but it is inverted because the Sacramento and San Joaquin rivers converge and then flow into the San Francisco Bay.

Estuary: Body of brackish water connected to both the ocean and a freshwater source

Watershed: Area of land where all the water from precipitation, groundwater, and surface water flows into one location

6TH GRADE STANDARDS:

California Science Content Standards

- 2.a. Students know water running downhill is the dominant process in shaping the landscape, including California's landscape.
- 2.b. Students know rivers and streams are dynamic systems that erode, transport sediment, change course, and flood their banks in natural and recurring patterns.

California Next Generation Science Standards

- MS-ESS2.C. The Roles of Water in Earth's Surface Processes
 - MS-ESS2-4. Water continually cycles among land, ocean, and atmosphere via transpiration, evaporation, condensation and crystallization, and precipitation, as well as downhill flows on land.

California Common Core Standards

ELA/Literacy

- WHST.6-8.2. Write informative/explanatory texts to examine a topic and convey ideas, concepts, and information through the selection, organization, and analysis of relevant information.
- WHST.6-8.9. Draw evidence from informational texts to support analysis, reflection, and research.

Name: _____

Date: _____

MODELING A WATERSHED

Observe the following pictures of a watershed model and then answer the questions next to the pictures.



1. Describe the water in the cup that is being poured over the mountains.

2. What happens to the soil as the rivers flow downhill?



3. What is different about the water when it gets to the bottom (the “bay”)?

Name: _____

Date: _____

THE SAN FRANCISCO BAY DELTA WATERSHED



Figure 1: San Francisco Bay Delta Watershed
<http://www2.epa.gov/sfbay-delta/about-watershed>

People rely on freshwater for drinking, growing food, transportation, recreation, and making products like books, clothes, or plastic water bottles. Animals and plants need freshwater to survive. Moving water provides habitats for living organisms and is constantly changing the landscape where we live. Water can do amazing things like create waterfalls or carry nutrients from one place to another. California has many rivers and streams carrying freshwater from the mountains to the ocean. These rivers connect all the organisms in their path. They are all part of the **watershed**.

What Is a Watershed?

A **watershed** is an area of land where all the rain, surface water, and groundwater flow into one place. The map in **Figure 1** shows San Francisco Bay Delta Watershed in California. This watershed covers more than 40 percent of California and flows into the San Francisco Bay. The major rivers in this watershed are the Sacramento River and the San Joaquin River. The flowing water erodes the soil around it and carries sediment downstream. These two rivers come

together to form the Sacramento-San Joaquin River Delta. A **delta** forms when rivers flow into a still body of water like a lake or the ocean. The sediment that the river carries settles to the bottom and creates a landform. The freshwater from the rivers flows into the San Francisco Bay and mixes with the saltwater flowing into the Bay from the Pacific Ocean. This mix of freshwater and saltwater creates an **estuary**, an important habitat for many animals.

The Importance of Watersheds

Watersheds have many parts, including mountains, valleys, rivers, lakes, deltas, and bays. The flowing water continuously creates many different habitats for plants and animals. The sediment that is carried by rivers and deposited in a delta or bay has nutrients, or food, that the animals need to survive. This creates an important habitat for plants and animals. There are 750 different species that make their home in the San Francisco Bay Delta! Salmon is one example of an animal that needs different parts of the watershed to survive. Salmon are born in freshwater streams. They migrate into estuaries to develop, and they spend their adult life in the ocean before returning to their home stream to reproduce.

The watershed also connects all the organisms within it. All the plants and animals living in the San Francisco Bay Delta Watershed are affected by changes anywhere in the watershed. This means that any human actions will affect organisms living in other parts of the watershed. Trash or pollution that gets into streams will flow through the watershed and out into the bay. Taking water out of the rivers will destroy habitats for animals living downstream. Positive actions also affect the watershed. Cleaning up and restoring a stream can give animals a new habitat. Leaving water in a stream will let freshwater get to the bay, bringing nutrients that the animals there need to survive. You make choices every day that affect the world around you.

Name: _____

Date: _____

THE SAN FRANCISCO BAY DELTA WATERSHED CONTINUED



1. What is a watershed?

2. The San Francisco Bay Delta Watershed covers _____ percent of the state of California.

3. What is an estuary?

4. What makes an estuary a productive habitat that can support many different animals?

5. Why are watersheds important? Explain your reasons.

EVENT CARDS



<p>There is a severe drought in California. Only half the normal amount of rain and snow has fallen in the mountains.</p>	<p>Logging companies are cutting down trees along the Sacramento River.</p>
<p>There is a severe rainstorm in Sacramento. Many of the nearby streams and rivers are flooding.</p>	<p>A volunteer program in Auburn plants native trees in their area.</p>
<p>Stockton is using water from the San Joaquin River for drinking water, landscaping, and agriculture.</p>	<p>All the sixth grade students at a school in Fresno decide to only use reusable water bottles to reduce the amount of plastic in the watershed.</p>
<p>The Friant Dam was built on the San Joaquin River near Fresno. This dam caused 60 miles of the river to run dry.</p>	<p>A neighborhood in Oakland is only planting native plants in their yards. Native plants need less water as grass to survive.</p>
<p>There are many large farms in the San Joaquin Valley that use fertilizer to help their crops grow. As it flows by, the water in the ground picks up the fertilizer.</p>	<p>A family in Pleasanton washes their car in the driveway. All the soapy water is rinsed into the storm drain.</p>
<p>Cars in San Jose are leaking oil onto the road instead of recycling it properly. It rains the next day.</p>	<p>A family in Merced accidentally left the sprinklers on in their yard while they were on vacation for a week.</p>
<p>A sixth grade class in Fremont decides to organize a day to clean up Alameda Creek.</p>	<p>Farms in the watershed use irrigation to make sure their crops have enough water to survive.</p>
<p>People having a picnic in the Sacramento-San Joaquin River Delta leave their trash on the ground.</p>	<p>In Redwood City, plastic shopping bags left on the ground are blown away by the wind.</p>
<p>One of the dams in the San Francisco Bay Delta Watershed was removed and more water is flowing through its river.</p>	<p>Schools in San Francisco are teaching students how to conserve water at school and at home.</p>

ORGANISM CARDS



<p>Humans</p> <p>Humans eat fish and other animals. They need water for drinking, agriculture, making products.</p>	<p>Leopard Shark</p> <p>This most common shark in San Francisco Bay eats clams, crabs, and worms that live in the sand.</p>
<p>River Otters</p> <p>These mammals eat fish, crayfish, and bird eggs. They need clean water to hunt and survive.</p>	<p>Bat Rays</p> <p>These fish live in the San Francisco Bay and have their babies in the shallow, protected waters.</p>
<p>Trout</p> <p>These fish in freshwater. They eat fish, eggs, and crustaceans. They are eaten by fish and mammals.</p>	<p>Newt</p> <p>This amphibian lives in freshwater.</p>
<p>Baby fish in the San Francisco Bay</p>	<p>Deer</p> <p>This mammal relies on freshwater and plants to survive.</p>
<p>Sturgeon</p> <p>These fish can live in freshwater or saltwater. They lay their eggs in cold, clean freshwater.</p>	<p>Mallard Duck</p> <p>This bird lives in freshwater. They stop in wetlands in California to rest during their long migration south in the winter.</p>
<p>Egret</p> <p>This water bird eats fish and small mammals. They are often found in estuaries.</p>	<p>Black Bear</p> <p>This mammal eats salmon, grasses, and berries.</p>

ORGANISM CARDS



<p>Cattail</p> <p>Plants that live in marshes on rivers or estuaries. Marshes slow flowing water. Sediment and pollutants settle out.</p>	<p>Phytoplankton</p> <p>Plant-like plankton that live in water and make up the base of the food chain.</p>
<p>Harbor Porpoise</p> <p>This marine mammal lives in the bay and needs clean, unpolluted water to live.</p>	<p>Zooplankton</p> <p>Animal plankton that live in water and eat phytoplankton and other zooplankton. Small fish eat them.</p>
<p>Eelgrass</p> <p>A plant that lives in the bay and provides food for animals and habitat for many baby animals.</p>	<p>Salmon</p> <p>These fish are born in freshwater, develop in estuaries, live as adults in the ocean, and swim back to freshwater streams to lay eggs.</p>

HUMANS AND THE WATERSHED, MINI PROJECT DAY 1

LESSON 3

Enduring Understanding: A watershed connects all the organisms that live within it. The health of the watershed depends on the actions of humans living there. Humans impact their environment and use natural resources. Analyzing the costs and benefits of human actions helps people make responsible and sustainable choices about how we use those resources.

Materials

- “Humans and the Watershed” handout

SETUP:

1. Make copies of “Humans and the Watershed” handout.

PROGRAM OUTLINE:

Introduction

- What do humans need to survive? Students brainstorm what humans need to survive in their environment. They will also determine what humans are doing to meet these needs.
 - Food: from farming, gathering, hunting, or raising livestock
 - Water: from rivers and lakes, precipitation
 - Shelter: using trees and other natural resources
 - Space: by clearing land

Analysis of natural resources in the San Francisco Bay Delta Watershed

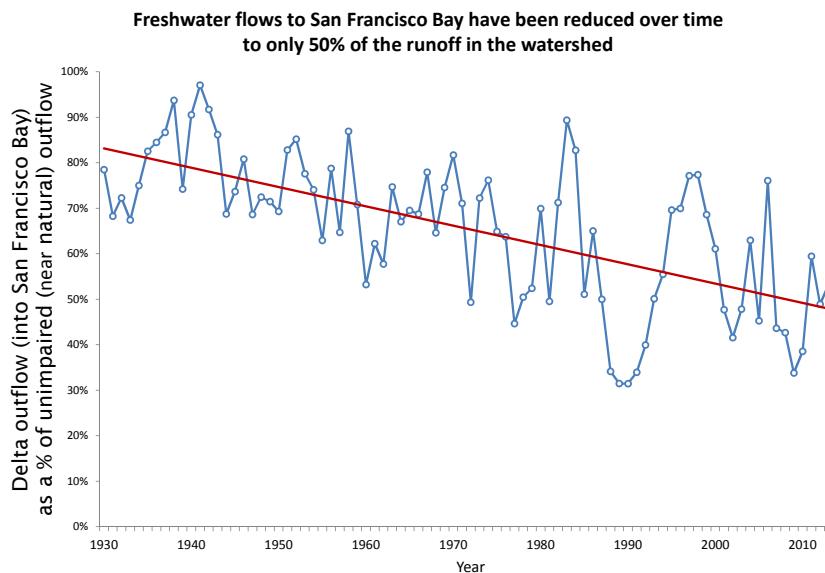
- Students work with a partner and use a map of the watershed to answer questions about how people use water and how that impacts the rest of the river and watershed.
 - People often settle near water because it is an important natural resource for drinking, as well as for growing food.
 - When people take water out of rivers, they reduce the habitat for the animals living there, there are fewer species, and the people living downstream have less water.



PROGRAM OUTLINE CONTINUED:

Negative impacts of humans on the watershed

- Students read about various negative impacts that humans have on the watershed and analyze a graph showing the amount of water that has been diverted from the San Francisco Bay Delta. They also answer an opinion question about their thoughts on water diversion. This can be discussed as a class or with a partner.
- There are several ways in which humans use their natural resources to meet their needs. These uses impact the watershed.
 - Water diversion for urban uses or irrigation
 - o In the 1940s, the Friant Dam was built on the San Joaquin River at the edge of Millerton Lake. Up to 95 percent of the river's flow was diverted.
 - o Water is being diverted upstream and in the delta in increasing quantities.
 - o Water diversion destroys habitats, creates an unbalanced ecosystem, and limits the water available in other areas.



The Bay Institute

What does this graph show?

This graph shows that the freshwater flows into San Francisco Bay are now half of what they were in 1930.

Is the amount of water flowing out of the delta increasing or decreasing?

Decreasing

Do you think this is good or bad for the environment? Why?

This is bad for the environment because freshwater brings sediment to make habitats and food. Animals need the freshwater to live there.

- Agricultural runoff
 - o Contains excess nutrients (phosphorous and nitrogen) and degrades water quality
 - o May also contain pesticides that contaminate water
- Building dams to generate electricity
 - o Hydroelectric power is renewable.
 - o Dams destroy habitats and block waterways necessary for animals to travel (salmon).

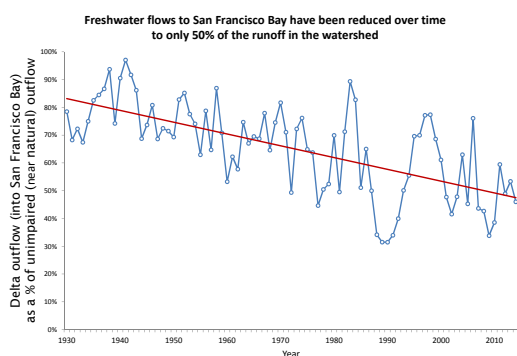
TEACHER BACKGROUND:

This lesson is the first in a mini project analyzing the use of water as a natural resource in California. This lesson is intended to serve as an introduction and background information day so that students can begin to think about why humans use natural resources and the balance that must be struck between our needs and the availability of resources. We must also be aware of the consequences of our actions, even when acquiring a necessity, such as water.

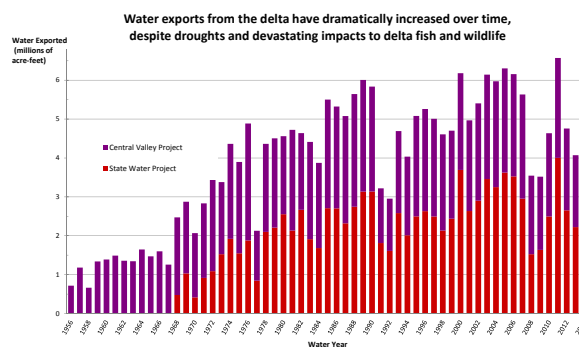
Humans meet their basic needs as well as their social and cultural needs using their natural resources. People need food, water, shelter, and space to survive. We also have a high demand for energy to run our buildings, move from place to place, and communicate with one another. People change the environment around them with buildings, roads, farms, cities, and dams. These changes have an impact on the natural world. Human impact on the **watershed**, in particular, happens in several ways, including water diversion and agricultural and **urban runoff**.

Water diversion occurs when water is pumped out of rivers and other parts of the watershed. It is diverted for both urban and agricultural uses, such as drinking, landscaping, and irrigation. One example of this is the San Joaquin River, the second longest river in California at over 350 miles. In the 1940s the San Joaquin River was dammed near Millerton Lake. Because of this, up to 95 percent of the water in the river was diverted, and at one point 60 miles of the river ran dry. This caused a huge drop in the salmon population, the destruction of the habitats of many other species, and poor water quality. This human action affected not only the local wildlife but also the human populations living downstream who relied on the water. The Bay Institute is currently implementing a restoration project to regain 18 percent of the river's historic flows and reintroduce the salmon populations.

Dams also block the waterways animals use to travel. Salmon, for example, are born in freshwater streams, migrate out to San Francisco Bay, where they undergo smoltification and become saltwater fish, and then migrate back to their home stream to reproduce. Blocking this pathway is detrimental to the salmon populations.



The Bay Institute



Agricultural runoff occurs when chemical fertilizers and pesticides used on agricultural lands get picked up by water and carried through the watershed. These pollutants can end up in the Sacramento-San Joaquin River Delta, the surrounding wetlands, and San Francisco Bay. The San Joaquin Valley has very productive agricultural land. There is a lot of runoff from this land, however, and it has contaminated many of the drainage ponds, the San Joaquin River, and other natural bodies of water. It has also harmed water birds and other animals using the water.

GLOSSARY:

Agricultural Runoff: Pollutants, such as chemical fertilizers, pesticides, or excess nutrients, picked up by groundwater on farms and carried through the watershed

Urban Runoff: Pollutants, such as oil, trash, plastics, and other harmful substances, picked up by water in cities and carried through the watershed

Watershed: Entire area of land where all the water from precipitation, groundwater, and surface water flows into one location

Water Diversion: Pumping water from a water source and moving it to another place where water is less available for human uses

6TH GRADE STANDARDS:

California Science Content Standards

- 2.b. Students know rivers and streams are dynamic systems that erode, transport sediment, change course, and flood their banks in natural and recurring patterns.
- 7.c. Construct appropriate graphs from data and develop qualitative statements about the relationships between variables.

California Next Generation Science Standards

- MS-ESS2.C. Human Impacts on Earth Systems
 - MS-ESS3.C. Human activities have significantly altered the biosphere, sometimes damaging or destroying natural habitats and causing the extinction of other species. But changes to Earth's environments can have different impacts (negative and positive) for different living things.

California Common Core Standards

ELA/Literacy

- WHST6-8.9. Draw evidence from informational texts to support analysis, reflection, and research.

Mathematics

- 6.SP.B.4. Summarize numerical data sets in relation to their content.

Name: _____

Date: _____

HUMANS AND THE WATERSHED



Human Survival

What do humans need to survive?	How do they get it?

Natural Resources

The map below shows the San Francisco Bay Delta Watershed. Study the ways the rivers are connected to each other and then answer the questions on the right



1. Looking at the map of rivers and thinking about what humans need to survive, where do you think would be a good place to live? Why?

2. How would a river change if you took water out of it?

3. How would taking water out of a river affect the animals that live in the river?

4. How would taking water out of a river affect other people?

<http://www2.epa.gov/sfbay-delta/about-watershed>

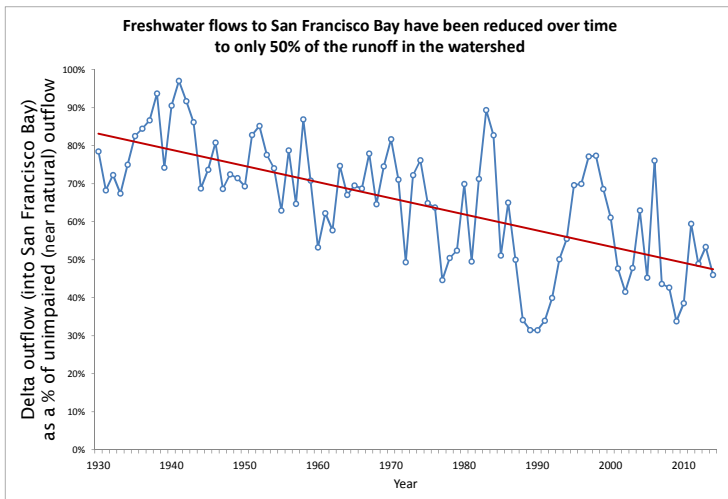
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Date: _____

WATER DIVERSION IN THE WATERSHED



Humans have basic needs that are required to survive. Humans need to drink water, eat food, and have a safe place to live. In order to do these things, humans use natural resources found in their environment. Water is necessary for survival and an important natural resource that people use. Taking water out of a river is called water diversion. People take water out of rivers for many reasons, not just to drink. Water is used for growing food, raising animals to eat, washing, and making goods. While it is important that people have enough water, it's also important to think about the consequences of our actions. When we take water out of rivers, it affects the whole watershed. It destroys habitats and forces some animals to find a new home.



The Bay Institute

What does this graph show?

Is the amount of water flowing out of the delta increasing or decreasing?

Do you think this is good or bad for the environment? Why?

Humans can impact rivers in other ways. One of these ways is agricultural runoff. When we farm to get food, we also add fertilizer and sometimes pesticides to the soil. These are chemicals that get picked up by the water in the ground. When this water flows through the watershed, it pollutes the water it flows into and harms animals and habitats downstream. This also happens in cities. When pollution like oil on the street or chemicals in yards washes down the city storm drains when it rains, the pollution ends up in the watershed and the bay! This is called urban runoff.

Do you think water diversion should be happening in our watershed? Why or why not? Be specific.

HUMAN IMPACT ANALYSIS, MINI PROJECT DAY 2 & 3

LESSON 4

Enduring Understanding: A watershed connects all the organisms that live within it. The health of the watershed depends on the actions of humans living there. Humans impact their environment and use natural resources. Analyzing the costs and benefits of human actions help people make responsible and sustainable choices about how we use those resources.

Materials

- Student data packet
- Watershed Weekly magazine template

SETUP:

1. Make copies of student data packet.
2. Copy Watershed Weekly magazine template for each student (double-sided).
 - Create magazine: Cut on the dotted lines, then slide the half sheet with page one through the slit in the middle of the half sheet with the cover page. Fold it in half to create a book with four pages.

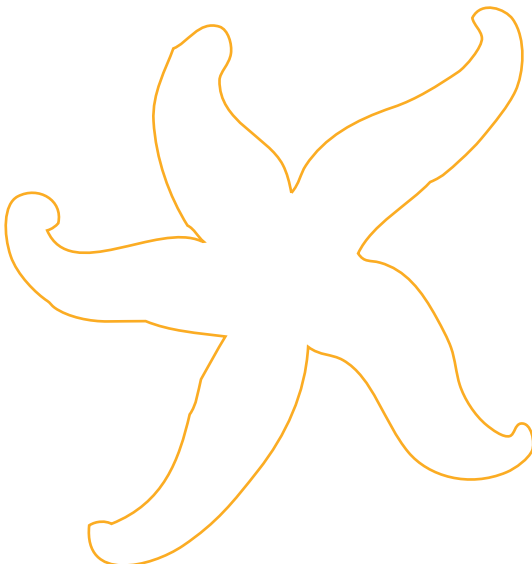
PROGRAM OUTLINE:

Introduction

- Discuss the main ideas of the previous lesson.
 - Humans use natural resources to meet their needs, such as for food and water.
 - Human actions impact the entire watershed in either a positive or negative way. Everything in the watershed is connected.
 - Water diversion is one major negative impact that humans have had on the watershed.

Project and data analysis

- Students analyze data showing water diversion from the Sacramento-San Joaquin River Delta. They will work with a partner to determine the impact that this water diversion has had on the environment.
 - Water diversion from the delta has been increasing over time.



PROGRAM OUTLINE CONTINUED:

- There are pros to water diversion:
 - o Readily available water to drink
 - o Water transported to locations with less water availability; used to grow food or livestock
 - There are cons to water diversion:
 - o Destruction of habitat for local animals
 - o Degradation of water quality
 - o Decrease in water flow to San Francisco Bay, decreasing nutrients available to organisms there
- Students create an argument about the future of water diversion in this area. Should it be increased, decreased, or stay the same? Why? Students should use evidence from the data provided to support their conclusion.
- Students write their conclusion as a magazine article (or other format) that includes
 - Introduction to the delta and its importance; explanation of concept of water diversion
 - Pros of water diversion
 - Cons of water diversion
 - Student's opinion about whether the current water diversion should be increased, decreased, or the same

Closing

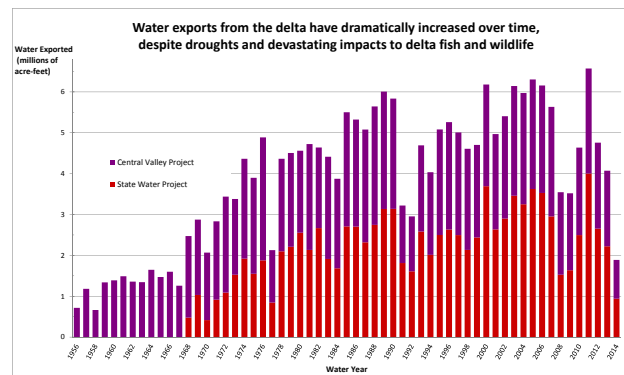
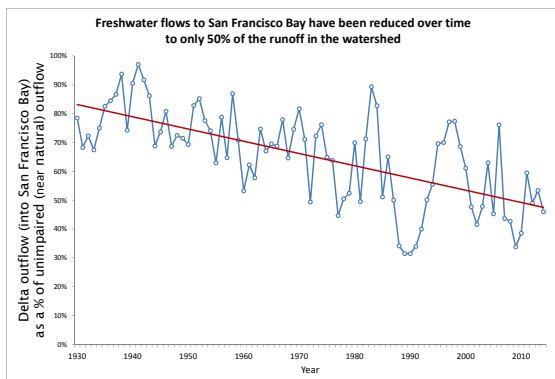
- Students share their opinions and arguments with the class by one of the following:
 - Informal discussion with small group or whole class about the issue and their personal and differing opinions
 - Formal presentation of each student's argument
 - o It's important to be aware of differing opinions people have about issues and respect others' opinions. Remind students that it's important to consider all sides to an issue.



TEACHER BACKGROUND:

Humans meet their basic needs as well as their social and cultural needs using their natural resources. People need food, water, shelter, and space to survive. We also have a high demand for energy to run our buildings, move from place to place, and communicate with one another. People change the environment around them with buildings, roads, farms, cities, and dams. These changes have an impact on the natural world. Human impact on the **watershed**, in particular, happens in several ways, including water diversion and agricultural and **urban runoff**.

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The Bay Institute

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Water Diversion: Pumping water from a water source and moving it to another place where water is less available for human development

6TH GRADE STANDARDS:

California Science Content Standards

- 7.c. Construct appropriate graphs from data and develop qualitative statements about the relationships between variables.
- 7.d. Communicate the steps and results from an investigation in written reports and oral presentations.

California Next Generation Science Standards

- MS-ESS2.C. Human Impacts on Earth Systems
 - MS-ESS3.C. Human activities have significantly altered the biosphere, sometimes damaging or destroying natural habitats and causing the extinction of other species. But changes to Earth's environments can have different impacts (negative and positive) for different living things.
- MS-ESS3-3. Apply scientific principles to design a method for monitoring and minimizing a human impact on the environment.

California Common Core Standards

ELA/Literacy

- RST.6-8.1. Cite specific textual evidence to support analysis of science and technical texts.
- WHST6-8.1. Write arguments focused on discipline content.

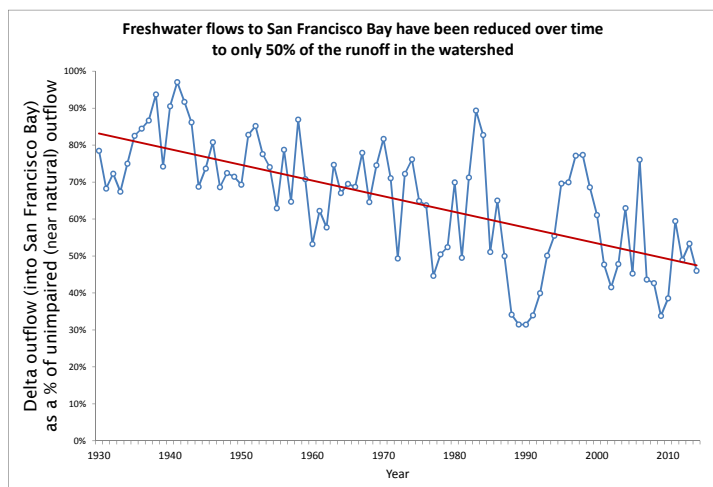
Mathematics

- 6.SP.B.4. Summarize numerical data sets in relation to their content.

Name: _____

Date: _____

WATER DIVERSION DATA

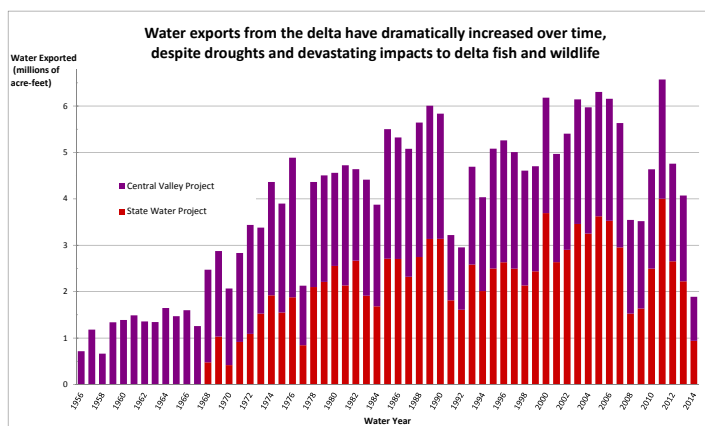


The Bay Institute

What is this graph measuring?

Is more or less water flowing into San Francisco Bay in 2010 compared to 1930?

How do you know?



The Bay Institute

What is this graph measuring?

Is more or less water flowing into San Francisco Bay in 2010 compared to 1930?

How do you know?

Agricultural Production in the San Joaquin Valley: Statistics

• The San Francisco Bay Delta Watershed includes 7,000 square miles of agriculture. <http://www.epa.gov/region9/strategicplan/sanjoaquin.html>

• The San Joaquin Valley grows over 250 different crops.

http://vric.ucdavis.edu/virtual_tour/sanjoq.htm

• California produces nearly half of the fruits, nuts, and vegetables grown in the U.S. <http://www.cdfa.ca.gov/statistics/>

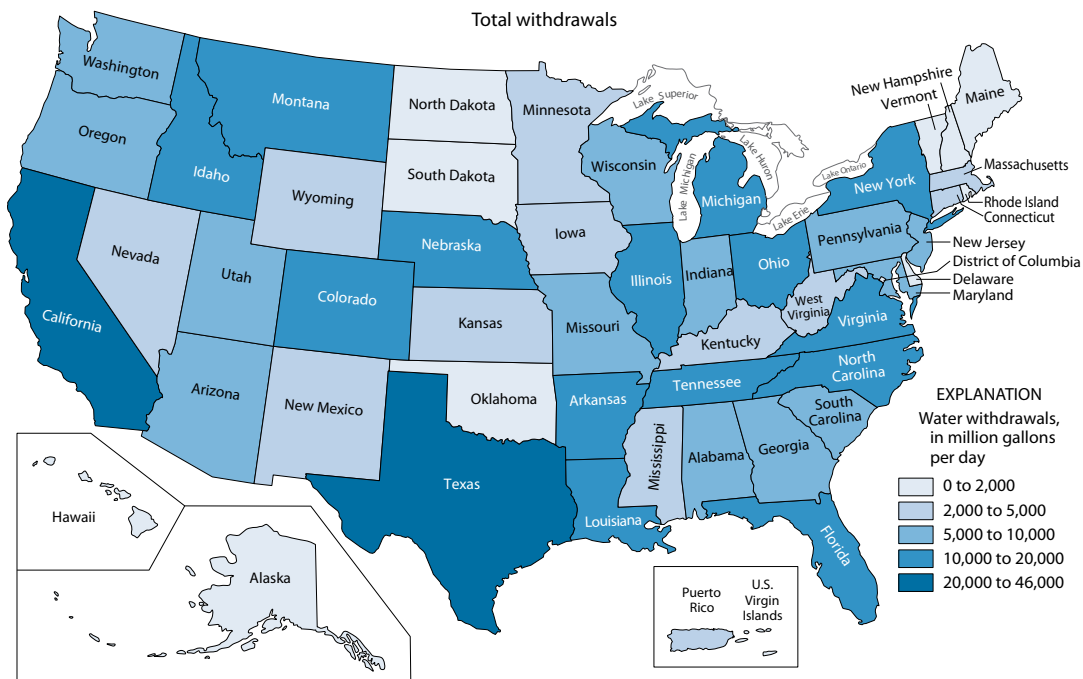
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WATER DIVERSION DATA CONTINUED

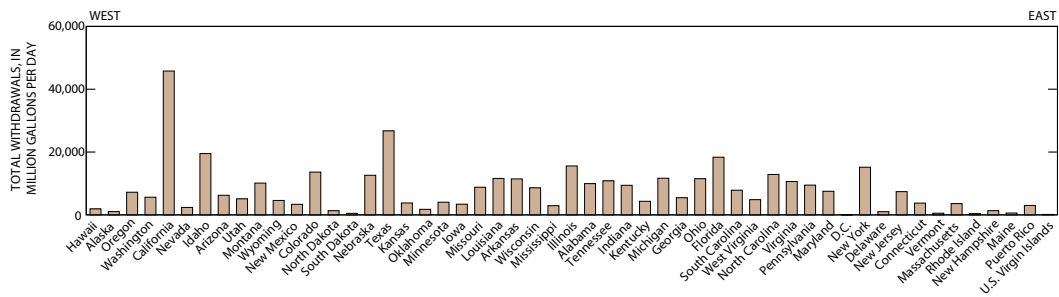


Estimated Use of Water in the United States in 2005



EXPLANATION
Water withdrawals, in million gallons per day

- 0 to 2,000
- 2,000 to 5,000
- 5,000 to 10,000
- 10,000 to 20,000
- 20,000 to 46,000



What is measured in this diagram? _____

Approximately how much water is being used in California each day? _____

How does California's water use compare to other states? _____

Why do you think this is? _____

Name: _____

Date: _____

WATERSHED WEEKLY MAGAZINE BRAINSTORM



Introduction

The Sacramento-San Joaquin River Delta
What is a delta?

Where is the Sacramento-San Joaquin River Delta?

Why is this delta important?

Water diversion
What is water diversion?

Why do people divert water?

Pros of water diversion

1.

2.

Cons of water diversion

1.

2.

My opinion

Do you think the water diversion in the delta should be increased, decreased, or stay the same?

Why?

Evidence:

6TH GRADE

RESOURCES



Websites

- Aquarium of the Bay

<http://aquariumofthebay.org/otterly-amazing/river-otter-conservation/otters-in-the-sf-bay-watershed>

The river otter exhibit focuses on the importance of watershed health and how it connects the organisms living there. The website has information about the San Francisco Bay Watershed and what we can learn from river otters specifically.

- The Bay Institute

www.bay.org

The Bay Institute is committed to the protection and restoration of the San Francisco Bay and its watershed. The website has information on projects in the bay, coast and ocean, rivers, and delta.

- The Bay Model

<http://www.spn.usace.army.mil/Missions/Recreation/BayModelVisitorCenter.aspx>

The Bay Model was built by the U.S. Army Corps of Engineers in Sausalito in 1957. The hydraulic system is designed to model the flows and circulation in the San Francisco Bay and parts of the Sacramento-San Joaquin River Delta. The visitor center website includes information about the model, the bay, the delta, and some history of exploration in the area, as well as “Marinship” (a World War II assembly yard for ships).

- San Francisco Estuary Institute

<http://www.sfei.org/>

The institute provides local scientific information. The “Data Center” includes many tools showing water quality, landscape ecology, and historical maps of the bay and its watershed.

- San Francisco Estuary Partnership

<http://www.sfestuary.org/>

This coalition of different groups and individuals around the San Francisco Bay is working to restore and protect the area. The website has information about estuaries, reports, videos, and plans to restore the natural habitats in and around San Francisco Bay.



6TH GRADE

RESOURCES CONTINUED



Websites Continued

- Save the Bay

<http://www.savesfbay.org/>

Information on pollution, restoration, and volunteer opportunities in and around San Francisco Bay. The website lists many teacher resources, including watershed-specific lessons.

- Sierra Club, San Francisco Bay Chapter

<http://sfbay.sierraclub.org/environment/clean-water.htm>

This national environmental organization is dedicated to exploring and protecting the earth. The website includes information about current issues in water use, management, and conservation in the San Francisco Bay Area.

- U.S. Environmental Protection Agency

www.epa.gov

The EPA works to protect the environment and human health. The website has information about the scientific and human aspects of various environmental issues and legal issues.

- U.S. Geological Survey

<http://www.usgs.gov>

USGS is a science organization that reports information on the environment, natural hazards, natural resources, and climate change. It offers scientific publications and educational materials.



6TH GRADE

RESOURCES CONTINUED



Books

- Dobson, Clive, and Gregor Gilpin Beck. *Watersheds: A Practical Handbook for Healthy Water*. Buffalo: Firefly Books, Ltd., 1999.

Contains the basics of watershed ecology and dynamics, as well as human impact issues and action items

- Grace, Stephen. *Dam Nation: How Water Shaped the West and Will Determine Its Future*. Guilford: Globe Pequot, 2013.

Written as a narrative describing the history of human urbanization and water usage in the American West

- Ingram, B Lynn, and Frances Malamud-Roam. *The West without Water: What Past Floods, Droughts, and Other Climatic Clues Tell Us about Tomorrow*. Berkeley and Los Angeles: University of California Press, 2013.

Describes the history of climate- and water-related natural events in the American West; includes human impacts on water in the West and implications for our future water resources

- Lund, Jay, Ellen Hanak, William Fleener, William Bennett, Richard Howitt, Jeffrey Mount, and Peter Moyle. *Comparing Futures for the Sacramento-San Joaquin Delta*. Berkeley and Los Angeles: University of California Press, 2010.

Detailed academic exploration of the Sacramento-San Joaquin River Delta; includes overview of the delta region, history of the delta and human impact in the area, management issues, and future directions for water management

- Okamoto, Ariel, and Kathleen Wong. *Natural History of the San Francisco Bay*. Berkeley and Los Angeles: University of California Press, 2011.

Natural history guide of the San Francisco Bay and its watershed; includes information on the natural characteristics of the bay and watershed, estuaries, area wildlife, climate change, human impact, and conservation efforts