Student Reading—1
Activity 3: Estuary and 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.

Whether large or small, a watershed's characteristics can greatly affect how water flows through it. Heavy storms may cause streams to rise rapidly. Human-made features of the watershed like dams or large paved areas can change stream flow and alter the watershed. If the terrain is steep, changes in stream flow due to runoff can be significant.

In some watersheds, stream flow may take a long time to respond to rainfall runoff. On heavily vegetated, relatively flat terrain, much of the rainfall is absorbed by the soil and the vegetation slows runoff. In these areas, stream flow will rise slowly, but also recede slowly. On steep terrain with a scarcity of vegetation, heavy rain can cause rapid stream flow and runoff with very little absorption by the ground. These grade changes create different habitats in the stream that support different forms of life and change the quality of water in the watershed.

Water quality is critically impacted by everything that goes on within the 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 protecting stream banks and shorelines by maintaining vegetated buffer strips, treating all wastes to remove harmful pollutants, or using grass-lined catchment basins in urban areas to trap sediment and pollutants. Also, protecting wetlands is essential since they are important in slowing runoff, absorbing floodwaters, and cleaning storm water.

Estuaries lie at the mouth of watersheds. San Francisco Bay is a shallow, extremely large estuary that drains about forty percent of California. Nearly ninety percent of the fresh water flowing into the bay comes from the Sacramento and San Joaquin rivers. Technically, both rivers flow into Suisun Bay, which flows through the Carquinez Strait to meet with the Napa River at the entrance to San Pablo Bay, which then connects at its south end to San Francisco Bay. This entire group of interconnected bays is referred to as San Francisco Bay.

San Francisco Bay has lost approximately *80-90%* of its historic tidal wetlands due to human and industrial activities within and around the bay. Tidal wetlands are critical for flood prevention; sediment management; and habitats for small mammals, migratory birds and fish species, many of which are threatened and endangered.

What happens upstream can affect the quality of water and the living conditions for organisms that live in the tidal estuary. In this activity, you will investigate the San Francisco Bay watershed and estuary. The North or San Pablo Bay receives he waters of the Sacramento and San Joaquin rivers via Suisun Bay and the Carquinez Strait on its east end, and it connects to San Francisco Bay on its south end.

Student Reading—1
Continues…. Activity 3: Estuary and Watershed

San Pablo Bay is a primary wintering stop for the canvasback duck population on the Pacific Flyway, as well as a migratory staging ground for numerous species of waterfowl. Endangered species that are found in the bay include the salt marsh harvest mouse. Endangered saltwater fishes found in the bay include striped bass, sturgeon, starry flounder, leopard shark, and anchovy. The southwestern end, near the town of San Rafael, was the site of a Chinese shrimp-fishing village where some 500 people lived in the 1880s, sending some 90% of their catch of bay shrimp back to China. The location is now part of China Camp State Park, which 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 was taken at this site.

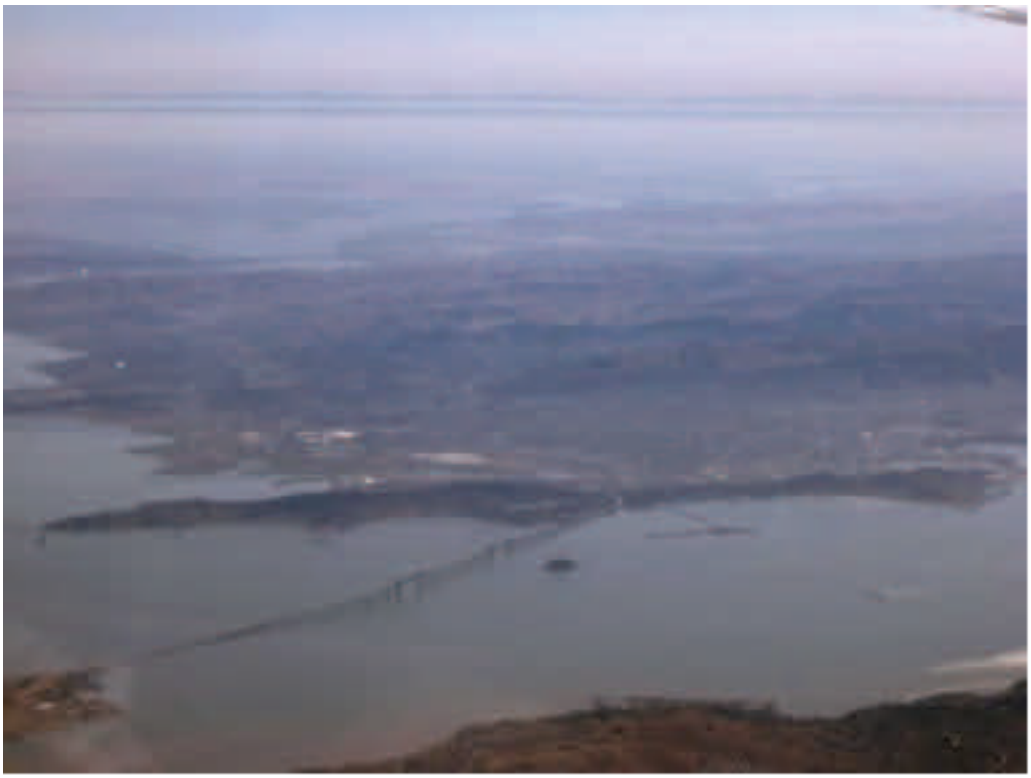

Figure 1. San Pablo Bay or North Bay

Student Worksheet
Activity 3: Estuary and Watershed

Part 1 — Exploring the San Francisco Watershed

In this part of the activity, you will examine the San Francisco Bay 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.

Obtain a piece of plastic overlay and put it over the Oblique View of the San Francisco area on *Student Data Sheet 1 — Orienting Yourself to the San Francisco Estuary and Watershed.*

Use a marker and outline any high ridges or mountains you see surrounding low basin areas.

Use a map of California to label cities and the names of mountains present in the image.

Sketch the path of the Sacramento and San Joaquin Rivers as far as you can. (The lines marking the tops of the mountains outline the huge watershed of San Francisco Bay.)

Figure 2. South Bay is the large bay at the bottom of this image. South Bay has very little fresh water flowing into it. (Image courtesy of US Geological Survey)

Take a closer look at both the estuary and the nature of the watershed using Google Earth.

If you are unfamiliar with Google Earth, your teacher will give you a short demonstration on how to navigate and change your viewing altitude using the software.

If San Francisco Bay is not preset, enter 37° 48' 53.12 N, 122° 28' 38.26 W, the coordinates of the Golden Gate Bridge, into the Search box.

Press the Go button (magnifying glass).

Consult the Road Map on *Student Data Sheet* to orient yourself to the series of bays in the estuary and to the location of the city of San Francisco.

After taking a look at the bridge, increase your viewing altitude to 20 km.

Fly straight north by pressing the "up" arrow until you reach North Bay (San Pablo Bay). You should see the town of Gallinas on the western shore of the bay.

1a. Fly around the bay in a clockwise direction, identify the rivers that empty into the bay, and list them.

As you reach the eastern side of the bay, notice a large channel heading towards the right side of the screen. Follow it past Grizzly and Suisun Bay to Sherman Island. 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. This point is the river's source or headwater.

1b. Where is the source of the Sacramento River?

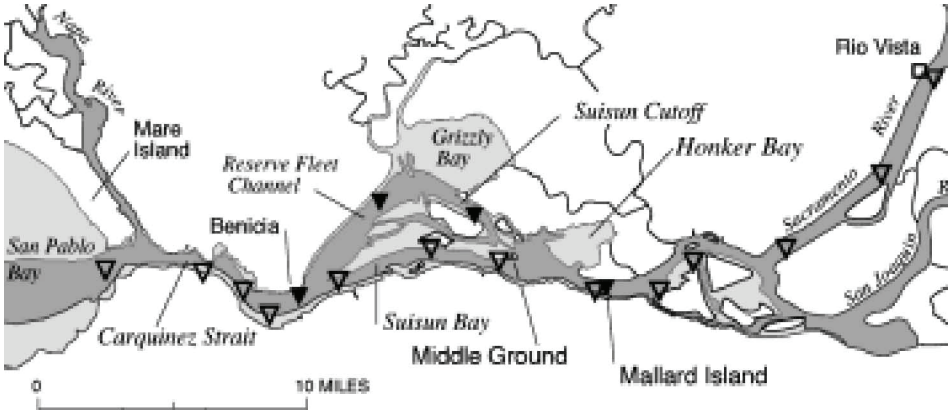

Figure 3. Most of the fresh water that mixes with ocean water in the estuary comes from two sources —the Sacramento and San Joaquin Rivers.

Figure 4. An oblique satellite image of the same scene. The vertical scale of this image is enhanced 5 times.

Travel back to the junction of the two rivers and trace the path of the San Joaquin River and locate its headwaters.

1c. Where is the source of the San Joaquin located?

Travel back to the Golden Gate Bridge and explore the rest of the estuary, including South Bay. List any additional sources of fresh water flowing into the estuary.

1d. Describe what kinds of human activity you see along the sequence of bays and channels from San Pablo Bay to the junction of the Sacramento and San Joaquin Rivers.

1e. Describe how the terrain up the rivers differs from the types of terrain along the coast. Can you detect any geologic landforms or features that might be a source for salts, minerals, or materials that would affect water quality in the estuary?

Part 2 — What's Upstream Comes Downstream

You will now take a closer look at the 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.

Pick one of the two major rivers (Sacramento or San Joaquin) flowing into San Pablo Bay to follow upstream. Fly low—one kilometer or less—to see features like chemical or other industrial plants, sewage treatment plants, golf courses, and other possible sources of contaminants.

Selected River (circle one): Sacramento River San Joaquin River

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

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

9. _____ _____

10. _____ _____

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 in the estuary and San Francisco Bay?

Part 3 — Water Quality at the Mouth of a Watershed

You will attempt to determine how a major weather event might affect water quality near the mouth of a watershed, in this case, in the San Pablo Bay region of the estuary at China Camp State Park.

Imagine the following: A major storm dumps several inches of rain in the Sierra Nevada mountains and the cities of Sacramento and San Joaquin. Regional flooding occurs along the banks of both rivers and the runoff increases the volume of fresh water running into the bay and estuary system.

3a. Predict how this event would affect these water quality factors in the estuary:

water surface temperature _____

pH _____

dissolved oxygen _____

salinity _____

turbidity _____

3b. Consult the *Student Data Sheet 2 — Water Quality Data*, look for evidence of a major storm event that occurred in 2006, and list its approximate dates.

3c. What happened to each of the water quality indicators during and immediately following this event?

water surface temperature _____

pH _____

dissolved oxygen _____

salinity _____

turbidity _____

3d. How well did your predictions match what actually happened during the storm event?

3e. What geologic landforms, features, farming, or industrial concerns affect the quality of water at the mouth of your local watershed?

Part 4 — Mapping Your Local Watershed

Cover the topographic map of a watershed supplied by your teacher with a piece of clear plastic.

Find, mark, and label with blue pen the following items on the map:

- streams
- ditches
- ponds
- rivers
- lakes
- ocean
- water wells
- water treatment plant
- water storage tanks
- schools
- sewage lagoon or catchment ponds

Find the highest and lowest points in the watershed. Mark all the high points (hilltops) with a black "H." Mark the lowest spot with a red "L."

From the black "H" high points, draw arrows on your map to show the flow of runoff. Where does water flow into ponds, lakes, streams, rivers, or ocean?

Draw a black line around the perimeter of the watershed. To do this, start at the lowest point (the mouth of a stream or river where it drains into another body of water) and start clockwise up the nearest ridge. Connect the "Hs" on the ridge until you have completely enclosed the stream and end up back at the starting point.

4a. Compare the watershed model you made with the watershed formed by the Sacramento and San Joaquin Rivers. How are they similar? How are they different?

4b. What geologic landforms, features, farming, or industrial concerns affect the quality of water in the estuary or mouth of your local watershed?

Student Data Sheet - 1
Activity 3: Orienting Yourself to the San Francisco Estuary and Watershed

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.

Road Map

Figure 6. Road map of the San Francisco Bay area

Satellite View

Figure 7. A satellite view of the San Francisco Bay area. Your tour of the rivers that drain the San Francisco Bay watershed begins in the upper-right portion of this image.

View of the Estuary

Figure 8. The San Francisco estuary has many parts.

Student Data Sheet - 2
Activity 3: Water Quality Data

China Camp, San Pablo Bay

All data from the China Camp Monitoring Station in San Pablo Bay, Dec 20, 2005 to Jan 19, 2006

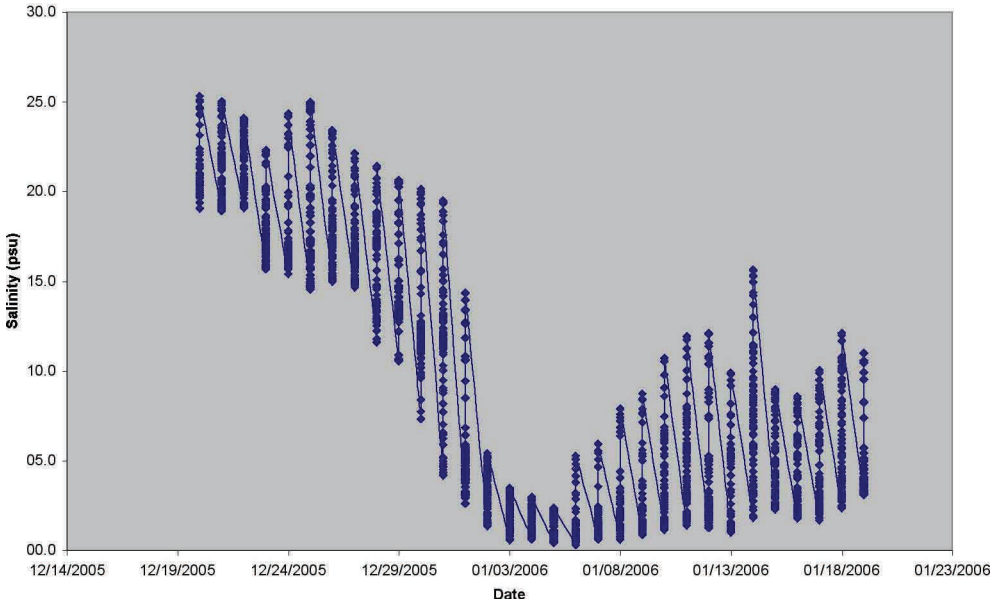

Figure 9. Salinity Drop with Storm

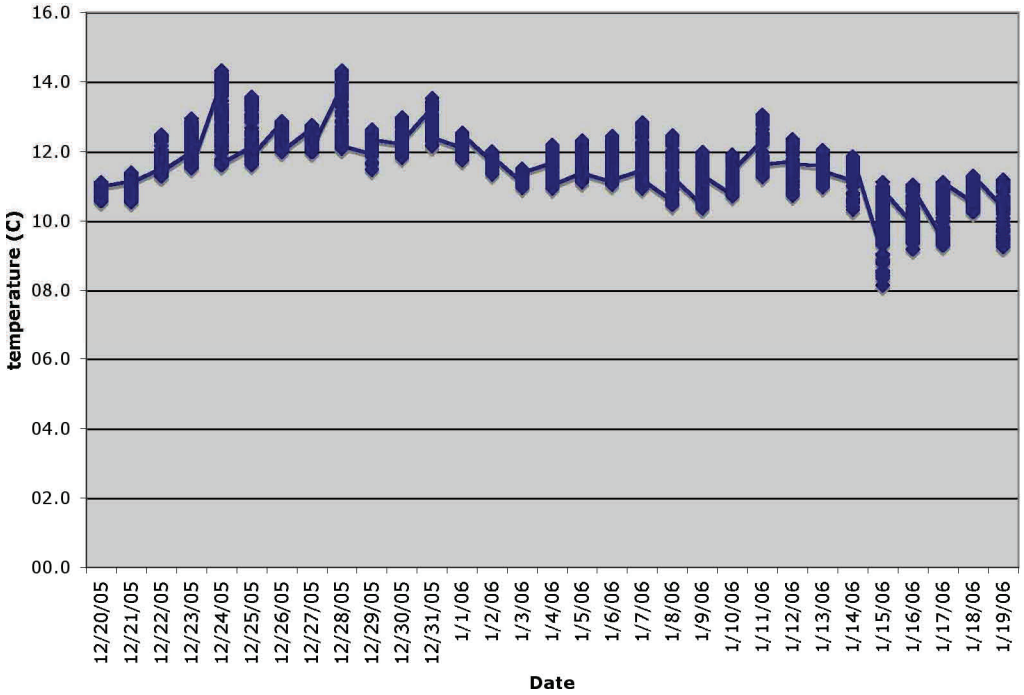

Figure 10 . Water Temperature

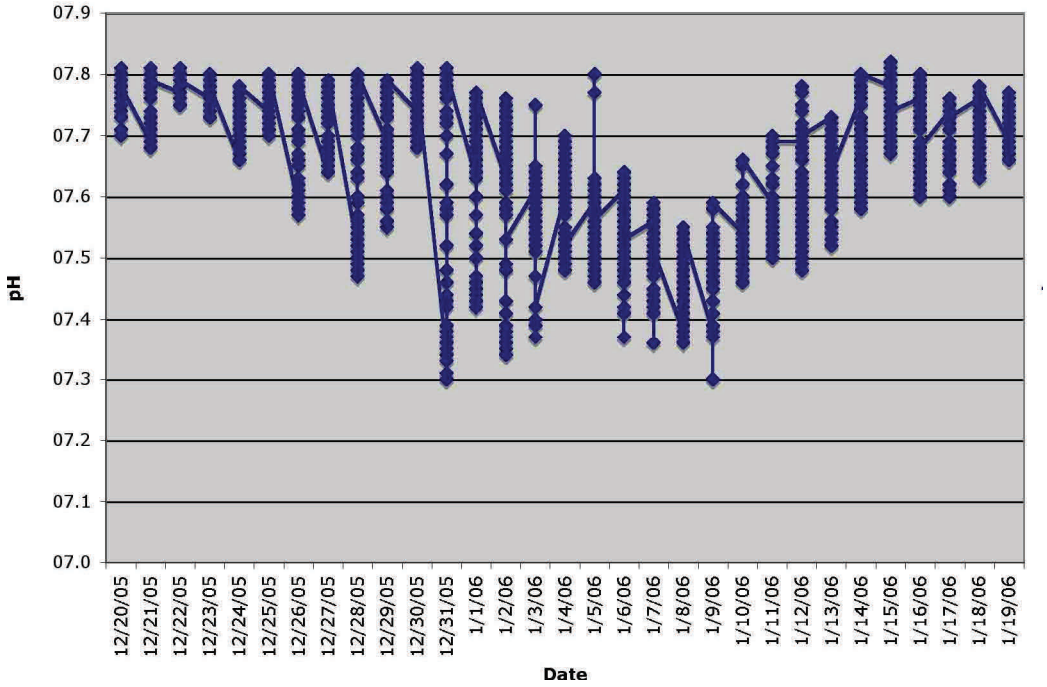

Figure 11. pH

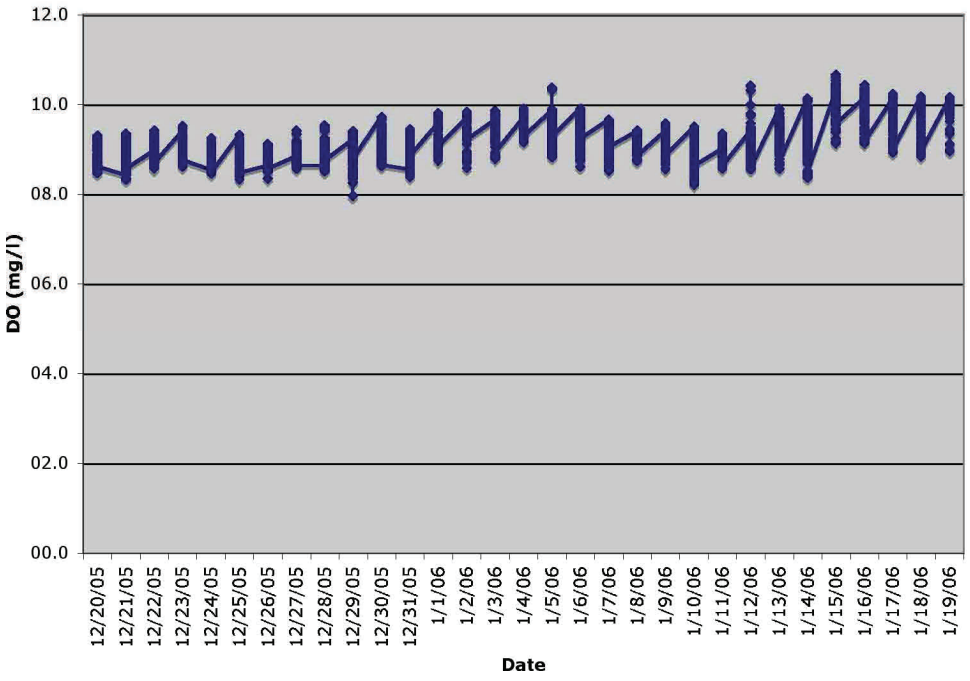

Figure 12. Dissolved Oxygen

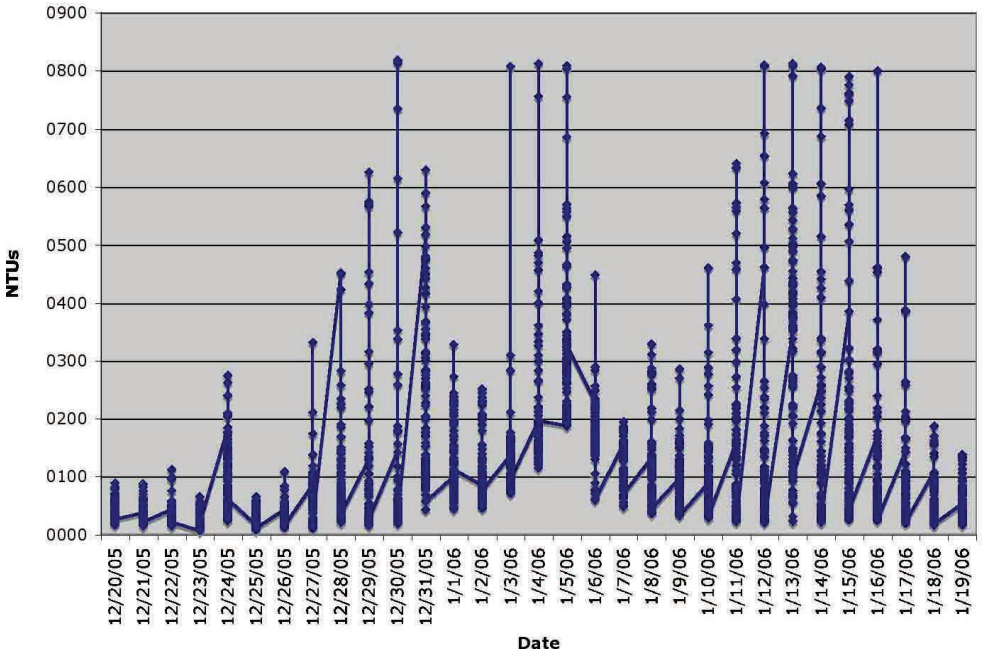

Figure 13. Turbidity