LESSON 4

Water Pollution

Applicable TEKS

Science Grade 4	Science Grade 5	Science Grade 6
4.2 D, F 4.3 A	5.2 D, F 5.3 A 5.5 D 5.9 C, D	6.2 E 6.3 A

Duration

Two to three 40-minute lessons

Objectives

Students will learn about water pollution and pollution indicators. Students will identify potential water pollution sources within a watershed using sight and smell.

Prerequisites

Students should complete *Handout 2—Area Watershed Survey* before starting this lesson.

Materials

- *Student Reference Tables*
- *Handout 4—Water Pollution*

Procedure

1. Review with your students the information in the guide under the sections "What Is Water Pollution?," "Pollutant Types," and "Sources of Pollution." Your students should understand the pollutant types and how they change the water's quality. They should also understand the difference between point source and nonpoint source pollution.
2. Have your students turn to the topographic map of the survey area. Ask students to name all of the possible human and natural activities that might be taking place within the watershed.
3. Ask students to name possible pollution sources that might be found in the survey area. Let them know that it might be difficult to identify pollution sources because watersheds can be complex and there could be many human and natural activities occurring within the watershed.
4. Using the information in the guide under "Pollution Indicators," briefly introduce your students to the following pollution indicators they will use in their survey:
   a. temperature
   b. pH
   c. dissolved oxygen
   d. *E. coli* bacteria
   e. nutrients
   f. benthic macroinvertebrates
5. Tell them: besides using these pollution indicators to tell if there is a pollution issue, you can tell if there are any pollution problems by just using your sight and smell; from that, you can then guess what the pollution source might be.
6. Have all students open their binders to *Handout 4—Water Pollution* and pull out the *Student Reference Tables*.
7. Let them know that the handout lists different things they might see or smell along a stream. They will then use the *Student Reference Tables* to determine the possible pollutant and its source.

Handout Answers

	Scenario	Possible Pollutant(s)	Possible Pollutant Source(s)
1	A rainbow film is on the surface and a nearby ditch carries stormwater from the highway into the stream.	Toxic substance (motor oil)	Motor oil leaking from highway vehicles (nonpoint source)
2	There is a musty odor; animal feedlots and construction sites are nearby.	Oxygen-demanding substance (organic materials)	Manure from the animals (nonpoint source)
3	A storm caused trees to fall into the stream over a month ago; the water now resembles coffee.	Oxygen-demanding substance (organic materials)	Decaying leaves from the trees (nonpoint source)
4	There is a faint odor of bleach; aquatic plants near an outfall are very light colored.	Toxic substance (chlorine)	Chlorine from the wastewater-treatment plant; using too much disinfectant (point source)
5	Water is bright green; next to the stream are very lush residential yards and a construction site.	Nutrients (nitrogen and/or phosphorus compounds)	Overfertilized residential yards (nonpoint source)
6	A stream near a construction site is very turbid and light brown. Also nearby is a residential area.	Suspended solids (particles like clay and silt)	Soil erosion from the construction site with inadequate erosion and sediment controls (nonpoint source)
7	There is a smell of rotten eggs; a road and an old residential area (that uses septic systems) are next to the stream.	Oxygen-demanding substance (raw sewage or organic materials)	Raw sewage coming from leaking septic systems in the residential area (nonpoint source)
8	An unusual smell is coming from the stream, very sharp and pungent. Nearby are a city and outfalls for both an industrial source and a wastewater-treatment plant.	Toxic substance (chemicals or pesticides)	Chemicals from an industrial source (point source) or from the city (nonpoint source)
9	The stream contains fungus that feels slimy and resembles the texture of cotton. It is found near an outfall.	Oxygen-demanding substance (organic materials)	An outfall from a wastewater-treatment plant or an industrial source; did not remove enough organic materials (point source)
10	The bottom of a stream became very muddy and the water is turning green. Nearby are forests and also croplands.	Sedimentation (organic and inorganic particles) and nutrients (nitrogen and/or phosphorus compounds)	Soil erosion and fertilizer from the croplands (nonpoint source)

Water Pollution

This section discusses water pollution, the types of pollution, and the indicators used to identify possible pollution problems. Even though water quality is improving, we must continue to monitor and evaluate its quality to protect and keep improving our Texas waters.

What is Water Pollution?

Water pollution is defined as the alteration of the chemical, physical, or biological integrity of water. Pollution is caused by activities that affect overall water quality. A *pollutant* is a substance that can cause pollution.

Pollutant Types

There are several main groups of pollutants that can affect water quality. This guide will focus on nutrients, oxygen-demanding substances, suspended solids, and sedimentation since the effects of these pollutants are easily observable or measurable with simple test kits. A fifth pollutant category, toxic substances, is also important; this pollutant is discussed below but requires advanced methods to determine its presence.

Nutrients

Nutrients, such as nitrogen and phosphorus, are essential for plant growth. The rate of plant growth is controlled by a limiting nutrient—a nutrient available in quantities smaller than necessary for plants to reach maximum abundance. When the limiting nutrient is used up, plant growth stops even if there is an adequate supply of other nutrients available. The limiting nutrient is typically nitrogen or phosphorus, although it can be any of the essential minerals needed for growth.

When excessive nutrients are available, an *algal bloom* may occur, in which algae multiply at an accelerated rate and may continue to grow until the limiting nutrient is exhausted. During these blooms, the levels of oxygen in the water (dissolved oxygen) during daylight hours can be very high from the abundance of algae producing oxygen during photosynthesis. However, oxygen production ceases at night and the DO levels may drop to lethal levels from algae and animals using the DO for respiration. In severe cases, algal blooms can kill fish and other aquatic organisms.

Sources of nutrients can include fertilizers and manure from agricultural activities, urban runoff containing fertilizer from lawns and golf courses, and domestic and industrial wastewater effluent.

Oxygen-Demanding Substances

In a body of water, the DO level will increase because of photosynthesis and natural aeration (rain, wind, waves, water currents, etc.) and will decrease from respiration. The DO level is also influenced by the water's temperature; the colder the water, the more oxygen it can hold.

Organic material (an oxygen-demanding substance because of its chemical nature) introduced into a water body can cause respiration levels to rise; that happens when organisms use DO and the organic materials for respiration. When respiration increases, DO decreases. Very low DO levels can kill fish.

The effects of organic materials are generally long lasting, with gradual deterioration of an aquatic ecosystem over time. The amount of oxygen required to decompose organic materials is called *biochemical oxygen demand* (BOD). When the BOD of the organic materials exceeds the available DO, the DO in the water body is reduced or depleted and is unavailable for aquatic life.

Sources of oxygen-demanding substances include raw sewage, household pet waste, waste from food-processing plants, and animal feedlot waste. With the exception of household pet waste, discharge from these sources requires permits with limits on the amount of oxygen-demanding substances released, so the water quality will not be reduced. For more information about permits, see the section "Pollution Management."

Suspended Solids

The term *suspended solids* is commonly used to describe the mineral and organic particles suspended in the water column. Most often, they are small clay and silt particles held in suspension by water currents. *Turbidity* refers to the amount of light blocked due to solids suspended in the water. When turbidity increases, light penetration decreases. Increases in turbidity affect aquatic life in several ways:

- When suspended solids block out light, primary producers (phytoplankton, algae, and other aquatic plants) are less able to produce oxygen. If light levels get too low, photosynthesis may stop altogether and plant life will die. Conditions that reduce photosynthesis also increase oxygen use and the amount of carbon dioxide produced.
- Turbid water reduces the visibility for fish and increases their difficulty in finding food. High turbidity also makes it easier for small fish to hide from larger predators.
- If the sediment load is too high, fish gills can become clogged.
- Suspended solids carry plant nutrients and also provide attachment places for other pollutants, such as metals and bacteria.
- Turbidity increases the temperature of the water when suspended particles absorb heat from the sun.

Sources of suspended solids can include runoff from construction sites or surface-mining operations without adequate erosion and sediment controls (silt fences, sediment traps, etc.), runoff from erodible agricultural lands, and upstream soil or substrate erosion naturally caused by fast-moving water during heavy rains.

Sedimentation

Sedimentation is a decrease in water flow and speed, allowing suspended materials to drop to the bottom. Sediment is mostly a mixture of loose inorganic particles (sand, silt, and clay) and organic substances (decomposing plants and animals).

In a natural river system, high flows scour the bottom carrying the sediment downstream; during floods, water leaves the river channel and sedimentation occurs on the floodplain. Since reservoirs can control the flow of water, a reservoir built on this river system may cause much of the sediment to deposit into the reservoir rather than downstream. Sedimentation may also increase downstream if the water flow is reduced so that sedimentation no longer occurs on the floodplain.

Increased sedimentation, especially in slow-moving areas, creates problems for aquatic organisms by covering up habitats. The reduction of aquatic habitats changes the types of aquatic plants and animals living in a water body. For example, a sandy or clay bottom may become a mucky bottom where different (and possibly fewer) organisms live.

Sources of sediment can include runoff from construction sites or surface-mining operations without adequate erosion and sediment controls (silt fences, sediment traps, etc.), runoff from erodible agricultural lands, and upstream soil or substrate erosion naturally caused by fast-moving water during heavy rains.

Toxic Substances

Substances that are considered toxic are distinct from the other pollutants because of the severe effect they can have on aquatic ecosystems. These are substances that can kill or harm organisms directly and in a relatively short time. Toxins generally disrupt an entire ecosystem, severely reducing the stream's natural ability to recover. *Acute toxicity* refers to high concentrations of a substance that cause immediate danger or death, whereas *chronic toxicity* refers to the long-term effect of sublethal levels of a substance that alters growth, reproduction, or development of aquatic organisms.

Common substances toxic to aquatic life are ammonia, chlorine, and heavy metals.

Ammonia is a valuable component of fertilizer and is also used in household cleaning supplies (like window cleaner), but it is highly toxic in nature. Ammonia enters water bodies in a variety of ways; the most common sources are raw (or partially treated) sewage and runoff from animal-feeding operations without adequate ammonia controls.

Chlorine is a very common disinfectant used in household cleaning supplies and wastewater-treatment plants, but is a chronic source of stress on the aquatic environment. Chlorine commonly enters the aquatic environment from treated domestic wastewater (discharged from wastewater-treatment plants).

Heavy metals are used in various industrial practices and in bridge pilings. Heavy metals can enter water bodies from industries that do not properly control (remove) the heavy metals in their wastewater or stormwater; they can also enter from the erosion of the bridge pilings.

Certain toxic substances enter bodies of water in very low concentrations that pose no apparent risk at that level; however, these toxins can *bioaccumulate* in an organism's body. If an animal eats many organisms that contain these toxins, the toxicity level in that animal increases; this is called *biomagnification*. The toxin level increases the higher you go up the food web.

Sources of Pollution

Water pollution can occur naturally or from human activities. If the water pollution originates from a human activity, it is classified as *point source* or *nonpoint source* pollution.

Point Source Pollution

"Point source pollution" refers to discharge of pollutants at a specific location, such as a pipe discharging wastewater or runoff into a stream. Regulations categorize point sources and then set pollution-control requirements for those categories. To ensure compliance with water quality standards, many point source owners or operators must monitor and document the chemical parameters of their discharge.

Nonpoint Source Pollution

"Nonpoint source" refers to pollutants that do not have a specific point of origin. These pollutants are generally carried by runoff. As the runoff flows over the land, it might pick up nutrients, oxygen-demanding substances, sediments, toxic substances, bacteria, and other pollutants. Nonpoint source pollution includes runoff that contains:

- excess fertilizers, herbicides, or insecticides from agricultural lands and residential areas
- motor oil, grease, or toxic chemicals from urban areas (roadways, parking lots, etc.)
- sediment from poorly managed construction sites, agricultural lands, or logging sites
- bacteria from a faulty septic system, livestock waste, or pet waste
- household chemicals that were improperly disposed of

Pollution Indicators

High Levels of *E. coli* Bacteria

Bacteria have long served as an indicator for determining if water is safe for drinking or recreational use. Indicator bacteria are not necessarily harmful, but may indicate the presence of harmful bacteria and viruses found in raw sewage. The higher level of indicator bacteria, the higher chance pathogens are in the water.

Historically, *fecal coliform* bacteria (commonly found in the small intestines of humans and other warm-blooded animals) were the most widely used indicator bacteria in surface waters. *Escherichia coli* (more commonly associated with human waste only) replaced *fecal coliform* as the indicator bacterium for freshwater bodies in Texas.

The presence of *fecal coliform* or *E. coli* is usually associated with inadequately treated sewage, improperly managed animal waste from livestock or pets, failing septic systems, and wildlife (birds and mammals) living near water (example: birds nesting under a bridge).

The Presence of Sewage Fungus

Sewage fungus is an indicator of organic material pollution (oxygen-demanding substances). Sewage fungus is:

- found in flowing waters
- white, gray, or brown
- slimy with cottony, wood-like plume
- generally found in massive amounts with long streamers clinging to twigs, leaves, or even the sides and bed of the stream

Changes in the Algae Concentration

The presence of little or no algae in a water body indicates a low nutrient content. Water bodies with low nutrient concentrations are known as *oligotrophic*. Besides low nutrient concentrations, oligotrophic water bodies are characterized by clear water capable of only supporting small populations of plants, invertebrates, fish, and wildlife. In contrast, water bodies with high nutrient levels capable of supporting an abundance of living organisms are called *eutrophic*. Eutrophic water bodies are also susceptible to algal blooms.

When algal blooms occur, the algae floating on the surface can decrease light penetration to the algae underneath and cause the algae to die off. Decay of the dead algae uses up oxygen, leading to very low dissolved-oxygen levels, potential fish kills, and strong odors. The effect is intensified at night when photosynthesis stops and oxygen consumption continues by aquatic plants including algae, as well as animals.

Algae attract attention because of their bright colors and overabundance in nutrient-enriched streams, ponds, and lakes. While the majority of freshwater algae are microscopic, the more obvious forms are often referred to as "pond moss" or "scum." Slick rocks in streams often result from algal growth.

Fish and Benthic Macroinvertebrates

Biological communities (fish and freshwater macroinvertebrates) can be used to determine past and present water quality. You can also tell if the water quality is improving, degrading, or remaining the same by analyzing any changes to this community over time.

Fish and benthic macroinvertebrates are placed into categories based on their tolerance to pollution and are used as indicator organisms in evaluating the health of streams. The three main categories of pollution tolerance are:

- **Intolerant:** sensitive to poor stream conditions.
- **Intermediate:** moderately tolerant of degraded habitat and water quality.
- **Tolerant:** most tolerant of degraded habitat and water quality.

As a general rule for healthy streams, intolerant organisms will be present along with intermediate and tolerant organisms.

Water quality is not always the limiting factor in the presence or absence of aquatic organisms. Physical habitat also plays a key role in the whether an organism inhabits a water body. The lack of physical habitat can be just as limiting as poor water quality.

The type and number of organisms present can tell a lot about a stream. If the aquatic community is made up of more intolerant species and a few intermediate and tolerant forms, the stream can be considered healthy. The presence of intolerant and intermediate species generally means that no significant pollution exists. Poor water quality is indicated when the number of tolerant species exceeds that of intermediate species, and intolerant species are absent. The number of individuals of any one species is also an indicator of quality. A good quality stream will have a larger number of species with fewer individuals per species, increased variety, and a balanced system. An unhealthy community includes a few species with numerous individuals, lacks variety, and is unbalanced.

Table 1.

Temperature Ranges Required for Growth of Certain Organisms

Temperature	Examples of Life
Over 68° F (warm water)	Most plant life; most bass, crappie, bluegill, carp, catfish, caddis-fly
Less than 68°F (cold water) • Upper Range (55-68°F)	Some plant life; stonefly; mayfly, caddis-fly, water beetle
• Lower Range (less than 55°F)	Trout, caddis-fly, stonefly, mayfly

Increased Turbidity

Material that becomes mixed and suspended in the water column increases water turbidity and decreases water clarity. Increased water turbidity can cause water temperatures to rise, thus decreasing the maximum amount of DO held in a body of water.

Factors contributing to turbidity are varied. In the summer, an important contributor is plankton. Planktonic organisms grow and multiply very rapidly in nutrient-rich waters that are warm and receive direct sunlight. During periods of heavy runoff, silt is also a factor.

Unexpected Changes to Water Temperature

Water temperature, one of the simplest water quality measurements, is one of the most important to the health of an aquatic ecosystem. Temperature characteristics of an aquatic environment affect the composition of its biological community (see Table 1). In general, aquatic organisms are cold-blooded and have body temperatures that fluctuate with the water temperature. Each aquatic species has an optimum temperature at which it functions the best. Most fish and other aquatic species in Texas are among those that can tolerate warmer water in summer and colder in winter.

The effects of temperature on a stream are normally chronic, with gradual changes in the aquatic community. However, extreme weather conditions can cause die-offs due to drastic temperature changes. Artificially heated water bodies (for example, bodies receiving discharges of warm water) can create a dependence on warm water. Fish kills can occur if warm water discharges stop during cold weather.

Removal of tree canopy and channelization of a stream reduce the thermal buffering capacity of that water body, resulting in bigger and more rapid shifts in temperature—higher than average temperatures in summer and colder than average in winter. Native aquatic fish and invertebrate species are adapted to the normal seasonal shifts in temperature, but can be affected by alterations to the normal stream conditions.

High water temperatures increase metabolism, respiration, and oxygen demand of fish and other aquatic organisms (in general, metabolic rates in aquatic organisms double with every rise of 10°C in temperature). Increased temperatures also enhance the effect of nutrients on plankton blooms. The effects of oxygen-demanding substances are intensified by temperature increases. Unnaturally warm temperatures can have impacts on aquatic organisms and favor tolerant over intolerant species. This can lead to an aquatic community dominated by tolerant species (such as carp and gar) with reduced number of intolerant species (such as darters and Guadalupe bass—the state fish of Texas).

Low Levels of Dissolved Oxygen

DO is one of the most important indicators of water quality for aquatic life because it is essential for all aquatic plants and animals. DO is a particularly sensitive factor because chemicals, biological processes, and temperature often determine its availability at different times during the year. DO levels often vary during the day; levels are usually lowest in the early morning, slightly after dawn and before photosynthesis begins.

The DO saturation level tells you how much DO the water can hold at a given temperature, pressure, and salinity. Elevated temperatures, increased salinity (salts), and pressure decreases reduce the amount of DO that the water can hold. For example, water at sea level (where pressure equals 1 atmosphere), with no salts, and at 0°C can hold up to 14.6 parts per million of DO. When this same water is at 30°C, it can hold up to 7.6 ppm of DO. Table 2 shows this relationship at various temperatures.

As shown in Table 2, DO levels can vary greatly. In addition to temperature, pressure, and salinity, there are other things that influence DO levels—including photosynthesis, natural aeration, and respiration. For example: during algal blooms, DO levels in the daylight hours can be extremely high (often greater than 10 ppm) because of photosynthesis; at night, DO can drop to lethal levels when photosynthesis stops producing oxygen and organisms respire only using the DO stored in the water. As another example, decreased sunlight causes a reduction in photosynthesis, which results in a net loss of DO.

Table 2.

Variation in Levels of Dissolved Oxygen as Temperature Increases

Temperature		Saturation*
°F	°C	mg/L (ppm)
32	0	14.6
33.8	1	14.2
35.6	2	13.8
37.4	3	13.5
39.2	4	13.1
41	5	12.8
42.8	6	12.5
44.6	7	12.1
46.4	8	11.8
48.2	9	11.6
50	10	11.3
51.8	11	11.0
53.6	12	10.8
55.4	13	10.5
57.2	14	10.3
59	15	10.1
60.8	16	9.9
62.6	17	9.7
64.4	18	9.5
66.2	19	9.3
68	20	9.1
69.8	21	8.9
71.6	22	8.7
73.4	23	8.6
75.2	24	8.4
77	25	8.3
78.8	26	8.1
80.6	27	8.0
82.4	28	7.8
84.2	29	7.7
86	30	7.6

Maximum amount of oxygen water will hold at a given temperature, under 1 atmosphere of pressure and 0% salinity.

Water can sometimes have DO levels above its saturation level, called supersaturation. Water bodies with elevated nutrient concentrations (eutrophic), high temperatures, and large amounts of filamentous and planktonic algae can create supersaturated conditions during daylight hours.

Texas changes greatly in climate, geology, and topography from east to west. For example, streams in the Hill Country of central Texas are generally higher in gradient (slope), are swift-moving, and have rocky bottoms. Aquatic organisms living in these streams are generally adapted for cooler water and high DO levels. In contrast, streams in east Texas are lower in gradient, warmer, are slower-moving, and have muddier bottoms. Aquatic organisms inhabiting these streams are generally more tolerant of warmer temperatures and lower DO levels. A DO level of 5.0 ppm or greater is generally considered the optimum to sustain the growth and health of aquatic organisms.

When DO levels fall below 2 to 3 ppm, fish and many other aquatic organisms may become stressed and some may not survive. Many fish kills in ponds and streams during the summer months are caused by low DO levels from a combination of elevated nutrients and warm water.

High or Low pH

The pH scale, numbered from 0 to 14, is used to measure the acidity of a water body. Pure water has a pH value of 7.0, which is considered neutral and is neither acidic nor basic. When the pH is less than 7.0, water is considered acidic; a pH greater than 7.0 is considered basic (alkaline). Generally, the ability of aquatic organisms to complete a life cycle greatly diminishes as pH becomes greater than 9.0 or less than 5.0. Figure 3 shows the habitable pH ranges for certain aquatic organisms.

The pH scale is logarithmic, with a base of 10. This means each whole number on the pH scale is ten times the whole number that precedes it. For example, a pH of 4 is 10 times more acidic than a pH of 5; a pH of 4 is 100 times more acidic than a pH of 6. A pH change of one whole number is therefore quite a large change.

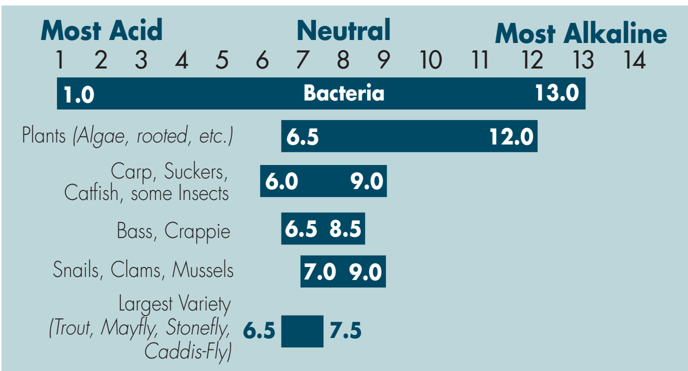
The pH of an aquatic system is influenced by a number of factors. Water dissolves mineral substances it comes in contact with, picks up aerosols and dust from the air, receives human-originated wastes, and supports photosynthetic organisms—all of which affect pH.

As explained in the discussion of the water cycle, carbon dioxide reacts with water to form a weak acid called carbonic acid. This weak acid serves as a buffer (conferring the ability to resist pH change) which diminishes extreme fluctuations in the water's pH. When photosynthesis occurs, carbon dioxide (CO_2) levels in the water reduce, along with carbonic acid levels. When carbonic acid decreases, pH increases. Therefore, you should expect the pH to increase in waters with abundant plant life (including planktonic algae) during a sunny afternoon, especially in slow or still waters.

Other events in the watershed that may also affect pH include increased leaching of soils or minerals during heavy rainfall runoff, accidental spills, agricultural runoff (pesticides, fertilizers, soil leachates), and sewage overflows.

Figure 3.

pH Ranges That Support Aquatic Life



Increased Nutrient Content

The addition of excessive nutrients to water bodies can cause an algal bloom (normally composed of phytoplankton or filamentous algae). An algal bloom is often followed by a zooplankton bloom, and later decomposition, which reduces the water's DO level.

Nonpoint source runoff may contain phosphorus or nitrogen compounds; for example, rainwater could carry excess fertilizer (containing phosphates and nitrate) into a stream. Point source pollution may also contain these compounds; for example, household chemicals flushed down the drain could enter a water body if they are not removed by the wastewater-treatment plant.

Upstream Channelization

Channelization is one of the major causes of the decreasing health of the biological community. It is the straightening of a stream's channel by removing its natural meanders. Channelization is used to control flooding; however, this change can cause a stream to become nearly lifeless. Channelization typically involves removal of large trees and natural bank vegetation, resulting in banks that are high, steep, and exposed. While most channelized streams have grass-covered banks, some in urban areas are lined with concrete. Bottom sediments are disturbed and important habitats (such as logs, rocks, tree stumps, and root mats) are removed.

Effects of Channelization

WATER-TEMPERATURE INCREASES

The removal of stream-bank vegetation reduces shading (to almost zero) and increases exposure to sunlight, increasing water temperature.

INCREASED TURBIDITY

Erosion of exposed banks during storms and high flows increases turbidity. Turbidity can also increase water temperature by absorbing the sun's rays.

CHANGES IN FLOW

The removal of natural stream-channel characteristics, and straightening the channels to accommodate flood waters, increase the velocity of the water and the potential for downstream flooding. Under normal conditions, the flow in a stream will leave the stream channel and move onto the floodplain, thereby displacing the water over a larger area. With flows confined to a straight and narrow channel, the stream loses the ability to reduce the force of the water. Restricting flow within a channel also eliminates the ability of a stream to deposit part of its sediment load onto the floodplain.

BOTTOM SUBSTRATE

Channelized stream bottoms tend to be unstable, muddy, and unsuitable for many benthic organisms. Channelization can also result in increased sediment buildup in streams.

Student Reference Tables

The following tables can help you determine if there is possible pollution in your stream by only using your senses. Use *Table 1—Physical Indicators of Water Pollution* to help determine the possible pollutant and then use *Table 2—General Land Uses That Might Affect Water Quality* to help determine the possible pollution source.

Table 1—Physical Indicators of Water Pollution

If you see the color(s) ...	The issue could be ...
Muddy tan to light brown	Suspended solids (silt and clay) due to: • upstream erosion of the banks and substrate due to channelization, • stormwater from logging or construction sites with inadequate erosion and sediment controls, or • Stormwater from one or more areas with soil erosion, such as poorly maintained croplands and rangelands, riparian zones with removed vegetation, exposed banks, etc.
Pea green, bright green, yellow, brown, brown-green, brown-yellow, blue-green	An algal bloom due to high nutrient content (phosphorus, nitrogen, or both). Water color is dependent on the dominant plankton type.
Tea or coffee	Dissolved decaying matter originating from the organic portion of the soil. This is usually seen in woodland or swampy areas.
Milky white	Paint (from a construction site) or milk (from a food processing site).
Dark red, purple, blue or black	Fabric dyes or inks from paper or cardboard manufacturers.
Milky gray or black	Oxygen depletion from raw sewage or other oxygen-demanding substance; a rotten-egg or hydrogen sulfide odor might be present.
Clear black	Turnover of oxygen-depleted bottom waters or sulfuric acid spill.
Orange-red	Deposits on stream beds often associated with oil-production areas, but not always (check for petroleum odor). The color could be due to iron in the water.
White, crusty deposits	Common in dry or arid areas where the evaporation of water leaves behind salt deposits. These deposits are also associated with brine water discharge (from oil production areas); check to see if the stream has a petroleum odor or an oily sheen along the banks.
If you smell ...	**The odor is from ...**
Rotten eggs or hydrogen sulfide	Raw sewage (oxygen-demanding substance) or oxygen-poor sediment.
Chlorine	Treated effluent, swimming pool overflow, or industrial discharges.
Sharp, pungent odor	Chemicals or pesticides.
Musty odor	Presence of raw or partially treated sewage or livestock waste (organic-demanding substances). Musty odor could also be caused by algae.
If you see on the surface ...	**Possibly caused by ...**
Tan foam	Water containing organic materials with high flow or wave action. This harmless foam can be in small patches to very large clumps.
White foam (thin or billowy)	Soap in treated effluent, possibly around a wastewater outfall.
Yellow, brown, black film	Pine, cedar, and oak pollens that form a film on the surface of ponds, backwater areas, or slow-moving water of streams.
Rainbow film	Oil or other fuel type. Sheens are common after rains when oil and gas residue wash off streets. Other sources include spills, pipelines, and oil and gas-production areas.

Table 2 — General Land Uses That Might Affect Water Quality

Land Use Type	Potential Effects
Woodland	Erosion from logging, road construction, or clear cutting may cause muddy waters.
Agricultural Land (croplands, pastures, feedlots, etc.)	Fertilizers or manure draining into a stream may increase the nutrient content and cause excessive algal and aquatic plant growth. Sedimentation may occur from soil erosion. Streams may also receive pesticides and herbicides in the runoff.
Cities and Towns	Depending on the activities occurring in the city or town, urban runoff might carry a variety of contaminants such as oil, pesticides, metals, and chemicals.
Industry	Industries have numerous types of chemicals and products that could cause color changes to the water, excessive algal growth, odors, absence of aquatic life, fish kills, elevated organic matter levels, and sewage fungus.
Wastewater-Treatment Plants	Effects may include excessive algal growth, white foam, sludge deposits (fluffy dark brown or gray solids), absence of fish and insects (or the abundance of tolerant forms), variable dissolved-oxygen levels, chlorine odor (and possible bleached vegetation near the outfall), sewage fungus, and elevated levels of *E. coli*.
Construction	Runoff from construction sites can cause water to become muddy and turbid.
Residential	Runoff from residential areas may contain fertilizers (nutrients), oil drained from cars (toxic substances), raw sewage from septic systems that overflow or leak (oxygen-demanding substances), detergents used to wash cars (toxic substances), and even litter (cans, bottles, paper, etc.).