ACKNOWLEDGMENTS

Prepared By:
Maine Department of Environmental Protection
  Jeff Varricchione
  Erin Crowley

Primary Contributors and Reviewers:
Maine Department of Environmental Protection
  Mary-Ellen Dennis
  Wendy Garland

Additional Contributors
Maine Department of Environmental Protection
  Jeff Dennis
  Kathy Hoppe
  Don Kale
  Norm Marcotte
  Mark Whiting
  Don Witherill
  Barb Welch

Maine Department of Inland Fisheries & Wildlife
  Merry Gallagher
  Phillip Wick

Cumberland County Soil & Water Conservation District
  Heather True
  Betty Williams

Design/Production:
Graphics Communications: Julie Motherwell

Photos Credits: Jeff Varricchione unless otherwise credited; section title pages: Helen McAlpin
# A Citizen’s Guide
## to Basic Watershed, Habitat, and Geomorphology Surveys in Stream and River Watersheds — Volume I

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Jeff Varricchione, MDEP, 312 Conco Rd., Portland, ME 04103)
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Unit 2: Stream, River, and Watershed Basics

An Overview

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UNIT 1: INTRODUCTION
Unit 2:
Stream, River, and Watershed Basics – An Overview

This unit explains the very basics about streams and watersheds needed before conducting a survey. Appendix A contains a glossary that may be helpful too.

The Ups and Downs Along Water’s Path...
...all about stormwater runoff and its contents

Stormwater, which consists of rainwater and melted ice and snow, flows over the landscape into streams and rivers, and eventually into lakes, ponds, or the coast. Along the way, it picks up and carries with it contaminants largely produced by humans. Stormwater that carries contaminants is called polluted runoff or nonpoint source pollution (NPS); that is, not coming from a single point source — such as a discharge pipe at a factory or industrial plant.

Polluted runoff is diffuse, and its sources are diverse and difficult to identify. Yet it’s every bit as damaging as point source pollution. Contaminants found in polluted runoff include oil, trash, sediment, metals, toxics, nutrients, and sewage.

To understand how polluted runoff affects stream water quality, it is important to understand the concepts of watershed, the water cycle (hydrologic cycle), stormwater runoff, and vegetated buffers, all of which are described in the remainder of this unit.

■ What Is a Watershed?

A watershed is an area of land from which water drains downhill into a body of water at the low point in the landscape.

Every river, stream, pond, wetland, lake, estuary, or coastal embayment has a watershed. Imagine a watershed as a bowl with a pool of water at the bottom. Water that falls onto the inside rim of the bowl flows down along the surface to the bottom of the bowl. Much like a bowl’s rim, high points in the landscape, such as ridges and hilltops, are the boundaries that separate watersheds.

The shape and size of watersheds are determined by the topography of the land. For example, a coastal watershed may be comprised of several smaller watersheds of tributary streams and rivers.

For a more detailed discussion about these topics, the reader is referred to the Maine Stream Team Program guide, Volume 2: A Citizen’s Primer on Stream Ecology, Water Quality, Hydrology, and Fluvial Geomorphology. To download a copy, visit the Maine Stream Team Program website: http://www.maine.gov/dep/blwq/docstream/team/streamteam.htm.

Alternatively, if an introductory level of information regarding streams is desired, the reader is referred to the brief, but informative booklet, Streams. This booklet is a project of the Maine DEP and Gulf of Maine
Aquarium, and is available online at:
The Hydrologic Cycle

Water continually cycles from earth to the atmosphere and then back to earth again. Water evaporates from oceans, lakes, rivers, and streams into the atmosphere, where it later precipitates as rain or snow. Rain or melted snow runs off, through watersheds, into surface waters and infiltrates the soil and rock, where it becomes groundwater. Some water goes directly back into the atmosphere through plants. Groundwater eventually discharges to streams, lakes, wetlands, or oceans.

The sun’s heat drives the processes that cycle the water: evaporation, condensation, and precipitation. Because the amount of water on earth is finite, it is critical to keep it clean as it moves through the hydrologic cycle.

Stormwater Runoff

Stormwater runoff is water that runs over ground that is saturated or covered by hardened surfaces. The volume and flow rate of stormwater increases when we change the nature of ground surfaces in the following ways:

- smoothing out irregularities in the landscape by filling and grading;
- increasing the amount of ground covered by hard surfaces — “impervious” areas such as rooftops, parking areas, and roads where water runs off without soaking into the ground;
- reducing the amount of forested area or naturally vegetated areas.

In undeveloped watersheds, forests and other vegetated areas act like a sponge. They soak up stormwater and slowly release it to rivers and streams. Through vegetated buffers, stormwater reaches streams, rivers, and downstream waterbodies more gradually and cleaner.
Vegetated Riparian Buffers

Riparian zones are areas adjacent to streams, rivers, and other waterbodies, and include streambanks and floodplains. They are areas of trees, shrubs, and other vegetation between an upland area, that often is developed, and a water body. Vegetated riparian zones are important components of stream (and other waterbody) ecosystems that are highly valuable towards keeping water clean.

Vegetated riparian “buffers” are tools that watershed managers and landowners manage or restore in landscapes altered by humans, to protect streams and other waterbodies. These buffers can include trees, shrubs, bushes, and ground cover plants.

The irregularities and depressions of the ground in natural buffers retain and treat polluted runoff, because water is allowed to percolate into the ground. Forested areas are most effective in the retention of stormwater because of the duff layer (thick, soft layer) of decomposing pine needles, bark, leaves, and other organic material that has fallen on the ground. The duff layer in forests can be up to several inches thick — an incredible natural sponge! Over time, planted buffers can be as effective as natural ones.

Buffers prevent pollutants from reaching surface waters in several ways: they filter pollutants out of stormwater, they slow the flow rate of stormwater runoff, and they reduce the volume of stormwater runoff. Additionally, vegetated riparian zones (or managed “buffers”) along rivers and streams also provide values such as shading, habitat, and food sources for wildlife and aquatic organisms.
The Pollutants and Their Sources

Polluted Runoff and Its Threat to Streams, Rivers, and Receiving Waters

In the past, rivers, streams, and other waterbodies were disposal areas for untreated industrial and manufacturing wastes and raw sewage discharged from point sources. People thought that these waters had a limitless ability to dilute pollutants. However, years of discharging pollutants in some areas of the country led to waters that were toxic to aquatic life and humans.

Point source pollution discharges were addressed when the Federal Clean Water Act was passed in the early 1970s. Industrial and municipal wastewater discharges were regulated, pollutant loads were reduced, and municipalities constructed sewage treatment plants with federal funds. State programs, such as the Small Community Grants Program and the Overboard Discharge Program, have funded the removal of untreated discharges and the elimination of overboard discharge pipes (and combined sewer overflows [CSOs]). These changes have resulted in great improvements to the quality of Maine’s waters.

Today, it is nonpoint source pollution (NPS) (also known as polluted runoff / polluted stormwater) that poses the greatest threat to Maine’s waters, particularly as urban and suburban populations increase.

- The driving forces of the hydrologic cycle and the topography of a watershed carry nonpoint source pollution from the land into rivers, streams, wetlands, groundwater, and eventually into receiving waters such as lakes and coastal waters.

- Human activities on land and water generate pollutants such as sediments, nutrients, toxics, and pathogenic organisms (e.g., harmful types of bacteria). Human transformation of natural forest land into impervious surfaces, such as roads, parking lots, and rooftops, can decrease the infiltration of precipitation into the ground and thus increase the speed and volume of runoff and any pollutants it may carry.

- Many Maine towns are experiencing rapid growth. The potential cumulative impacts of many small activities connected with this expansion can degrade water quality. Runoff from a single fertilized lawn seems like a small problem; however, contaminated runoff from many lawns in the watershed, year after year, may have a severe cumulative impact.

These pollutants threaten the health of our environment, our people and our economy. The investment we could make to prevent pollution is minimal compared to the potential costs of losing our water resources. Some of these pollutants can come from natural sources: weathering of soils, wildlife, and decomposing vegetation. Most polluted runoff is caused by, and can be reduced by, humans.
Meet the Pollutants: Sediments, Nutrients, Toxics, Pathogenic Organisms

SEDIMENTS

Sediments (sand, silt, and other soil particles) suspended and transported in streams, rivers, and other waterbodies are harmful in several ways:

• they fill in the spaces between gravel in stream bottoms, eliminating spawning areas of many fish, suffocating any eggs present, and eliminating habitats for fish food such as aquatic insects (e.g., stoneflies, mayflies, etc.) and other invertebrates;
• they reduce visibility, which interferes with fishes’ ability to feed;
• they raise water temperature, which reduces the amount of oxygen in the water;
• they clog the feeding apparatus of filter feeders;
• they damage fish and aquatic insect gills;
• they block sunlight, which impairs photosynthesis of aquatic plants;
• they carry nutrients (e.g., phosphorous) and toxins which cling to settled or suspended sediments, resulting in impaired ecosystems, public health risks, and negative consequences for Maine’s economy.

Creating larger impervious areas (roads and parking lots) increases the volume and speed of stormwater runoff, which erodes stream banks and deposits sediments downstream where they create large sediment deltas in rivers, lakes, and ponds. Construction projects that leave soil exposed during and after construction are another source of sediment in streams and other waterbodies. Logging or farming too close to water bodies can expose soil, making it vulnerable to erosion.

Wide vegetated riparian buffers (and state-of-the-art stormwater treatment systems in urban areas) are encouraged in all these land-use types to help minimize erosion and sedimentation problems.

NUTRIENTS

Major nutrients are carbon, hydrogen, oxygen, sulfur, silica, nitrogen, and phosphorus. To grow and reproduce, plants and animals need a certain portion of each type of nutrient. In most cases, nutrients are a good/required thing to have in streams. Some nutrients can be toxic to organisms. For example, the nitrate (NO₃⁻) form of nitrogen generally helps plants grow; while the ammonia (NH₃) form of nitrogen can be toxic to fish and other organisms in concentrated amounts.

A nutrient that is the least abundant relative to a plant’s need for it is called the limiting nutrient. Limiting nutrients limit the growth and reproduction of organisms. Phosphorus is usually the primary limiting nutrient for algae growth in freshwater, such as lakes, rivers, and streams. (Nitrogen is usually the primary limiting nutrient for growth of algae in marine waters, which can be downstream of coastal streams and rivers. Nitrogen sources are often the same as phosphorus sources.)
When extra phosphorus enters freshwaters, it may, given the right conditions (e.g., adequate sunlight), promote excess growth of algae and other aquatic plants. Phosphorus enters freshwaters as a result of human activities:

- agricultural sites (e.g., chemical fertilizer, manure, organic matter, soil);
- residential areas (e.g., lawn fertilizer, pet waste, soil);
- urban developments (e.g., runoff from roads, parking lots, automobiles); and
- point source discharges (e.g., treated wastewater and sewage).

Some presence of algae and other aquatic plants in stream ecosystems is a natural condition, especially where sunlight is ample. When excess nutrients are introduced into streams and other waterways, typically from human activities, there can be excessive growth of algae and plants and associated negative impacts. (In heavily shaded headwater streams, sunlight availability is minimal and, therefore, algae and plant growth is also minimal. Still, be careful, the rocks in the stream can be pretty slippery when they’re coated with films of tea-colored diatom algae!)

During the daytime when conditions are sunny, algae and plants generate dissolved oxygen via photosynthesis during sunny conditions, which is beneficial to other aquatic organisms. Also during the daytime, algae and other aquatic plants, plus bacteria and animals, use up oxygen for processes such as respiration and decomposition.

At night and before dawn, sunlight is not present and plant photosynthesis is not producing dissolved oxygen. In certain instances, stream reaches having excessive growth of algae and other aquatic plants, large amounts of dead organic material, or large inputs of organic waste such as sewage, can use up significant amounts of oxygen via respiration and decomposition, which occurs 24 hours a day. These night-time lows in dissolved oxygen concentrations can stress sensitive species of fish, macroinvertebrates, and other aquatic organisms.

**TOXICS**

*Toxics are chemicals that can kill or limit the growth or reproduction of aquatic organisms. A harmless substance can become toxic if its chemical form, quantity, or availability is changed.* For instance, a trace metal could be a nutritional requirement for an organism in small amounts, yet toxic if consumed in higher concentrations.

Lead, mercury, arsenic, cadmium, silver, nickel, selenium, chromium, zinc, and copper are heavy metals that can be toxic in fresh and marine waters. Metals can be transported into water bodies from vehicle emissions, industrial processes, and improper use or disposal of paints and pesticides. Metals also occur naturally in rocks and minerals and can leach into the environment over time. Soil disturbance can accelerate the release of metals into the aquatic environment.

Many petroleum products are toxic, particularly the polycyclic aromatic hydrocarbons (PAHs) that enter the water through oil spills and the burning of fossil fuels. Polychlorinated biphenyls (PCBs) formerly used in electrical transformers and other products, chlorinated pesticides, and dioxin are other major toxics found in Maine’s aquatic environments.
PCBs and many pesticides are now banned because of their toxic properties. Some of these toxins take a long time to degrade, and their persistence in the environment means they will continue to cause problems. Landfills and illegal disposal sites are primary sources of these contaminants.

Heavy metals and organic toxins inhibit the growth, reproduction, and immune systems of aquatic organisms. These contaminants accumulate in sediments and are consumed by bottom-feeding organisms. Fish and crustaceans eat the bottom-feeding organisms (e.g., aquatic insects and mollusks), accumulating the contaminants. Birds, humans, and other organisms then eat the fish and crustaceans and, with them, the accumulated contaminants.

**PATHOGENIC ORGANISMS**

Pathogenic organisms are certain bacteria or viruses, that can cause disease. Pathogens from sewage and animal wastes, are responsible for the closure of swimming areas and shellfish areas downstream of coastal streams that may be contaminated. Some gastro-intestinal illnesses can be contracted by swimming in severely contaminated waters.

Sewage enters streams, rivers, and other waterbodies from malfunctioning septic systems and publicly owned treatment works (POTWs), overboard discharge systems, combined sewer overflows (CSOs), and discharges from boats. Pollution from animal wastes is primarily generated from agricultural activities, such as spreading manure to fertilize fields, but is also generated by pets and wildlife.

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Learning More About Various Aspects of Stream Physical, Chemical, and Biological Properties and Processes

There are many topics about streams that we don’t get into much detail about in this manual (Volume 1). For more detailed information about topics such as stream organisms, habitats, hydrology, water quality, ecosystem processes, dynamics, geomorphology, etc., we refer you to the Maine Stream Team Program guide *Volume 2: A Citizen’s Primer on Stream Ecology, Water Quality, Hydrology, and Fluvial Geomorphology*.

To download a copy, visit the Maine Stream Team Program’s website: http://www.maine.gov/dep/blwq/docstream/team/streamteam.htm.

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