Student Reading
Part 1- Exploring the San Francisco Watershed

A watershed, also called a drainage basin, is the area in which all water, sediments, and dissolved materials drain from the land into a common body of water, such as a river, lake, estuary, or ocean. A watershed encompasses not only the water but also the surrounding land from which the water drains. Watersheds range in size from huge areas like the Mississippi River drainage basin to small areas like your backyard. A large watershed is made up of smaller ones, which may be made up even smaller ones. These watersheds within a watershed can be called sub-watersheds.

Whether large or small, a watershed's characteristics can greatly affect how water flows through it. For example, if the terrain in the watershed is steep (like in a canyon), rainfall can wash down into the river quickly, causing flash flooding. In general, in a watershed with steep terrain with little vegetation, heavy rain can cause rapid increase in stream flow. In other watersheds, heavy rains will cause a gradual increase in stream flow. For example, on heavily vegetated, relatively flat terrain, much of the rainfall is absorbed by the soil, and runoff is slowed by vegetation, so the water takes a longer time to reach the river. In these areas, stream flow will rise slowly even after heavy rains. These differences in the watershed change the quality of water in the rivers. For example, swiftly moving water, like that found in a steep watershed or after very heavy rains, are more likely to be muddy (have high turbidity).

Human-made features of the watershed, like dams or large paved areas, can also change stream flow and alter the watershed. Water flows off paved areas very quickly because it can't be absorbed by the soil and there is no vegetation to slow the flow.

Water quality of a body of water is impacted by everything that goes on within its watershed. Mining, forestry, agriculture, and construction practices, urban runoff from streets, parking lots, chemically-treated lawns and gardens, failing septic systems, and improperly treated municipal sewage discharges all affect water quality. Reducing pollution and protecting water quality requires identifying, regulating, monitoring, and controlling potential sources of pollution. Some examples of control practices include creating small wetlands or catchment basins in urban areas to trap sediment and pollutants flowing off paved areas before they reach the river. Creating and/or protecting wetlands throughout the watershed is beneficial because wetlands slow runoff, absorb floodwaters, and filter sediment and other pollutants from the water.

Estuaries are semi-enclosed bodies of water where freshwater meets the ocean (or Great Lake). As such, they lie at the mouth of watersheds. Large estuaries, like Chesapeake Bay, Mississippi River Delta, and San Francisco Bay are made up of many sub-watersheds and drain large portions of the United States.

San Francisco Estuary is a shallow, extremely large estuary and its' watershed drains about forty percent of the land in California. Nearly ninety percent of the fresh water flowing into the estuary comes from the Sacramento and San Joaquin Rivers. The saltwater comes from the Pacific Ocean.

In this activity, you will virtually explore the San Francisco Estuary and its' watershed. Later in the activity, you will analyze and interpret graphs of water-quality data collected at China Camp State Park in San Rafael, CA. China Camp is located on the northwest shore of the estuary and was the site of a Chinese shrimp-fishing village where some 500 people lived in the 1880s. The location is part of the San Francisco Bay National Estuarine Research Reserve (NERR). The water quality data you will examine in Part 3 of this activity were collected at this site.

Student Worksheet
Part 1 — Exploring the San Francisco Watershed

In this part of the activity, you will examine the San Francisco Bay's estuary and watershed, and then investigate the impact of the natural and man-made features that cause materials to be carried down river into parts of the estuary.

1. Look at your color copy of the "Oblique View" of the San Francisco Bay Area on *Student Data Sheet 1 — Exploring the San Francisco Watershed*. Locate the San Francisco Estuary in the middle of the image. Use a dark-colored marker and outline any high ridges or mountains you see surrounding low basin areas. Did you outline the San Francisco Estuary's watershed? Does your outline include smaller sub-watersheds that make up the larger Estuary's watershed? Adjust your outline, if necessary, so the entire San Francisco Estuary's watershed is outlined. Are there small watersheds that are not part of the San Francisco Estuary's watershed?

Part 1 — Exploring the San Francisco Watershed (continued)

Now you will take a closer look at both the estuary and the nature of the watershed using Google Maps with Earth view. If you are unfamiliar with Google Maps, your teacher will give you a short demonstration on how to navigate and change your viewing altitude. Enter 37° 48' 53.12 N, 122° 28' 38.26 W, the coordinates of the Golden Gate Bridge, into the Search box. After taking a look at the bridge, increase your viewing altitude (zoom out) so you can see the entire San Francisco Estuary. Zoom back in so you can see the Golden Gate National Recreation Area to the north and most of the city of San Francisco to the south, as well as some of the Pacific Ocean to the west and Treasure Island to the east. The scale bar in the bottom right of the screen should say "1 mile". This is a good viewing altitude to explore at.

2a. Fly around the bay in a clockwise direction, identify the rivers that empty into the bay, and list the name of the river (if you can find a label) or the closest labeled landmark to where the river meets the bay.

2b. Describe what kinds of human activity or evidence of man-made changes you see along the shore of the estuary.

2c. What is the most interesting thing you saw along the shoreline? What do you wonder about it?

Part 1 — Exploring the San Francisco Watershed (continued)

When you return to the Golden Gate Bridge, check your list of major rivers. Did you notice a huge channel entering the estuary called the "Carquinez Straight". Fly back to it and follow the channel east past Grizzly and Suisun Bay to Browns and Sherman Islands. Two major rivers intersect here—the Sacramento and San Joaquin Rivers. Follow the northern river (Sacramento) along its course. When it branches, keep taking the northern branch until you can no longer observe its course. At this point, search for "source of the Sacramento River" in the map's search bar. It should take you to a remote part of the Klamath Mountains. Try to loosely follow the path of the water as it travels from the source all the way to the San Francisco Estuary.

2d. List at least five interesting features you noticed on the journey back to the estuary.

1. _____

2. _____

3. _____

4. _____

5. _____

Travel back to the junction of the two rivers and trace the path of the San Joaquin River and locate its source (using search feature on the map). You should end up in a remote part of the Ansel Adams Wilderness called Thousand Island Lake. Try to follow the water as it travels from Thousand Island Lake all the way to the San Francisco Estuary.

2e. How is the land that the San Joaquin River travels through different from that of the Sacramento River?

Student Worksheet
Part 2 — What's Upstream Comes Downstream

You will now take a closer look at a sub-watershed within the San Francisco Estuary's watershed and try to determine the nature of the pollutants and contaminants that might be washed downstream into the estuary by heavy rain and floods. Choose a medium sized river flowing into San Francisco Estuary to follow upstream (good choices are Napa River or Coyote Creek). Napa River enters the estuary in the north, near the Mare Island Shipyards and the city of Vallejo. Coyote Creek enters the estuary at the South Bay Salt Ponds, near the San Jose-Santa Clara Wastewater Facility. Fly low—1,000 feet on the scale bar to start with —to see features that could be possible sources of contaminants.

Selected River (circle one): Napa River Coyote Creek

2a. List ten possible sources of pollutants or contaminants along the river. Record the source and an approximate place name or latitude and longitude coordinates for it.

Possible Source of Pollution/Contaminants	Name or Location
1. _____	_____
2. _____	_____
3. _____	_____
4. _____	_____
5. _____	_____
6. _____	_____
7. _____	_____
8. _____	_____
9. _____	_____
10. _____	_____

Part 2 — What's Upstream Comes Downstream (continued)

2b. What do you think is the most likely source of pollution and contamination along the river you investigated?

2c. Can you see any evidence that contaminants are being released into the river?

2d. How could you collect evidence of pollution or contaminants?

2e. Did you see any natural or manmade features that might clean the water before it enters the river or estuary?

Student Worksheet
Part 3 — Water Quality at the Mouth of a Watershed

In this activity, you will make predictions about how a major storm might affect water quality in San Francisco Estuary, specifically at China Camp State Park in San Rafael, CA. Imagine the following: A major storm dumps several inches of rain across the watershed of the San Francisco Estuary. Regional flooding occurs along rivers flowing into the estuary and the runoff increases the volume of fresh water running into the estuary.

3a. Predict how this major rainfall event would affect these water quality factors in the estuary (i.e. would they increase, decrease, or stay the same) and briefly explain your reasoning:

	Increase, Decrease, Same	Patterns/Changes
Water Temperature		
pH		
Dissolved Oxygen		
Salinity		
Turbidity		

3b. Consult the *Student Data Sheet 2, Part 3: Water Quality Data*. These are graphs of real data collected by automated instrument. Familiarize yourself with the graphs; they show water-quality data from before, during, and after a major rain storm. Can you determine from looking at the graphs when the storm started? What evidence did you use to determine when it occurred?

Part 3 — Water Quality at the Mouth of a Watershed (continued)

3c. Look at the graphs again and record what happened to each of the water quality parameters in response to the storm. Did the parameter increase, decrease or stay the same? Describe patterns or changes you notice.

	Increase, Decrease, Same	Patterns/Changes
Water Temperature		
pH		
Dissolved Oxygen		
Salinity		
Turbidity		

3d. How well did your predictions match what actually happened during the storm event? For any predictions that didn't match, explain why your original reasoning may or may not have been correct.

Student Data Sheet - 1
Part 1: Exploring the San Francisco Watershed

Student Data Sheet 1:
Oblique View

Figure 5. An oblique view of the San Francisco Bay area showing the outer margins of the large watershed drained by the San Joaquin and Sacramento Rivers. The Sierra Nevada Mountains are on the top right edge of the image. The vertical scale has been exaggerated by a factor of 5.

Student Data Sheet 1:
Optional Resource: Road Map

Figure 6. Road map of the San Francisco Bay area

Student Data Sheet 1:
Optional Resource: Satellite View

Figure 7. A satellite view of the San Francisco Estuary.

Student Data Sheet 1:
Optional Resource: San Francisco Estuary

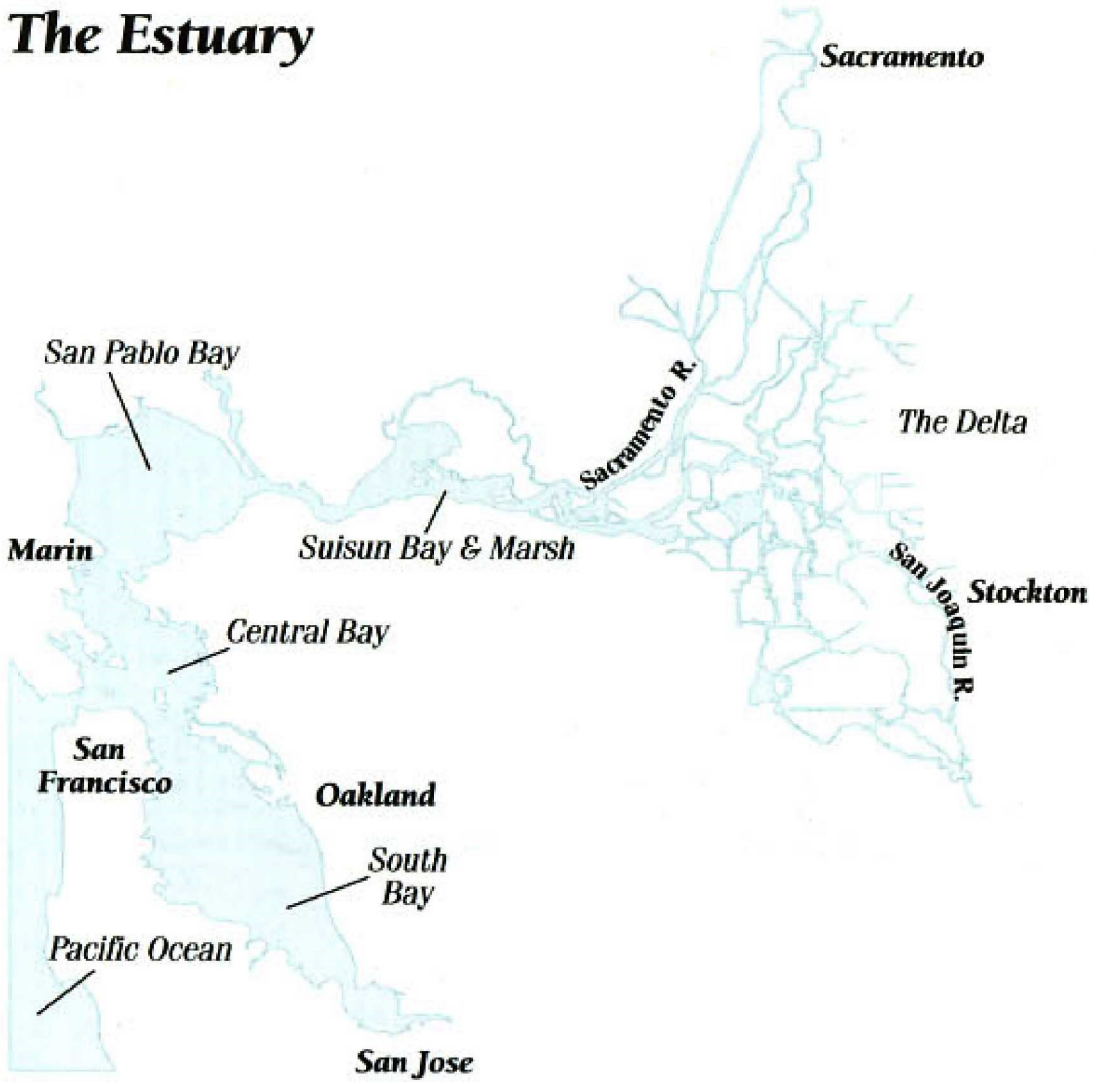
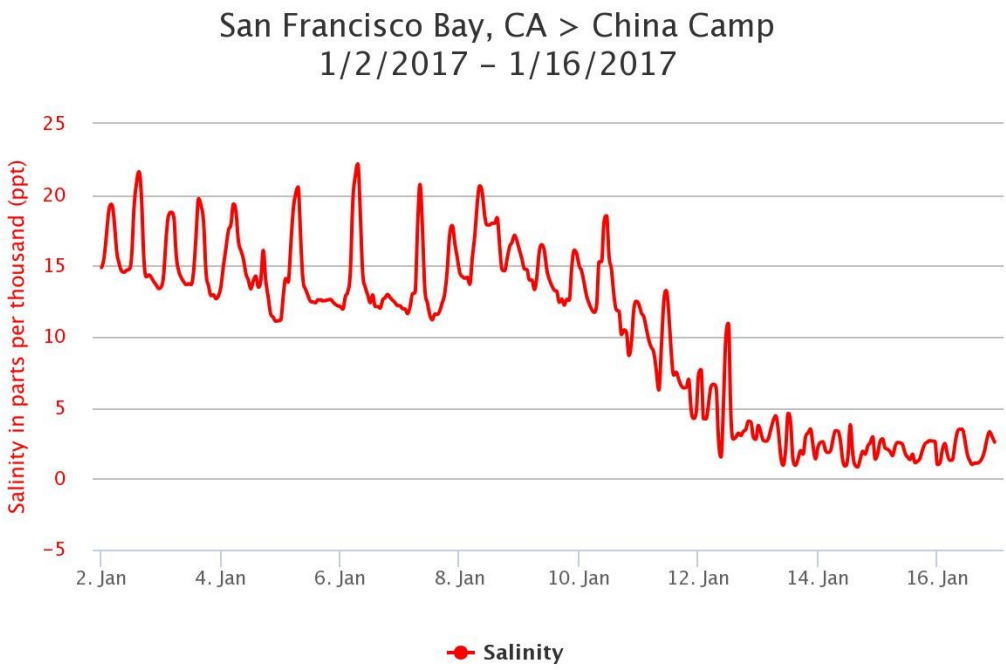


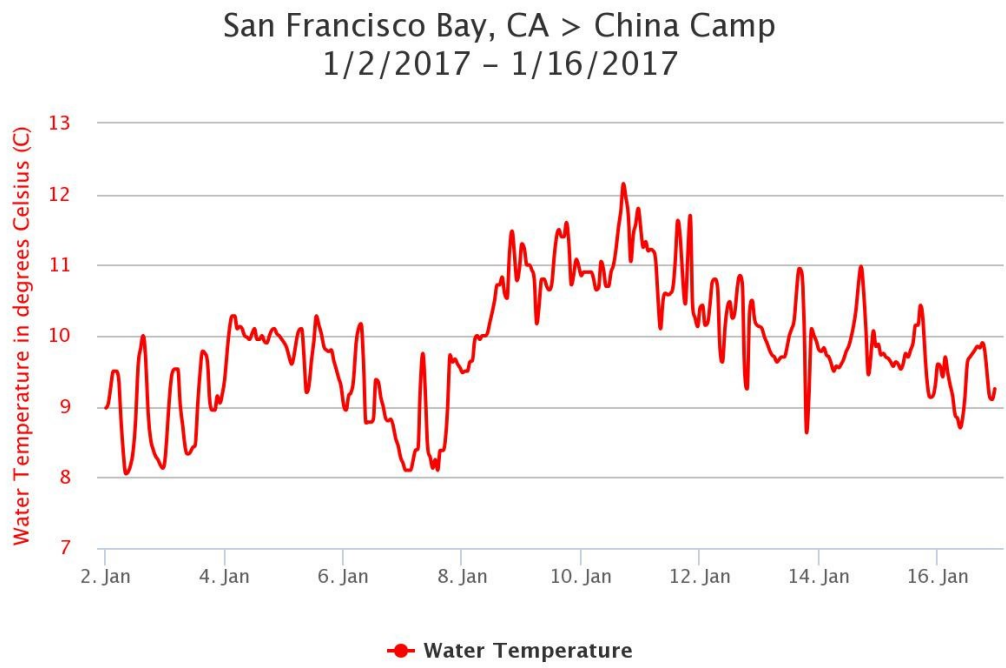
Figure 8. The San Francisco estuary has many parts.

Student Data Sheet - 2
Part 3: Water Quality at the Mouth of the Watershed

China Camp State Park, San Francisco Estuary

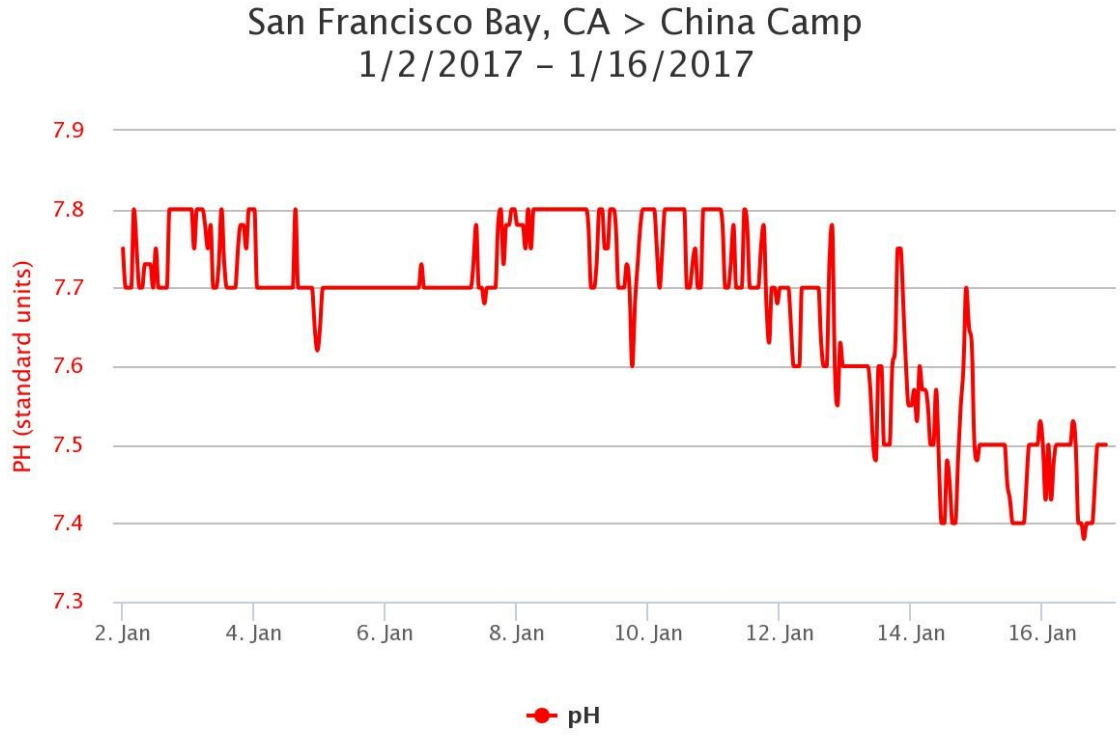
All data are from the NERRS System-wide Monitoring Program San Francisco Bay—China Camp water-quality station. Data available online at: https://coast.noaa.gov/estuaries/science-data/.

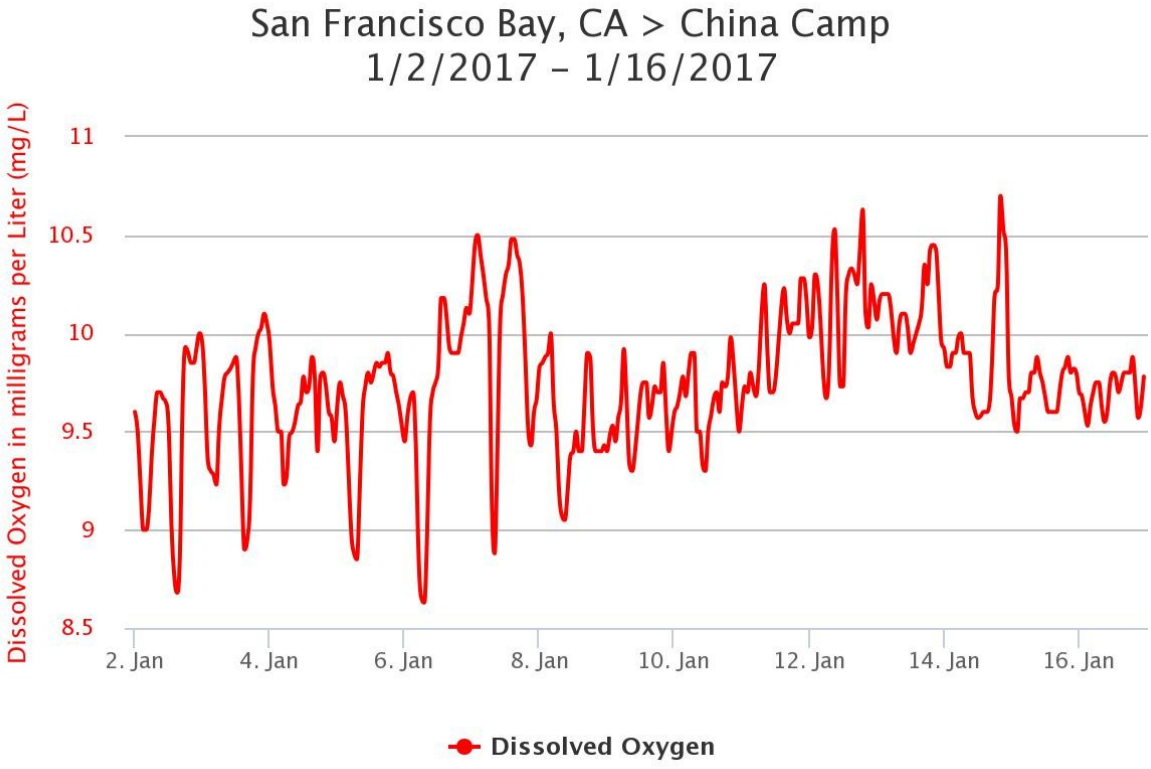




Student Data Sheet - 2

Part 3: Water Quality at the Mouth of the Watershed (continued)





Student Data Sheet - 2

Part 3: Water Quality at the Mouth of the Watershed (continued)