Chapter 3. Potential Sources of Contamination

3.1 Introduction

All pollutants are categorized in two ways for the practical operation of water pollution abatement. The common categories are 1) the manner in which pollutants enter the water and 2) the way pollutants can be treated and removed from water.

Pollutants can enter water through direct, piped and channeled discharges – point sources, or they can enter groundwater, lakes, or streams from nonpoint sources. Nonpoint sources (see Table 3.1.1) considered to be major contributors to water pollution are: runoff from paved streets and parking lots, agricultural lands and construction sites; soil erosion from road cuts, streams and from logging or farm operations, and atmospheric deposition of acidic or toxic air pollutants.

Transported soil can be both a pollutant itself and a vehicle for carrying other pollutants which become attached to soil particles. For example, the soil contains phosphorus, but much of the phosphorus added to soil through the use of fertilizers also gets bound to the soil particles. When soil is disturbed (erosion), it may be transported by rivers and streams to the lake. The soil particles themselves may be considered a pollutant because they cause the lake water to become cloudy. The phosphorus in the transported soil may later become available to aquatic plants. Particles may also protect microbes from harm in nature or in disinfection of drinking water. This is why drinking water standards require very low turbidity (cloudiness).

Pollutants also can be classified by treatment technology as conventional, non-conventional or toxic. Conventional pollutants include organic materials that require oxygen to decompose (biodegradable). Wastes from sewage treatment plants, tanneries, paper mills, and food processing operations fall into this category, as do oil and grease. Inorganic sediments such as sand or silt are conventional pollutants – that is, these substances can be removed from wastewater with conventional treatment. Bacteria associated with the intestinal tract of humans (fecal bacteria, as indicated by the coliform group) are conventional pollutants and can easily be destroyed by disinfection with chlorine, ozone or ultraviolet light.

Non-conventional pollutants include excessive levels of nutrients, such as nitrogen and phosphorus, which require more advanced treatment to be removed from wastewater. These substances may come from many sources, including fertilizers, atmospheric deposition, and sewage.

Toxic pollutants such as heavy metals (chromium, lead), inorganic chemicals (salts, acids), and organic chemicals (pesticides, solvents) can damage human health, aquatic organisms, and the overall health of the ecosystem. Toxic effects can be acute, causing immediate death or impairment, or chronic, causing subtle damage that may not emerge until years after exposure. Toxics often persist in the environment, collecting either in water or in lake bottom sediments. Toxics can bioaccumulate in the tissues of organisms after repeated intake or exposure. Toxic concentrations can increase at higher levels in the food chain, called biomagnification (NYSDEC & Federation of Lake Associations)

3.2 Surface Runoff

Surface water flows within the watershed occur as overland runoff and as stream flow. Overland flow, or stormwater as it is commonly called, is generated when the capacity of the soils and vegetation to absorb water from precipitation is exceeded and water runs across the surface of the land. In clay-rich soils, the water-retention capacity is low and runoff from these soils is generated quickly. In sandy soils, a larger portion of the precipitation infiltrates the land surface and recharges the underlying groundwater system, resulting in less runoff.

Since precipitation-generated runoff is the major transport mechanism for nonpoint source pollution, a direct relationship exists between the timing and magnitude of precipitation events and the resulting level of nonpoint source pollution. Factors that affect the rate at which precipitation becomes runoff include the soil moisture conditions at the time of the precipitation event, vegetation type and density, and urbanization with its associated impervious surfaces. Of these factors, only the time of the precipitation event vary significantly with climate change. Therefore, climatic conditions preceding the precipitation event and the timing of the event are important factors in determining the amount of precipitation that will be available for the “first flush” of the watershed. Clearly, larger and more intense rain events carry more pollutants from the watershed into downgradient waters.

Table 3.1.1
Nonpoint Sources of Pollution and Potential Impacts on Water Resources

Pollutant/ Associated Land Use	Impacts
Sediment: construction, urban runoff, gravel operations, agriculture, logging, hydromodification	**On Fisheries**: • Decreases transmission of light, which affects plant production (food and cover), behavioral activities (nesting, feeding, mating), respiration, digestion, reproduction • Increases surface water temperature, which decreases dissolved oxygen concentration in water • Decreases spawning habitat (fills pools and nest sites) • Transports absorbed contaminants **On Water Supply**: • Damages water treatment pumps, equipment • Increases treatment costs • Reduces reservoir volume • Toxic substances may adhere to sediment • Nutrients increase, which stimulates algae growth • Decreases river bottom infiltration, which reduces well yields **On Wetlands**: • Reduces flood storage • Increases peak discharges • Alters habitat **On Recreation**: • Decreases clarity of water (public health and safety) • Reduces aesthetic and recreational value • Reduces sport fishing populations
Phosphorus and Nitrogen: urban development, gravel operations, agriculture, land disposal (sludge and septic systems), illegal waste disposal	**On Fisheries**: • Promotes algae blooms, which inhibit aquatic plant growth • Favors survival of less desirable species over more desirable (commercial and recreational) species • Reduces dissolved oxygen levels through increased productivity and decay of organic matter **On Water Supply**: • Promotes algae blooms, which cause odors and poor taste • Increases treatment costs • Increases nitrate concentration (safe limit is 10 mg/l **On Wetlands**: • Alters wetland vegetation/habitat **On Recreation**: • Promotes eutrophication of lakes and streams • Increases algae growth, which may create public health risks • Decreases aesthetic value • Degrades fishing and boating activities • Reduces tourism and property values
Metals: urban runoff, mining, land disposal, natural deposits	**On Fisheries**: • Accumulates in sediments, which poses risk to bottom feeders • Bioaccumulates in fish tissue • Affects reproductive rates and life spans of aquatic organisms • Hinders photosynthesis in aquatic plants **On Water Supply:** • Increases treatment costs • Forms deposits in pipes, which reduces carrying capacity • Colors water, which leaves stains on fixtures, clothing • Poses possible health hazard from toxic metals **On Wetlands:** • Bioaccumulates in existing food web

	• Hinders photosynthesis in aquatic plants • Affects reproductive rates and life spans of wetland organisms **On Recreation**: • Reduces waterfront property values • Restricts sport fishing if contamination is found in fish tissue
Pesticides and Herbicides: (agriculture, urban runoff, hydrologic/habitat modification, lawn and golf course care	**On Fisheries**: • Accumulates in sediments, which poses risk to bottom feeders • Bioaccumulates in fish tissue • May kill fish and other aquatic organisms • Hinders photosynthesis in aquatic plants **On Water Supply:** • Causes orders in water supply • Carcinogenic effects cause public health risks **On Wetlands**: • Adversely impacts survival of wetland fauna and flora **On Recreation**: • Reduces waterfront property values • Restricts sport fishing if contamination is found in fish tissue
Pathogens – Bacteria and Viruses: agriculture, urban runoff, land disposal, septic tanks (or illegal waste disposal), sludge	**On Fisheries**: • Introduces disease-bearing organisms to aquatic life • Closes shellfish areas **On Water Supply**: • Increases public health risks • Increases treatment costs for drinking water supplies **On Wetlands**: • Results in loss of wetland recreation areas • Introduces harmful organisms to aquatic life and food chain **On Recreation**: • Closes swimming area
Thermal Energy: construction, mining and gravel operations, logging, agriculture, urban runoff, hydrologic/habitat modification	**On Fisheries**: • Reduces vigor and growth of fish • Reduces resistance to disease • Reduces dissolved oxygen and stream temperature increases • Changes cold water sport fishery to warm water fishery **On Water Supply**: • Increased temperature accelerates pump/equipment corrosion • Promotes biological activity, which produces odors and poor taste • Creates a more favorable environment for pathogens **On Recreation:** • May stimulate growth of algae and aquatic plants, which reduces water clarity, aethetic value, sport fishing populations, and tourism
Salts: mining, urban runoff, contruction, road deicing	**On Fisheries**: • Favors salt-tolerant species • Fluctuations in salinity create stressful environment • Destroys habitat and food source plants for some species • Alters species composition of affected areas **On Water Supply**: • Reduces drinking water quality **On Wetlands**: • Alters wetland vegetation/species composition • Destroys habitat and food sources for wetland animals **On Recreation**: • May cause skin/eye irritations

Source: Adapted from Massachusetts Department of Environmental Protection (1993)

Generally, the first inch of rainfall typically removes most of the pollutants from the watershed. Thus, as rainfall exceeds one inch, pollutant concentrations will decrease significantly, even though pollutant loadings will continue to slightly increase (Jeer, et al).

Urbanized land contributes large amounts of contamination to water bodies via stormwater runoff. Urban areas are characterized by a higher percentage of impervious surface coverage; thus, the ability of stormwater runoff to transport more pollutants is magnified. In the Cayuga Lake Watershed this can be seen in many of the subwatersheds, especially in the downstream portions of those subwatersheds. These include the following subwatersheds: Glenwood Creek Area (Town of Ithaca and Town of Ulysses), Lansing Area (Town and Village of Lansing, Cayuga Heights, Town of Ithaca), Big Salmon Creek/Little Salmon Creek/Salmon Creek/Locke Creek (Town of Lansing), Virgil Creek/Fall Creek (Village and Town of Dryden, Village of Freeville, Cayuga Heights, City and Town of Ithaca), Cascadilla Creek/Sixmile Creek/Buttermilk Creek/Cayuga Inlet/West Branch/Fish Kill/Enfield Creek (City and Town of Ithaca).

Urban developments tend to encroach on natural resources as well, allowing more and more people the opportunity to use lakes, rivers, beaches, and wetlands. Each natural habitat use has a one-time impact and a cumulative effect – many small impacts add up over time. Water-quality degradation caused by development also fragments existing habitats, restricting the territory available to plant and animal species and eliminating buffers between them and human use areas.

Direct Inputs from Wetfall and Dryfall

Nonpoint source inputs not only occur from the runoff of precipitation, but also from precipitation falling directly onto the land surface or the lake. Precipitation occurs as wet deposition (wetfall) of rain droplets and snow, and dry deposition (dryfall) of particulate matter. In the atmosphere, the mixture of gases, water vapor, particulate matter, and wind currents form a dynamic environment in which changes in chemical composition of precipitation frequently occur. Precipitation can carry increasing amounts of inorganic contaminants and sediments to groundwater and surface waters, particularly from heavily developed areas. Dissolved oxides of nitrogen and sulfur are frequently found in the atmosphere, and can be carried down in precipitation as acid rain. These compounds originate from automobile exhaust and power plant emissions, as well as from other minor sources. Precipitation also carries phosphorus.

3.3 Underground Discharges

"Underground discharge" is a broad term encompassing inputs from a variety of underground sources, much the same way that surface runoff encompasses inputs from a variety of above-ground sources. Included in this category are not only on-site wastewater systems (see Section 3.13), but also inputs from floor drains, dry wells, leaching catch basins, leaching chambers, or other structures. These potential sources may occur from a variety of land uses. Underground stormwater infiltration sites also contribute contaminants in the first flush of a watershed to groundwater.