Chapter V

CHARACTERIZATION OF THE STREAM ENVIRONMENT

Prior to monitoring, a survey of the watershed is useful in creating a picture of land use patterns, stream habitat value, and actual and potential problem areas. A survey will aid the student in understanding the relationship between land use and stream water quality, and what can be done to protect water bodies.

Before the Survey:

In order to conduct a survey, the local watershed must first be identified. State drainage basin maps indicate the areas drained by larger streams. Using the procedure described in Activity 3A, the local basin can be delineated. The direction of stream flow is important to note in determining potential influences on water quality. USGS topographic maps indicate land contours from which flow direction can be determined. Topographic maps also indicate physical features, such as railroads, highways, and cities, which act as pollution sources. The locations of active ground/surface water discharge sites can be identified using a State Leachate and Wastewater Discharge Sources map.

Conducting the Survey:

On-site observations of the watershed enable identification of land use practices and non-point source pollution. Surveys from cars or bikes may turn up logging areas, agricultural lands, recreational uses (*e.g.,* golf courses, boat landings), construction sites, gravel pits, sediment control violations, or illegal dumping. Further surveys of the riparian zone and stream corridor provide information on bank erosion, streamside vegetation coverage, and in-stream characterization of the sediment, substrate, and water. To conduct a survey, refer to Activity 5A. Rationales for each of the characteristics noted in the activity follow.

Predominant land use: Land use practices directly affect the quality of surface and ground waters. As the human population grows, more and more land is developed for homes, shopping areas, and roads. The type of development and the way it is designed will determine the type and amount of pollutants produced. In already developed areas, much can be done to reduce polluted runoff and improve water quality. Technological advancements and best management practices for farms, forestry operations, and construction activities are two ways to reduce runoff. Following are descriptions of how a number of natural areas and land use practices affect the quality of surface and ground waters.

<u>Forests/Fields</u>: Forested areas and abandoned fields along streams act as buffers, protecting the stream from pollutants by filtering runoff waters. As the rate of runoff is slowed by shrubs and tree trunks, water soaks into the ground. Trees and other vegetation help to absorb soil waters, removing pollutants and converting many to less harmful substances. Trees also provide

shade, keeping the stream cooler and, in turn, better oxygenated. Leaves falling from trees provide food for aquatic bacteria, fungi, and macroinvertebrates known as shredders.

Once water is absorbed from the soil by roots, much of it is lost through transpiration, or the evaporation of water from leaf stomata (pores). Root absorption affects stream flow, since the volume of water reaching the stream is reduced. In areas that have been cleared of vegetation, stream flow and the potential for flooding can be greater, since less water is absorbed and transpired.

Agricultural/Pasture: Modern agriculture uses many chemicals that are detrimental to aquatic ecosystems, wildlife, and people. Fertilizers, like nitrates and phosphates, are used to promote plant growth. During rainfall, fertilizers can wash off crop fields into nearby surface waters, causing excess algae growth and oxygen depletion as algae die and decompose. If fertilizers accumulate in ground water, excess nitrates can endanger human health by interfering with oxygen transport to unborn babies.

Other chemicals, like herbicides and fungicides, are used to control unwanted plant and fungal growth. Pesticides are designed to kill specific pests. If any of these chemicals leach into ground water, they can contaminate aquifers and wells. If washed into surface waters during rainfall, they can kill aquatic organisms or bioaccumulate (build up over time) in the fatty tissues of fish and crustaceans. Wildlife or people that eat these animals can be harmed.

If farm fields serve as pasture for livestock, rainwaters can carry manure to nearby streams or waterbodies. Animal wastes can contribute pathogens and may rob surface waters of available oxygen as bacteria work to decompose the wastes. If pastures are overgrazed, eroding soil can wash into streams, burying spawning beds and macroinvertebrate habitats. If livestock have direct access to the stream, the streambank and substrate can be trampled.

Residential: Residential areas are a serious source of polluted runoff. As rain falls onto neighborhood streets and lawns, pollutants, like motor oil, lawn chemicals, and pet wastes, can wash into storm drains or nearby surface waters. In some neighborhoods, storm drains lead directly to local streams and ponds. In others, storm drains empty into wastewater treatment plants where runoff waters are treated before being discharged into rivers. In heavily urbanized areas, where much of the land surface is paved and impervious, the volume of polluted runoff is greater since less rainwater can soak into the soil. Increased runoff puts greater demand on treatment facilities and may cause flooding.

Many of the pollutants washing into streams and other surface waters, including yard chemicals and home care products, are toxic to aquatic life, killing macroinvertebrates and accumulating in the fatty tissues of fish. Excess fertilizers can lead to algae blooms and eventual oxygen depletion in rivers and lakes.

In neighborhoods where hookup to sewage treatment plants is unavailable, people rely on septic systems. Underground tanks allow incoming solid wastes to settle and decompose, while wastewaters, containing bacteria, nutrients, and pollutants poured down the drain, leach into the surrounding soil. Unfortunately, some septic systems are installed where drainage is inadequate, causing sewage-containing waters to back up in the yard or contaminate private wells. Furthermore, many systems, which need to be cleaned out every two to five years, depending on volume and usage, are not regularly serviced.

Commercial: Commercial developments contribute many of the same pollutants coming from residential areas. Runoff from streets, parking lots, and other paved areas can wash automotive products, road salts, paints, and other pollutants into nearby surface waters or storm drains. Paved surfaces can also affect stream flow. As the amount and size of paved areas increase, rainwater, that once soaked into the ground, now flows quickly towards local waterways. The increased volume and speed of runoff can cause erosion, scouring of the stream bottom, and flooding.

Golf courses, in which streamside trees are often removed to improve the view, also contribute to increased runoff. Since golf courses generally use large amounts of fertilizers, herbicides, and pesticides, tree removal reduces the filtering of polluted runoff and allows pollutants to enter the stream directly.

Industrial: Industrial and municipal discharges into surface waters are regulated by the Clean Water Act under the National Pollution Discharge Elimination System (NPDES). This regulatory program is overseen by the EPA, which has delegated authority to individual states. Under the program, all dischargers are required to obtain a permit that specifies the type and amount of wastes that can be discharged. However, according to a 1991 investigation by the General Accounting Office (GAO), discharge guidelines have not been established for all types of industries and discharge limits have not been set for all toxins (U.S. GAO 1991).

Industries that send wastewater to sewage treatment plants are required to pre-treat wastes to remove toxic chemicals. Otherwise, the bacteria needed to break down the sewage can be killed and toxins can be released to streams and rivers. A 1989 investigation by the GAO, however, reports that 41% of industrial dischargers violated permits and failed to remove toxins from waters discharged to treatment plants (U.S. GAO 1989).

Local watershed erosion: Erosion, or the washing away of soil by rain or floodwaters, increases the turbidity (cloudiness) of streams and leads to the sedimentation of waterways. If sediment deposits accumulate into bars, the direction of stream flow can be altered, as water is diverted around the bar. For further descriptions of the effects of turbidity and sediment deposition, see the paragraph on "Turbidity" found below.

Local watershed nonpoint source pollution: Nonpoint source pollution is considered a primary cause of water quality problems. Unlike point sources, such as sewer and industrial pipes, nonpoint sources are diffuse in origin and difficult to control. Examples include atmospheric deposition and agricultural and urban runoff. As rain and snow fall through the atmosphere they become contaminated with air borne particles. Waters flowing over the land surface pick up additional pollutants, including fertilizers and pesticides, animal wastes, oil and grease from cars and trucks, road salts, and sand and soil from construction sites, plowed fields, and road and stream banks. If waters run off the land into nearby streams, these contaminants are carried to downstream waterbodies. Any water which percolates through the ground is filtered by layers of sand and soil. However, not all pollutants are removed by filtration, and some are discharged directly into ground waters (*e.g*., septic systems). Pollutants that pass through the soil unchanged can reach an aquifer and contaminate public wells. Those that wash directly into streams may be toxic to aquatic life or increase the microbial demand for oxygen and thereby deplete dissolved oxygen levels.

Canopy cover: Streamside vegetation influences both the chemistry of the water and the type of organisms found there. Open streams, which lack tree cover, are subject to wider temperature fluctuations than shaded streams, especially during summer months. As the temperature of water changes, the solubility of gases, like oxygen and carbon dioxide, is affected. Biological processes, including photosynthesis and respiration, are also impacted and, in turn, affect the chemistry of the water.

Different species of aquatic organisms have different requirements for temperature and dissolved gases. Optimal conditions for animal species can vary depending on life stage. In general, embryos and larval stages are more susceptible to fluctuations than adults.

Sediment and water odors: Stream odor can indicate the presence of certain pollutants. Natural smells can vary considerably; some might be called pleasant, others unpleasant. In many streams, neutral, "earthy," or "musky" smells are detected. In others, anoxic (without oxygen) sediments may smell like rotting eggs as hydrogen sulfide gas is released. Unnatural odors, such as petroleum and sewage, are indicative of pollution.

Sediment and water oils: Oils can be indicative of pollution, especially if accompanied by unnatural odors. Some oils, however, occur naturally, being released from plants as they decay. "Natural" oils usually appear in shallow pools or behind rocks and logs where leaves may accumulate and the current is slow.

Sediment deposits: The type of deposits found on the stream bottom can provide clues to upstream conditions, as well as pollution sources and local land use practices. Sand deposits may indicate upstream scouring, streambank erosion, or runoff from roads or construction sites. Sawdust is often evidence of nearby tree-cutting activity, while sludge may indicate discharge of mining spoils or wastes from oil refineries or steam boilers. As scoured or washed in materials settle to the stream bottom, spawning beds and macroinvertebrate habitats can be buried.

Inorganic substrate components: The type of organisms found in a stream will depend, in part, on the type of inorganic substrate present. In fast-flowing stream areas, called riffles, the bottom is often covered with different-sized rocks. Some organisms, like mayflies and stoneflies, require a rough substrate in which there are numerous holes for shelter. Others, like dragonfly and damselfly nymphs, prefer slow-moving streams with soft, silty substrates in which they can burrow.

Organic substrate components: The habitat quality of a stream depends not only on the type of inorganic substrate, but also on the type of food or organic materials available. Bacteria, fungi, and certain crustaceans and insects known as shredders, feed on coarse particulate organic materials (CPOM), such as leaves, twigs, bark, and flowers. The time required to break down these materials varies. Some plants or plant parts take longer to process than others. Once CPOM is broken down, other insects, the collectors, filter fine particulate organic materials (FPOM) from the water or gather it from the stream bottom. Scraper insects feed mostly on attached algae, while predators, both vertebrate and invertebrate, feed on organisms in all feeding groups. For a more thorough description of food and energy cycling in a stream, refer to Chapter II.

Turbidity: Turbidity, or cloudiness, is caused by the suspension of solid materials in water. All streams and rivers have a certain amount of suspended materials, including decayed organic matter, sediment, and plankton. However, if too many solids are in the water, aquatic life can be severely impacted. Suspended materials can block light from reaching underwater plants and can clog fish gills, causing suffocation. As materials settle to the stream bottom, fish spawning beds and macroinvertebrate habitats are buried. Suspended solids can also contain nutrients and toxins which can impact aquatic life both in the stream and in downstream lakes and ponds.

Water color: The color of a stream, called the apparent color, is due to reflections of the substrate and the presence of dissolved and suspended materials, including plankton, chemical pollutants, sediment, and organic compounds leached from humus and peat. The true color of stream water is due to dissolved substances only, and is determined by filtering out any suspended materials.

In Activity 5A, only the color of the substrate is factored out. Collected samples are not filtered to remove suspended solids. If waters are greenish colored, phytoplankton may be present. If brown or "tea" colored, waters may be flowing from a wetland where pigments leach from decaying plant materials. Brown-stained waters can also indicate increased development in the watershed, as land-clearing activities result in increased runoff.

ACTIVITY 5A: Characterizing the Stream Environment

Objective: Students will survey the local watershed of a stream to identify land use practices and pollution sources and to collect information on the stream's habitat value.

Setting: streamside

Time Needed: 30-40 minutes

Subject Areas: Earth Science, Emvironmental Science

Skills: cooperation, observation, inference

Vocabulary: land use, erosion, non-point source pollution, canopy, sediment, substrate, inorganic, organic, CPOM, detritus, FPOM, muck, marl, bedrock, boulder, cobble, gravel, silt, sand, clay, turbidity

Materials Needed: pencil, clipboard, clear vial, crown densiometer (optional), camera (optional), *Stream Environment Characterization Data Sheet*

Background:

Streams provide habitat for numerous aquatic organisms. The quality of the habitat depends on both the chemistry of the water and physical characteristics, including water temperature and color, substrate type, and turbidity.

Land cover and land use practices directly affect habitat quality by influencing the chemical and physical nature of a stream. In agricultural areas, fertilizers and manure can wash into local streams, causing eventual oxygen depletion. As land is developed for homes and businesses, the amount of impervious surface increases and more water runs off the land, carrying pollutants to nearby streams, waterbodies, and treatment plants. Forests and abandoned fields adjacent to streams help protect aquatic life by filtering pollutants from runoff waters. Vegetated buffers may also provide shade during summer months and protect stream life from suffocation and sediment burial by reducing erosion.

Procedure:

1) Select a group of students and designate a team leader who will be responsible for recording the data.

2) Hand out a *Stream Environment Characterization Data Sheet* to the data recorder.

3) Have students complete the data sheet using the instructions and questions on the back of the sheet as a guide.

Extensions:

1) Visit and compare the study stream with others that are visually different. For example, compare:
- closed and open canopy streams,
- streams surrounded by different land uses, or
- sandy-bottomed and rocky-bottomed streams.

Initial visual comparisons can be used to make predictions about the stream's macroinvertebrate populations and water chemistry. Predictions can be followed up with field testing.

2) Visit a local construction site and ask the developer or site manager for a tour. Look for evidence of erosion, including broken straw bales, fallen silt fences, and muddy water.

3) Visit and tour a local tree farm that uses best

management forestry practices. If possible, visit both clear-cut and selective-cut sites.

4) Visit and tour a local farm that uses best management practices (BMPs) for agriculture and/or livestock. Contact your local Natural Resource Conservation Service (formerly Soil Conservation Service) to locate the nearest BMP farm.

5) Have students conduct household and community surveys to locate sources of polluted runoff (see *Household and Community Checklists for Water Quality Protection*, page SM 5-3).

STREAM ENVIRONMENT CHARACTERIZATION DATA SHEET

Riparian Zone

Predominant Surrounding Land Use:

Forest/Field   Agricultural/Pasture   Residential   Commercial   Industrial   Other____

Local Watershed Erosion: None   Moderate   Severe

Local Non-Point Source Pollution: No evidence   Potential sources   Obvious sources

Canopy Cover: Open   Little shade (< 40%)   Moderate shade (40-80%)   Full shade (> 80%)

Stream Corridor

Sediment Odors: Normal   Sewage   Petroleum   Chemical   Anaerobic   Other

Sediment Oils: None   Slight   Moderate   Abundant

Sediment Deposits: Sludge   Sawdust   Sand   Relict shells   Other

Inorganic Substrate Components

Substrate Type	Diameter	% Composition of Site
Bedrock		
Boulder	>256 mm (10 in)	
Cobble	64-256 mm (2.5-10 in)	
Gravel	2-64 mm (0.1-2.5 in)	
Sand	0.06-2 mm (gritty)	
Silt	0.004-0.06 mm (no grit)	
Clay	0.004 mm (slick)	

Organic Substrate Components

Substrate Type	Characteristic	% Composition of Site
Detritus	Logs, Sticks, Wood, Coarse Particulate Organic Materials (CPOM)	
Muck-Mud	Brown or Black Fine Particulate Organic Materials (FPOM)	
Marl	Grey, Shell Fragments	
None	No Organic Matter	

Water Odors: Natural   Sewage   Petroleum   Chemical   Other

Water Surface Oils: None   Flecks   Globs   Sheen   Slick

Turbidity: Clear   Slightly turbid   Turbid   Opaque

Water Color:________________

Directions: Use the following instructions and questions to help you complete the Stream Environment Characterization Data Sheet.

Predominant land use: Look up- and downstream on both banks and observe how land adjacent to the stream is being used. Also make a note of any minor uses (*e.g.*, small corn field, parking lot, unpaved road) which may have an impact on the stream.

Local watershed erosion: Observe the condition of the land adjacent to the streambank. Is the land highly vegetated and stable? Are there any gullies eroding the streambank or is the bank being undercut?

Local watershed non-point source pollution: Observe any sources of pollution aside from sedimentation. Are there roads close to the streambank? Are there farms near the stream? Is the site adjacent to a golf course or residential or commercial area? How far is the nearest pond, lake, or marsh out flow?

Canopy cover: Stand in the center of the stream and look up. What percentage of the stream is shaded? Is the entire stream covered with tree canopy or is the vegetation predominantly shrubs or herbs? If using a crown densiometer, what percentage of the mirror is shaded?

Sediment odors: Carefully take a handful of sediment from the site. Can you detect any odors? Indicate any odor on the data sheet even if it is not listed. Note: anaerobic (without oxygen) sediments contain hydrogen sulfide and smell like rotting eggs.

Sediment oils: When collecting sediment for detecting odor, did any oils surface? Do any sediments on the streambank contain oil-like sheens? Record information as specific as possible.

Sediment deposits: Are any sediment deposits found at the site? Are the undersides of any loosely embedded rocks blackened? This indicates an anaerobic condition unfavorable to benthic invertebrates.

Inorganic substrate components: What types of inorganic substrate are present? Record the percentage of each type. Be sure to describe 100% of the substrate.

Organic substrate components: Are organic materials part of the substrate? Record the percentage of each type found. Make sure that 100% of the substrate is described.

Water odors: Sniff the stream waters and record any detectable odor. If no odor is recognizable, answer "natural".

Water surface oils: Note the presence of any oils on the surface of the water. In streams, oils are usually seen as a rainbow-like sheen when in sunlight. Are oils widespread? Are they in isolated areas, perhaps surrounding leaves? Plants naturally release oils as they decay.

Turbidity: Take a sample of water in a clear container and hold it up to a light background. Note the amount of turbidity (cloudiness) present. Turbidity is caused by the suspension of solid matter, including sediment and plankton. Determining turbidity will aid in evaluating water color.

Water color: Collect a water sample in a clear container and hold it up against a white background. What color does the water appear? Often a stream looks dark brown, tan, or green, but is actually clear, with the water color resulting from the substrate. If any strange colors are observed, indicate whether they appear throughout the stream or in isolated areas, such as below a discharge pipe.