NCF- ENVIROTHON MISSISSIPPI

CURRENT ENVIRONMENTAL ISSUE

2026

NON-POINT SOURCE POLLUTION MITIGATION - IT BEGINS AT HOME!

STUDY RESOURCES

PART A

ENVIROTHON MISSISSIPPI 2026

2026 NCF-Envirothon Mississippi

Current Issue Study Resources Part A

Non-Point Source Pollution:
It Begins at Home

Table of Contents

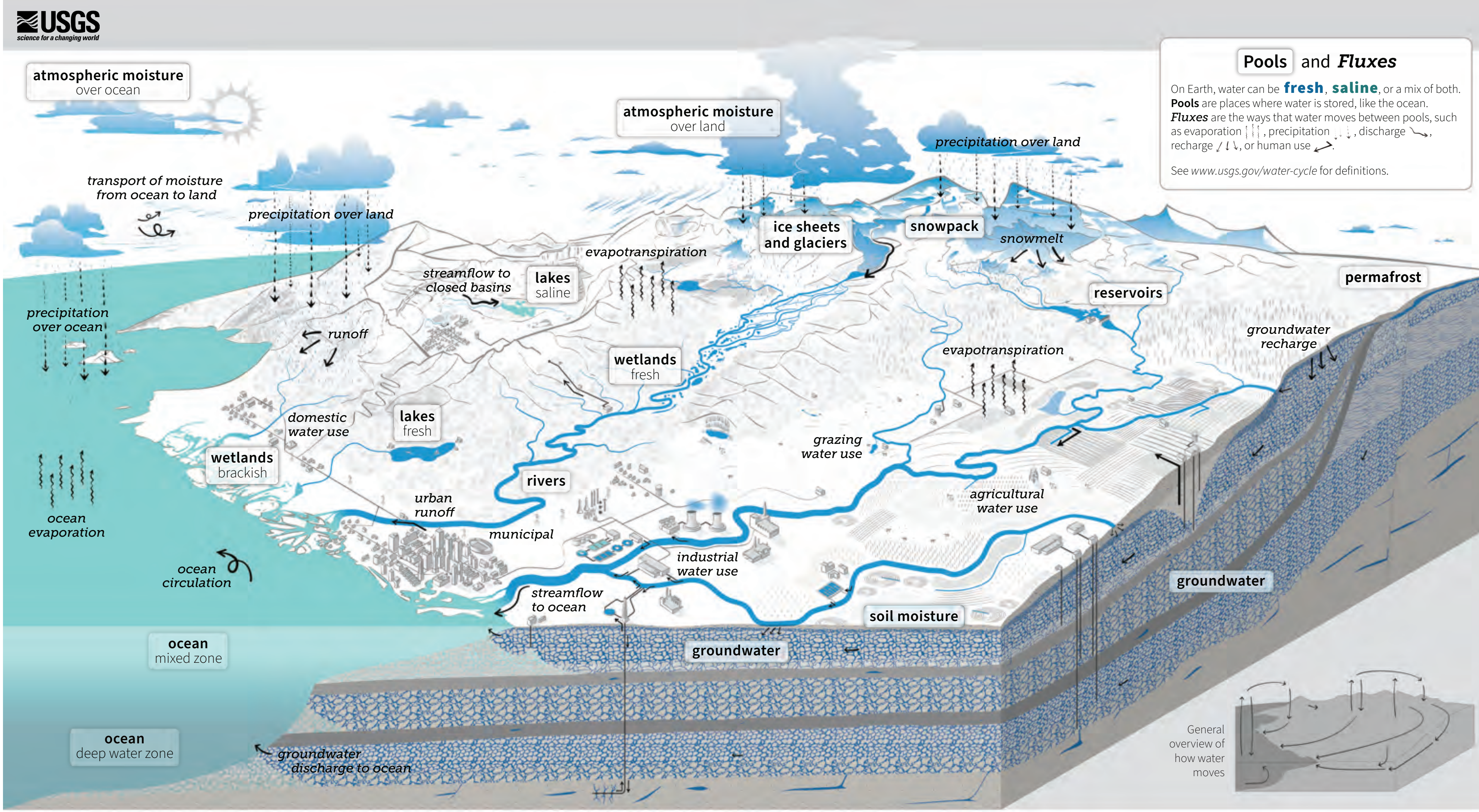
Non-Point Source Pollution Status	What is NPS pollution and why does it matter? Defines NPS pollution, its diffuse nature, and its impact on water resources. Builds foundational knowledge and observational skills.
NPS in a Growing World and Your Role in It	How human development and personal choices drive NPS pollution. Connects population growth, land use, and consumer behavior to environmental impact. Encourages systems thinking and self-reflection.
The Role of the Individual/Community in NPS Issues and Solutions	Change begins at home and spreads through community action. Focuses on civic engagement, community science, and grassroots solutions. Promotes empowerment and collaboration.
Strategies to Evaluate NPS Sources, Issues, and Solutions	How do we assess NPS pollution– and how do we know if solutions work? Introduces field and analytical tools for identifying, measuring, and evaluating NPS sources and responses.
Legislation, Regulations, and Voluntary Measures	What are the rules– and who makes them? Explores policy, governance, and incentives behind NPS management. Emphasizes civic literacy and institutional collaboration.
Your Best Management Practices for NPS	What works– and where? Focuses on applied solutions, technical practices, and BMPs. Builds site-specific decision-making and implementation skills.

Please Note: Any hyperlinks within the study resources, except for those specifically mentioned as a resource on the Key Topics pages and with a dedicated page in the resources (*i.e., YouTube videos*), are supplemental material ONLY. They may be used for additional information but are not required study resources.

Key Topic #1: Non-Point Source Pollution Status

Learning Objectives

1. **Define** non-point source (NPS) pollution and **differentiate** it from point source pollution using real-world examples from urban and rural settings.
2. **Explain** changes in watershed ecology that influence NPS pollution (Water cycle, nutrient cycles, carbon cycles, river continuum concept).
3. **Identify** major types, sources and pathways of NPS pollution in surface water systems, including stormwater runoff, agricultural fields, and impervious surfaces.
4. **Describe** the impacts of NPS pollution on water quality and designated water uses (e.g., recreation, fisheries, drinking water).



The Water Cycle

The water cycle describes where water is found on Earth and how it moves. Water can be stored in the atmosphere, on Earth's surface, or below the ground. It can be in a liquid, solid, or gaseous state. Water moves between the places it is stored at large scales and at very small scales. Water moves naturally and because of human interaction, both of which affect where water is stored, how it moves, and how clean it is.

Liquid water can be fresh, saline (salty), or a mix (brackish). Ninety-six percent of all water is saline and stored in **oceans**. Places like the ocean, where water is stored, are called **pools**. On land, saline water is stored in **saline lakes**, whereas fresh water is stored in liquid form in **freshwater lakes**, artificial **reservoirs**, **rivers**, **wetlands**, and in soil as **soil moisture**. Deeper underground, liquid water is stored as **groundwater** in aquifers, within the cracks and pores of rock. The solid, frozen form of water is stored in **ice sheets**, **glaciers**, and **snowpack** at high elevations or near the Earth's poles. Frozen water is also found in the soil as **permafrost**. Water vapor, the gaseous form of water, is stored as **atmospheric moisture** over the ocean and land.

As it moves, water can transform into a liquid, a solid, or a gas. The different ways in which water moves between pools are known as **fluxes**. **Circulation** mixes water in the oceans and transports water vapor in the atmosphere. Water moves between the atmosphere and the Earth's surface through **evaporation**, **evapotranspiration**, and **precipitation**. Water moves across the land surface through **snowmelt**, **runoff**, and **streamflow**. Through infiltration and **groundwater recharge**, water moves into the ground. When underground, groundwater flows within aquifers and can return to the surface through **springs** or from natural **groundwater discharge** into rivers and oceans.

Humans alter the water cycle. We redirect rivers, build dams to store water, and drain water from wetlands for development. We use water from rivers, lakes, reservoirs, and groundwater aquifers. We use that water (1) to supply our **homes** and **communities**; (2) for **agricultural** irrigation and **grazing** livestock; and (3) in **industrial** activities like thermoelectric power generation, mining, and aquaculture. The amount of available water depends on how much water is in each pool (water quantity). Water availability also depends on when and how fast water moves (water timing), how much water is used (water use), and how clean the water is (water quality).

Human activities affect **water quality**. In agricultural and urban areas, irrigation and precipitation wash fertilizers and pesticides into rivers and groundwater. Power plants and factories return heated and contaminated water to rivers. Runoff carries chemicals, sediment, and sewage into rivers and lakes. Downstream from these types of sources, contaminated water can cause harmful algal blooms, spread diseases, and harm habitats. **Climate change** is also affecting the water cycle. It affects water quality, quantity, timing, and use. Climate change is also causing ocean acidification, sea level rise, and extreme weather. Understanding these impacts can allow progress toward sustainable water use.

U.S. Department of the Interior
U.S. Geological Survey

7.3: Biogeochemical Cycles

Biogeochemical cycles, also known as nutrient cycles, describe the movement of chemical elements through different media, such as the atmosphere, soil, rocks, bodies of water, and organisms. Biogeochemical cycles keep essential elements available to plants and other organisms.

Energy flows directionally through ecosystems, entering as sunlight (or inorganic molecules for chemoautotrophs) and leaving as heat during energy transformation between trophic levels. Rather than flowing through an ecosystem, the matter that makes up organisms is conserved and recycled. The **law of conservation of mass** states that matter is neither created nor destroyed. For example, after a chemical reaction, the mass of the products (ending molecules) will be the same as the mass of the reactants (starting molecules). The same is true in an ecosystem. Matter moves through different media, and atoms may react to form new molecules, but the amount of matter remains constant.

The biogeochemical cycles of four elements—carbon, nitrogen, phosphorus, and sulfur—are discussed below. The cycling of these elements is interconnected with the water cycle. For example, the movement of water is critical for the leaching of sulfur and phosphorus into rivers, lakes, and oceans. Today, **anthropogenic** (human) activities are altering all major ecosystems and the biogeochemical cycles they drive.

The Carbon Cycle

Carbon is the basic building block of all organic materials, and therefore, of living organisms. The carbon cycle is actually comprised of several interconnected cycles: one dealing with rapid carbon exchange among living organisms and the other dealing with the long-term cycling of carbon through geologic processes (figure $7.3.a$). The overall effect is that carbon is constantly recycled in the dynamic processes taking place in the atmosphere, at the surface and in the crust of the earth. The vast majority of carbon resides as inorganic minerals in crustal rocks. Other **reservoirs** of carbon, places where carbon accumulates, include the oceans and atmosphere. Some of the carbon atoms in your body today may long ago have resided in a dinosaur's body, or perhaps were once buried deep in the Earth's crust as carbonate rock minerals.

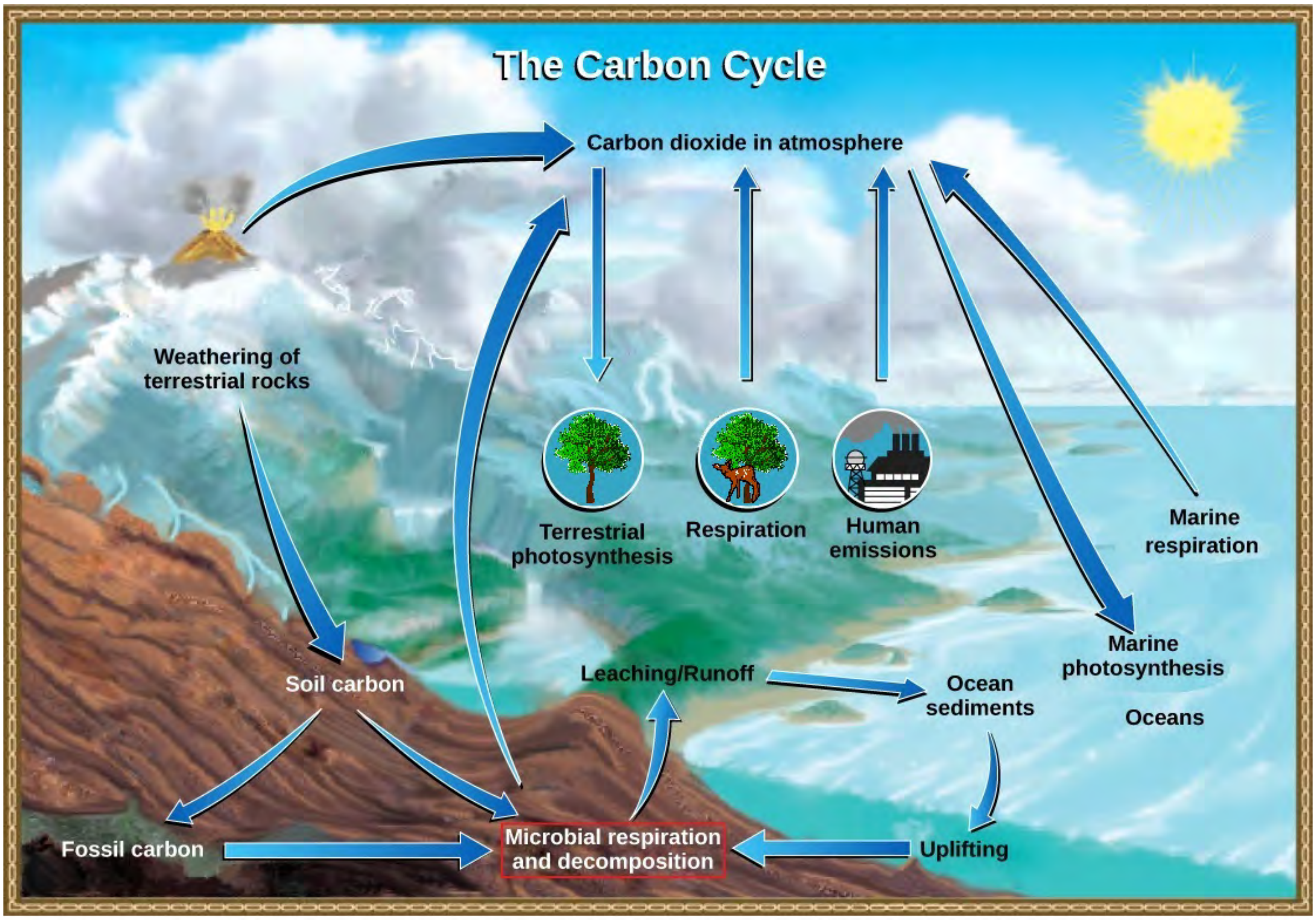


Figure $7.3.a$: Carbon dioxide in the atmosphere is converted to organic carbon through photosynthesis by terrestrial organisms (like trees) and marine organisms (like algae). Respiration by terrestrial organisms (like trees and deer) and marine organisms (like algae and fish) release carbon dioxide back into the atmosphere. Additionally, microbes that decompose dead organisms release carbon dioxide through respiration. Weathering of terrestrial rocks also brings carbon into the soil. Carbon in the soil enters the water through leaching and runoff. It can accumulate into ocean sediments and reenter land through uplifting. Long-term storage of organic carbon occurs when matter from living organisms is buried deep underground and becomes fossilized. Volcanic activity and, more recently, human emissions stored carbon back into the carbon cycle. Modified from John M. Evans and Howard Perlman, USGS using tree and deer (both public domain).

Carbon Cycles Slowly between Land and the Ocean

On land, carbon is stored in soil as organic carbon in the form of decomposing organisms or terrestrial rocks. Decomposed plants and algae are sometimes buried and compressed between layers of sediments. After millions of years fossil fuels such as coal, oil, and natural gas are formed. The **weathering** of terrestrial rock and minerals release carbon into the soil.

Carbon-containing compounds in the soil can be washed into bodies of water through **leaching.** This water eventually enters the ocean. Atmospheric carbon dioxide also dissolves in the ocean, reacting with water molecules to form carbonate ions (CO_3^{2-}). Some of these ions combine with calcium ions in the seawater to form calcium carbonate ($CaCO_3$), a major component of the shells of marine organisms. These organisms eventually die and their shells form sediments on the ocean floor. Over geologic time, the calcium carbonate forms limestone, which comprises the largest carbon reservoir on Earth.

Carbonate also precipitates in sediments, forming carbonate rocks, such as limestone. Carbon sediments from the ocean floor are taken deep within Earth by the process of **subduction**: the movement of one tectonic plate beneath another. The ocean sediments are subducted by the actions of **plate tectonics**, melted and then returned to the surface during volcanic activity. Plate tectonics can also cause **uplifting**, returning ocean sediments to land.

Carbon Cycles Quickly between Organisms and the Atmosphere

Carbon dioxide is converted into glucose, an energy-rich organic molecule through **photosynthesis** by plants, algae, and some bacteria (figure $7.3.b$). They can then produce other organic molecules like complex carbohydrates (such as starch), proteins and lipids, which animals can eat. Most terrestrial autotrophs obtain their carbon dioxide directly from the atmosphere, while marine autotrophs acquire it in the dissolved form (bicarbonate, HCO_3^-).

Figure 7.3.b: (a) Plants, (b) algae, and (c) certain bacteria, called cyanobacteria, are can carry out photosynthesis. Algae can grow over enormous areas in water, at times completely covering the surface. (credit a: Steve Hillebrand, U.S. Fish and Wildlife Service; credit b: "eutrophication&hypoxia"/Flickr; credit c: NASA; scale-bar data from Matt Russell)

Plants, animals, and other organisms break down these organic molecules during the process of **aerobic cellular respiration**, which consumes oxygen and releases energy, water and carbon dioxide. Carbon dioxide is returned to the atmosphere during gaseous exchange. Another process by which organic material is recycled is the decomposition of dead organisms. During this process, bacteria and fungi break down the complex organic compounds. Decomposers may do respiration, releasing carbon dioxide, or other processes that release methane (CH_4).

Photosynthesis and respiration are actually reciprocal to one another with regard to the cycling of carbon: photosynthesis removes carbon dioxide from the atmosphere and respiration returns it (figure 7.3.c). A significant disruption of one process can therefore affect the amount of carbon dioxide in the atmosphere.

Photosynthesis Equation						
Carbon dioxide	+	Water	SUNLIGHT →	Sugar	+	Oxygen
$6CO_2$		$6H_2O$		$C_6H_{12}O_6$		$6O_2$

Figure 7.3.c: This equation means that six molecules of carbon dioxide (CO_2) combine with six molecules of water (H_2O) in the presence of sunlight. This produces one molecule of glucose ($C_6H_{12}O_6$) and six molecules of oxygen (O_2).

Cellular respiration is only one process that releases carbon dioxide. Physical processes, such as the eruption of volcanoes and release from **hydrothermal vents** (openings in the ocean floor) add carbon dioxide to the atmosphere. Additionally, the **combustion** of wood and fossil fuels releases carbon dioxide. The level of carbon dioxide in the atmosphere is greatly influenced by the reservoir of carbon in the oceans. The exchange of carbon between the atmosphere and water reservoirs influences how much carbon is found in each.

Importance of the Carbon Cycle

The carbon cycle is crucially important to the biosphere. If not for the recycling processes, carbon might long ago have become completely sequestered in crustal rocks and sediments, and life would no longer exist (figure 7.3.e). Photosynthesis not only makes energy and carbon available to higher trophic levels, but it also releases gaseous oxygen (O_2). Gaseous oxygen is necessary for cellular respiration to occur. Photosynthetic bacteria were likely the first organisms to perform photosynthesis, dating back 2-3 billion years ago. Thanks to their activity, and a diversity of present-day photosynthesizing organisms, Earth's atmosphere is currently about 21% O_2. Also, this O_2 is vital for the creation of the ozone layer, which protects life from harmful ultraviolet radiation emitted by the sun. Ozone (O_3) is created from the breakdown and reassembly of O_2.

Figure 7.3.e: Decomposers will break down the organic compounds in this fallen tree at Cliffs of the Neuse State Park in Wayne County, North Carolina, releasing carbon dioxide into the atmosphere. Decomposition ensures that carbon dioxide will be available in the atmosphere for photosynthetic organisms, which then provide carbon for consumers. Image by Gerry Dincher (CC-BY-SA).

The global carbon cycle contributes substantially to the provisioning ecosystem services upon which humans depend. We harvest approximately 25% of the total plant biomass that is produced each year on the land surface to supply food, fuel wood and fiber from croplands, pastures and forests. In addition, the global carbon cycle plays a key role in regulating ecosystem services because it significantly influences climate via its effects on atmospheric CO_2 concentrations.

Human Alteration of the Carbon Cycle

Atmospheric CO_2 concentration increased from 280 parts per million (ppm) to 413 ppm between the start of industrial revolution in the late eighteenth century and 2020. This reflected a new flux in the global carbon cycle—anthropogenic CO_2 emissions—where humans release CO_2 into the atmosphere by burning fossil fuels and changing land use. Fossil fuel burning takes carbon from coal, gas, and oil reserves, where it would be otherwise stored on very long time scales, and introduces it into the active carbon cycle. Land use change releases carbon from soil and plant biomass pools into the atmosphere, particularly through the process of deforestation for wood extraction or conversion of land to agriculture. In 2018, the additional flux of carbon into the atmosphere from anthropogenic sources was estimated to be 36.6 gigatons of carbon (GtC = 1 billion tons of carbon)—a significant disturbance to the natural carbon cycle that had been in balance for several thousand years previously. High levels of carbon dioxide in the atmosphere cause warming that results in climate change. (See Threats to Biodiversity and Climate Change for more details.)

The Nitrogen Cycle

All organisms require nitrogen because it is an important component of nucleic acids, proteins, and other organic molecules. Getting nitrogen into living organisms is difficult. Plants and algae are not equipped to incorporate nitrogen from the atmosphere (where it exists as tightly bonded, triple covalent N_2) although this molecule comprises approximately 78 percent of the atmosphere. Because most of the nitrogen is stored in the atmosphere, the atmosphere is considered a reservoir of nitrogen.

The nitrogen molecule (N_2) is quite inert. To break it apart so that its atoms can combine with other atoms requires the input of substantial amounts of energy. **Nitrogen fixation** is the process of converting nitrogen gas into ammonia (NH_3), which spontaneously becomes ammonium (NH_4^+). Ammonium is found in bodies of water and in the soil (figure 7.3.f).

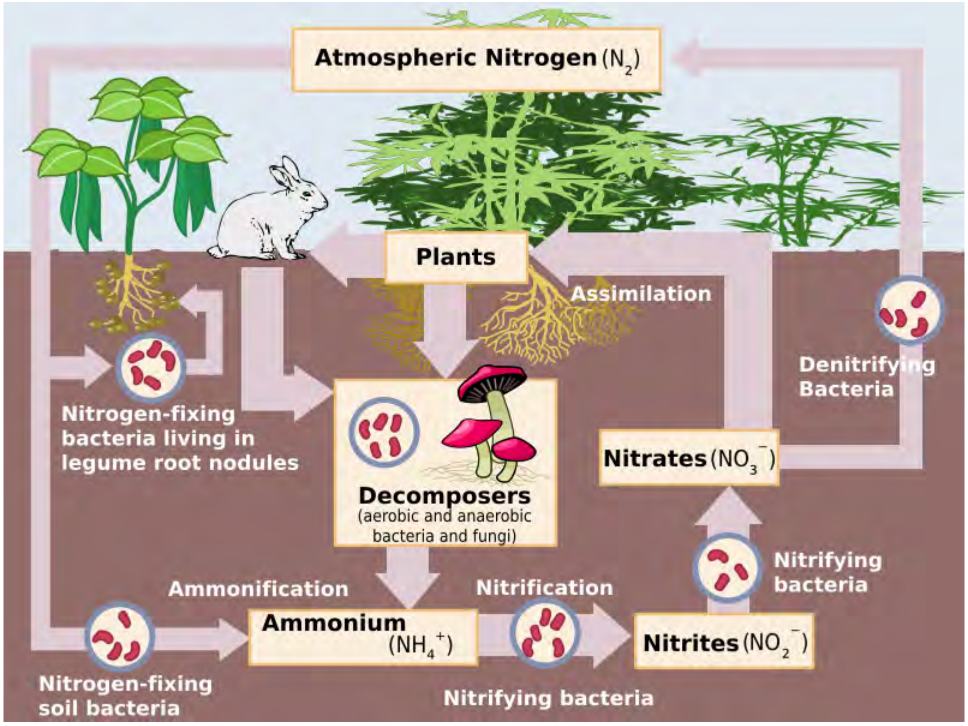


Figure 7.3.*f*: In the nitrogen cycle, nitrogen-fixing bacteria in the soil or legume root nodules convert nitrogen gas (N_2) from the atmosphere to ammonium (NH_4^+). Nitrification occurs when bacteria convert ammonium to nitrites (NO_2^-) and then to nitrates (NO_3^-). Nitrates re-enter the atmosphere as nitrogen gas through denitrification by bacteria. Plants assimilate ammonium and nitrates, producing organic nitrogen, which is available to consumers. Decomposers, including aerobic and anaerobic bacteria and fungi, break down organic nitrogen and release ammonium through ammonification. (credit: "Nitrogen cycle" by Johann Dréo & Raeky is licensed under CC BY-SA 3.0)

Three processes are responsible for most of the nitrogen fixation in the biosphere. The first is **atmospheric fixation** by lightning. The enormous energy of lightning breaks nitrogen molecules and enables their atoms to combine with oxygen in the air forming nitrogen oxides. These dissolve in rain, forming nitrates, that are carried to the earth. Atmospheric nitrogen fixation probably contributes some 5-8% of the total nitrogen fixed. The second process is **industrial fixation.** Under great pressure, at a temperature of 600°C (1112°F), and with the use of a **catalyst** (which facilitates chemical reactions), atmospheric nitrogen and hydrogen can be combined to form ammonia (NH_3). Ammonia can be used directly as fertilizer, but most of it is further processed to urea and ammonium nitrate (NH_4NO_3).

The third process is **biological fixation** by certain free-living or symbiotic bacteria. Some form a symbiotic relationship with plants in the legume family, which includes beans, peas, soybeans, alfalfa, and clovers (figure 7.3.*g*). Some nitrogen-fixing bacteria even establish symbiotic relationships with animals, e.g., termites and "shipworms" (wood-eating bivalves). Nitrogen-fixing cyanobacteria are essential to maintaining the fertility of semi-aquatic environments like rice paddies. Although the first stable product of the process is ammonia, this is quickly incorporated into protein and other organic nitrogen compounds.

Figure $7.3.g$: Nitrogen-fixing bacteria live in the spherical nodules of this soybean root. Image by United Soybean Board (CC-BY).

Ammonium is converted by bacteria and archaea into nitrites (NO_2^-) and then nitrates (NO_3^-) through the process of **nitrification**. Like ammonium, nitrites and nitrates are found in water and the soil. Some nitrates are converted back into nitrogen gas, which is released into the atmosphere. The process, called **denitrification**, is conducted by bacteria.

Plants and other producers directly use ammonium and nitrates to make organic molecules through the process of **assimilation**. This nitrogen is now available to consumers. Organic nitrogen is especially important to the study of ecosystem dynamics because many processes, such as primary production, are limited by the available supply of nitrogen.

Consumers excrete organic nitrogen compounds that return to the environment. Additionally dead organisms at each trophic level contain organic nitrogen. Microorganisms, such as bacteria and fungi, decompose these wastes and dead tissues, ultimately producing ammonium through the process of **ammonification.**

In marine ecosystems, nitrogen compounds created by bacteria, or through decomposition, collects in ocean floor sediments. It can then be moved to land in geologic time by uplift of Earth's crust and thereby incorporated into terrestrial rock. Although the movement of nitrogen from rock directly into living systems has been traditionally seen as insignificant compared with nitrogen fixed from the atmosphere, a recent study showed that this process may indeed be significant and should be included in any study of the global nitrogen cycle.

Human activity can alter the nitrogen cycle by two primary means: the combustion of fossil fuels, which releases different **nitrogen oxides** into the atmosphere, and by the use of artificial fertilizers in agriculture. Atmospheric nitrogen (other than N_2) is associated with several effects on Earth's ecosystems. Nitrogen oxides (HNO_3) can react in the atmosphere to form nitric acid, a form of **acid deposition**, also known as acid rain. Acid deposition damages healthy trees, destroys aquatic systems and erodes building materials such as marble and limestone. Like carbon dioxide, nitrous oxide (N_2O) causes warming resulting in climate change.

Humans are primarily dependent on the nitrogen cycle as a supporting ecosystem service for crop and forest productivity. Nitrogen fertilizers are added to enhance the growth of many crops and plantations (figure $7.3.h$). The enhanced use of fertilizers in agriculture was a key feature of the green revolution that boosted global crop yields in the 1970s. The industrial production of nitrogen-rich fertilizers has increased substantially over time and now matches more than half of the input to the land from biological nitrogen fixation (90 megatons = 1 million tons of nitrogen each year). If the nitrogen fixation from legume crops is included, then the anthropogenic flux of nitrogen from the atmosphere to the land exceeds natural fluxes to the land. Fertilizers are washed into lakes, streams, and rivers by surface runoff, resulting in saltwater and freshwater **eutrophication**, a process whereby nutrient runoff causes the overgrowth of algae, the depletion of oxygen, and death of aquatic fauna.

Figure $7.3.h$: Fertilizer containing nitrogen is conventionally applied at large scales in agriculture. Image by Bob Nichols, USDA Natural Resources Conservation Service (public domain).

The Phosphorus Cycle

Several forms of nitrogen (nitrogen gas, ammnoium, nitrates, etc.) were involved in the nitrogen cycle, but phosphorus remains primarily in the form of the phosphate ion (PO_4^{3-}). Also in contrast to the nitrogen cycle, there is no form of phosphorus in the atmosphere. Phosphorus is used to make nucleic acids and the phospholipids that comprise biological membranes.

Rocks are a reservoir for phosphorus, and these rocks have their origins in the ocean. Phosphate-containing ocean sediments form primarily from the bodies of ocean organisms and from their excretions. However, volcanic ash, aerosols, and mineral dust may also be significant phosphate sources. This sediment then is moved to land over geologic time by the uplifting of Earth's surface (figure $7.3.i$). The movement of phosphate from the ocean to the land and through the soil is extremely slow, with the average phosphate ion having an oceanic residence time between 20,000 and 100,000 years.

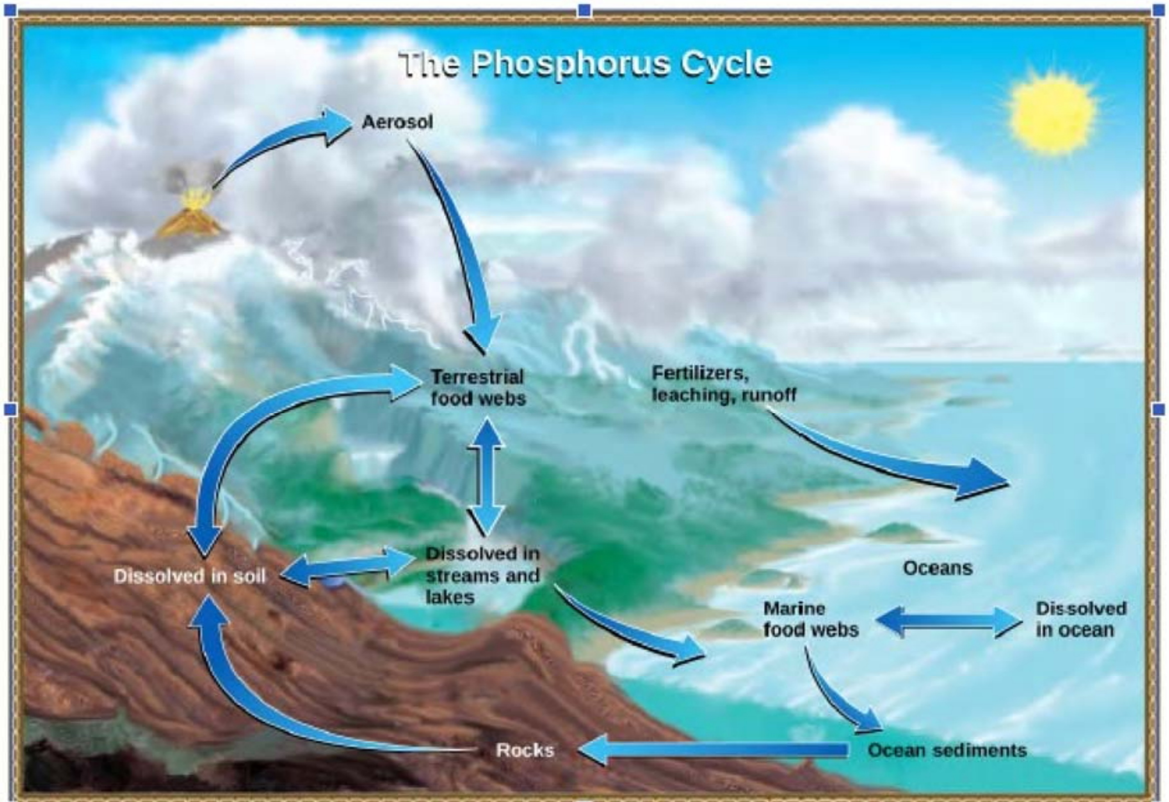


Figure 7.3: In nature, phosphorus exists as the phosphate ion (PO_4^{3-}). Phosphate enters the atmosphere from volcanic aerosols, which precipitate to Earth. Weathering of rocks also releases phosphate into the soil and water, where it becomes available to terrestrial food webs. Some of the phosphate from terrestrial food webs dissolves in streams and lakes, and the remainder enters the soil. Phosphate enters the ocean via surface runoff, groundwater flow, and river flow, where it becomes dissolved in ocean water or enters marine food webs. Some phosphate falls to the ocean floor where it becomes sediment. If uplifting occurs, this sediment can return to land. (credit: modification of work by John M. Evans and Howard Perlman, USGS)

Marine birds play a unique role in the phosphorous cycle. These birds take up phosphorous from ocean fish. Their droppings on land (**guano**) contain high levels of phosphorous and are sometimes mined for commercial use. A 2020 study estimated that the ecosystem services (natural processes and products that benefit humans) provided by guano are worth $470 million per year.

Weathering of rocks releases phosphates into the soil and bodies of water. Plants can assimilate phosphates in the soil and incorporate it into organic molecules, making phosphorus available to consumers in terrestrial food webs. Waste and dead organisms are decomposed by fungi and bacteria, releasing phosphates back into the soil. Some phosphate is leached from the soil, entering into rivers, lakes, and the ocean. Primary producers in aquatic food webs, such as algae and photosynthetic bacteria, assimilate phosphate, and organic phosphate is thus available to consumers in aquatic food webs. Similar to terrestrial food webs, phosphorus is reciprocally exchanged between phosphate dissolved in the ocean and organic phosphorus in marine organisms.

The movement of phosphorus from rock to living organisms is normally a very slow process, but some human activities speed up the process. Phosphate-bearing rock is often mined for use in the manufacture of fertilizers and detergents. This commercial production greatly accelerates the phosphorous cycle. In addition, runoff from agricultural land and the release of sewage into water systems can cause a local overload of phosphate. The increased availability of phosphate can cause overgrowth of algae. This reduces the oxygen level, causing eutrophication and the destruction of other aquatic species.

Eutrophication and Dead Zones

Eutrophication occurs when excess phosphorus and nitrogen from fertilizer runoff or sewage causes excessive growth of algae. Algal blooms that block light and therefore kill aquatic plants in rivers, lakes, and seas. The subsequent death and decay of these organisms depletes dissolved oxygen, which leads to the death of aquatic organisms such as shellfish and fish. This process is responsible for **dead zones**, large areas in lakes and oceans near the mouths of rivers that are periodically depleted of their normal flora and fauna, and for massive fish kills, which often occur during the summer months (figure 7.3.j). There are more than 500 dead zones worldwide. One of the worst dead zones is off the coast of the United States in the Gulf of Mexico. Fertilizer runoff from the Mississippi River basin created a dead zone, which reached its peak size of 8,776 square miles in 2017. Phosphate and nitrate runoff from fertilizers also negatively affect several lake and bay ecosystems including the Chesapeake Bay in the eastern United States.

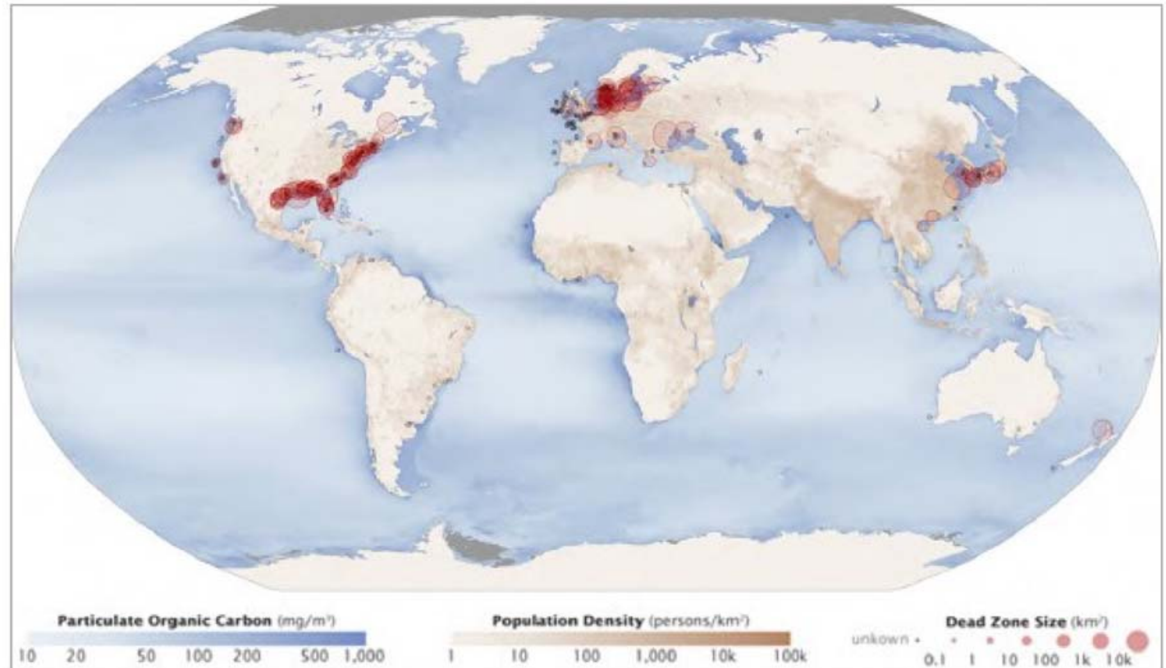


Figure 7.3.j: Dead zones occur when phosphorus and nitrogen from fertilizers cause excessive growth of microorganisms, which depletes oxygen and kills fauna. This map shows dead zones around the world in 2008. Worldwide, large dead zones are found in coastal areas of high population density. (credit: NASA Earth Observatory)

Everyday Connection: Chesapeake Bay

The Chesapeake Bay has long been valued as one of the most scenic areas on Earth; it is now in distress and is recognized as a declining ecosystem. In the 1970s, the Chesapeake Bay was one of the first ecosystems to have identified dead zones, which continue to kill many fish and bottom-dwelling species, such as clams, oysters, and worms (figure 7.3.k). Several species have declined in the Chesapeake Bay due to surface water runoff containing excess nutrients from artificial fertilizer used on land. The source of the fertilizers (with high nitrogen and phosphate content) is not limited to agricultural practices. There are many nearby urban areas and more than 150 rivers and streams empty into the bay that are carrying fertilizer runoff from lawns and gardens. Thus, the decline of the Chesapeake Bay is a complex issue and requires the cooperation of industry, agriculture, and everyday homeowners.

What is a Watershed?

A watershed – the land area that drains to one stream, lake or river – affects the water quality in the water body that it surrounds. Like water bodies (e.g., lakes, rivers, and streams), individual watersheds share similarities but also differ in many ways. Every inch of the United States is part of a watershed – in other words, all land drains into a lake, river, stream or other water body and directly affects its quality. Because we all live on the land, we all live in a watershed — thus watershed condition is important to everyone.

Watersheds exist at different geographic scales, too. The Mississippi River has a huge watershed that covers all or parts of 33 states. You might live in that watershed, but at the same time you live in a watershed of a smaller, local stream or river that flows eventually into the Mississippi. EPA's healthy watersheds activities mainly focus on these smaller watersheds.

What is a Healthy Watershed?

A healthy watershed is one in which natural land cover supports:

- dynamic hydrologic and geomorphologic processes within their natural range of variation,
- habitat of sufficient size and connectivity to support native aquatic and riparian species, and
- physical and chemical water quality conditions able to support healthy biological communities.

Natural vegetative cover in the landscape, including the riparian zone, helps maintain the natural *flow regime** and fluctuations in water levels in lakes and wetlands. This, in turn, helps maintain natural geomorphic processes, such as sediment storage and deposition, that form the basis of aquatic habitats. Connectivity of aquatic and riparian habitats in the longitudinal, lateral, vertical, and temporal dimensions helps ensure the flow of chemical and physical materials and movement of biota among habitats.

A healthy watershed has the structure and function in place to support healthy aquatic ecosystems. Key components of a healthy watershed include:

- intact and functioning headwater streams, floodplains, riparian corridors, biotic refugia, instream habitat, and biotic communities;
- natural vegetation in the landscape; and
- hydrology, sediment transport, fluvial geomorphology, and disturbance regimes expected for its location.

*A stream's *flow regime* refers to its characteristic pattern of flow magnitude, timing, frequency, duration, and rate of change. The flow regime plays a central role in shaping aquatic ecosystems and the health of biological communities. Alteration of natural flow regimes (e.g., more frequent floods) can reduce the quantity and quality of aquatic habitat, degrade aquatic life, and result in the loss of ecosystem services.

Are Healthy Watersheds Very Common?

Unfortunately not. Healthy watersheds are uncommon, particularly in the eastern U.S. as well as in most other parts of the nation that are urbanized, farmed, or mined. Large tracts of protected wildlands, mostly in the western U.S., are where most healthy watersheds can be found. However, some healthy watersheds exist in many regions of the country where water pollution has been prevented or well controlled, and where communities maintain the benefits of their clean waterways.

How Might Healthy Watersheds Affect Me?

You may potentially benefit from healthy watersheds in numerous ways, generally unseen and unrecognized by the average citizen:

- Healthy watersheds are necessary for virtually any high quality outdoor recreation sites involving the use of lakes, rivers, or streams. Great fishing opportunities are usually due to healthy watersheds that surround the waters that people love to fish.
- Your drinking water, if it comes from a surface water source, might be substantially less expensive to treat, if a healthy watershed around the water source filters pollution for free.
- Your property values may be higher, if you are fortunate enough to reside near healthy rather than impaired waters.

You and your community's quality of life may be better in these and other ways due to healthy watersheds; now, imagine how unhealthy watersheds might affect you as well.

Why Do Watersheds Need to Be Protected?

Healthy watersheds not only affect water quality in a good way, but also provide greater benefits to the communities of people and wildlife that live there.

A watershed – the land area that drains to a stream, lake or river – affects the water quality in the water body that it surrounds. Healthy watersheds not only help protect water quality, but also provide greater benefits than degraded watersheds to the people and wildlife that live there. We all live in a watershed, and watershed condition is important to everyone and everything that uses and needs water.

Healthy watersheds provide critical services, such as clean drinking water, productive fisheries, and outdoor recreation, that support our economies, environment and quality of life. The health of clean waters is heavily influenced by the condition of their surrounding watersheds, mainly because pollutants can wash off from the land to the water and cause substantial harm.

Streams, lakes, rivers and other waters are interconnected with the landscape and all its activities through their watersheds. They are influenced by naturally varying lake levels, water movement to and from groundwater, and amount of stream flow. Other factors, such as forest fires, stormwater runoff patterns, and the location and amount of pollution sources, also influence the health of our waters.

These dynamics between the land and the water largely determine the health of our waterways and the types of aquatic life found in a particular area. Effective protection of aquatic ecosystems recognizes their connectivity with each other and with their surrounding watersheds. Unfortunately, human activities have greatly altered many waters and their watersheds. For example:

- Over the last 50 years, coastal and freshwater wetlands have declined; surface water and groundwater withdrawals have increased by 46%; and non-native fish have established themselves in many watersheds (Heinz Center, 2008).
- A national water quality survey of the nation's rivers and streams showed that 55% of the nation's flowing waters are in poor biological condition and 23% are in fair biological condition (U.S. EPA, 2013). Compared to a 2006 survey (U.S. EPA, 2006), which only assessed wadeable streams, 7% fewer stream miles were in good condition.
- Nearly 40% of fish in North American freshwater streams, rivers and lakes are found to be vulnerable, threatened or endangered; nearly twice as many as were included on the imperiled list from a similar survey conducted in 1989 (Jelks et al., 2008)
- Rainbow trout habitat loss from warmer water temperatures associated with climate change already has been observed in the southern Appalachians (Flebbe et al., 2006).

Why is EPA Concerned with Healthy Watersheds?

One of EPA's most important jobs is to work with states and others to achieve the Clean Water Act <https://epa.gov/laws-regulations/summary-clean-water-act>'s primary goal – restore and maintain the integrity of the nation's waters. Despite this law's many pollution control successes, tens of thousands of streams, rivers and lakes have been reported as still impaired. The great majority of these involve pollution sources in their watersheds – the land area that surrounds and drains into these waters. Knowing the conditions in watersheds is crucial for restoring areas with degraded water quality, as well as protecting healthy waters from emerging problems before expensive damages occur.

Achieving the Clean Water Act's main goal depends on having good information about watersheds – their environmental conditions, possible pollution sources, and factors that may influence restoration and protection of water quality. EPA is investing in developing scientifically sound and consistent data sources, and making this information public and easily accessible to the wide variety of our partners working toward clean and healthy waters.

What is Being Done to Protect Healthy Watersheds?

A very wide range of activities could be called healthy watersheds protection. These may include regulatory and non-regulatory approaches. EPA's healthy watersheds protection activities are nonregulatory. Approaches used at state and local level could be either. The private sector is also actively involved in many forms of protection.

After decades of focusing almost exclusively on restoring impaired waters, EPA created the Healthy Watersheds Program (HWP) to bring more emphasis to proactively protecting high quality waters, following the Clean Water Act (CWA)'s objective "…to restore and maintain the chemical, physical, and biological integrity of the Nation's waters." The HWP takes a non-regulatory, collaborative approach to maintaining clean waters by supporting EPA and its partners in their efforts to identify, assess and protect watershed health through Clean Water Act programs. This approach is essential for addressing future threats such as:

- emerging water quality problems,
- loss and fragmentation of aquatic habitat,
- altered water flow and availability,
- invasive species, and
- climate change.

How is a Healthy Watershed Identi ied?

There are literally hundreds of watershed characteristics (such as environmental traits, sources of degradation, and community factors) that may influence environmental health and quality of life, for better or worse. Identifying and comparing these characteristics is known as watershed assessment. This process is the main way to compare watershed condition across large areas such as states, and find the healthy watersheds among the rest.

Understand Your Watershed: Hydrology and Geomorphology

In This Training Session

- Introduction
- What is a watershed?
- What is hydrology
  - Components of the hydrologic cycle
- Groundwater/surface water interactions
  - Groundwater recharge and discharge zones
  - Gaining and losing stream reaches
  - Groundwater and wetlands interactions
- Streamflow
  - Streamflow and hydrographs
  - Stream order
- Geomorphology – the shape of a river
  - Channel shape and function
  - Channel equilibrium
  - Shape depends on ten variables
  - Stream classification predicts shape
  - Why stream classification matters
- Connectivity
  - River Continuum Concept
  - Physical changes in the stream channel affect connectivity
  - Changes in land use affect connectivity
- Take a holistic approach to your TMDL study
- References

Acronyms

BMP - Best management practices
ET - Evapotranspiration
MDNR - Minnesota Department of Natural Resources
TMDL - Total Maximum Daily Load
USEPA - United States Environmental Protection Agency

Introduction

A watershed is an identified geographical area that drains to a common point such as a river, wetland, lake or estuary. Watersheds or subwatersheds are the common physical boundary used to study an impaired river or stream. Watersheds are useful physical boundaries within which to study an impaired waterbody since they integrate the complex physical, chemical and biological processes that ultimately influence waterbody health (Davenport, 2003).

The physical processes, which consist of the hydrologic and geomorphorphic forces within a watershed, are the focus of this chapter. These processes are often the primary factors that influence the health of a waterbody and are therefore must be carefully examined when conducting a TMDL study.

Understanding hydrology (the science of water) and geomorphology (the study of geologic forces that shape the landscape) and their application at various watershed scales is key to understanding water quality impairments. At the most basic level, this involves understanding the hydrologic cycle (also know as the water cycle) as the source of all water at a global, regional and local watershed scale. At a more complex level, it means understanding the unique interplay of the groundwater, surface water, topography, geologic forces and living things within a specific watershed. **Without this understanding, efforts to diagnose a waterbody impairment and to restore beneficial uses will likely prove ineffective.**

This chapter focuses on the basic principles of hydrology and geomorphology and how they interact to affect water quality at a watershed scale. Given the complexity of these two disciplines and the many linkages between them, presenting a general overview of important concepts and principles is challenging at best. Entire books have been written about specific principles within hydrology, for example. This chapter presents a simple overview of the basic principles and concepts within these two disciplines as they relate to watershed management.

This chapter provides only the most essential concepts, intended to stimulate more thorough discussions among you and your colleagues. For more in-depth, complete information on the physical processes within a watershed, we recommend the following resources:

***Hydrology and the Management of Watersheds*, 2003, Kenneth N. Brooks, et. al.**

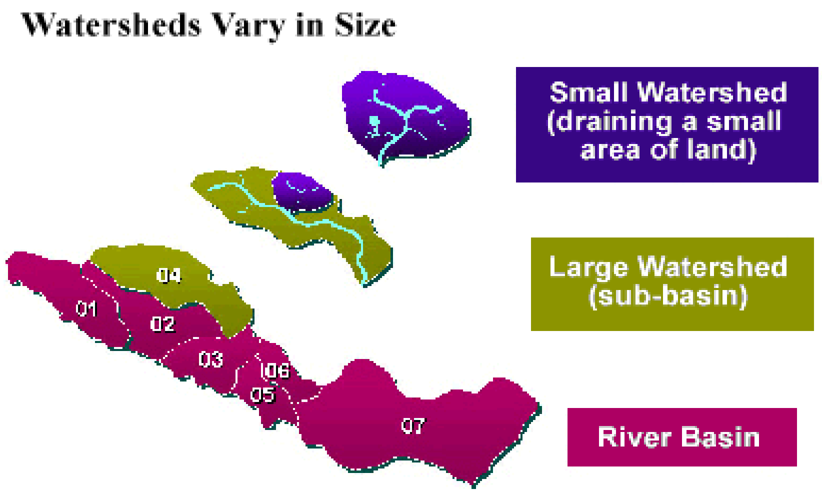
***Watershed Hydrology*, 1996, Peter Block.**

***Environmental Hydrology*, 2004, Andrew D. Ward and Stanley Trimble.**

***Eco-Hydrology*, 1999, Andrew Baird and Robert Wilby.**

What is a Watershed?

A watershed can be defined as all of the land area that drains to a common waterway, such as a stream, lake, estuary or wetland (EPA, 2005). A watershed can be very large (e.g. draining thousands of square miles to a major river or lake or the ocean), or very small, such as a 20-acre watershed that drains to a pond. A small watershed that nests inside of a larger watershed is sometimes referred to as a subwatershed (EPA, 2007).



Source: USEPA, 2007

There are maps and computer databases you can turn to that have watershed boundaries already delineated--particularly for larger basins and watersheds. EPA has a popular internet site called "Surf Your Watershed" found at: http://www.epa.gov/surf (EPA, 2007). Contact MPCA for more detailed information about your watershed.

2.1 BACKGROUND

211 Designated Uses and Why They are Important

4 CFR 131.3(f) defines designated uses as “those uses specified in water quality standards for each water body or segment whether or not they are being attained.” Designated uses represent each state’s or authorized Tribe’s water quality goals and expectations for its surface waters. Each designated use is protected by an associated level of water quality. Such designated uses can reflect a variety of goals for the waterbody such as recreation in and on the water, protection of human health and aquatic life, irrigation, agriculture, public water supply, and cultural uses of the waterbody.

Section 101(a)(2) of the CWA provides that “it is the national goal that wherever attainable, an interim goal of water quality which provides for the protection and propagation of fish, shellfish and wildlife and provides for recreation in and on the water be achieved...” Therefore, such uses must be protected unless shown to be unattainable. The U.S. Environmental Protection Agency’s regulation at 40 CFR 131.10 provides a framework for how a state or authorized Tribe would demonstrate a use specified in CWA Section 101(a)(2) is not attainable. Please see section 2.3 for more discussion.

What are Designated Uses?

Designated uses are “those uses specified in water quality standards for each water body or segment whether or not they are being attained.” Designated uses represent each state’s or authorized Tribe’s water quality goals and expectations for its surface waters. Each designated use is protected by an associated level of water quality. Such designated uses can reflect a variety of goals for the waterbody such as recreation in and on the water, protection of human health and aquatic life, irrigation, and agriculture.

Designated uses do not need to be currently attained to be designated, but rather can represent a state’s or authorized Tribe’s current or *future* management goals for a waterbody. For example, in anticipation of future population growth, a state or authorized Tribe may designate a waterbody for use as a public water supply. While the state or authorized Tribe does not currently use the waterbody as a source of drinking water, it anticipates the need to use the waterbody for such a use in the future based on projected population growth, and therefore, desires to protect water quality now for this future goal.

States and authorized Tribes have flexibility when establishing their designated uses as long as they meet the requirements of the CWA, 40 CFR Part 131, and other applicable legal requirements. The EPA has found that the clearer and more accurate the designated uses are in describing the water quality goals, the more effective those use designations can be in driving management actions necessary to restore, maintain, and protect water quality. Moreover, designated uses communicate to the public the state's or authorized Tribe's water quality goals for each of its waters. These designated uses are also essential to determine and implement actions necessary to restore and maintain water quality consistent with the objectives of the CWA.

Designated uses are also important because they inform the water quality criteria that states and authorized Tribes must adopt to protect their designated uses.[8] The CWA and 40 CFR Part 131 require establishing and reviewing designated uses and criteria protective of those designated uses through a public process, including a public hearing.[9] The criteria that a state or authorized Tribe adopts define the specific water quality conditions that will protect the designated use. These criteria are essential for determining whether the designated use provides for the protection required by CWA Section 101(a)(2). Clear and accurate designated uses and their associated criteria are foundational elements when implementing key CWA requirements, such as WQBELs for point source dischargers in NPDES permits under CWA Section 402 and TMDLs for waters not meeting applicable WQS under CWA Section 303(d).

Why are Designated Uses Important?

Designated uses communicate to the public the state's or authorized Tribe's water quality goals for each of its waters. These designated uses are essential to determine and implement actions necessary to restore and maintain water quality consistent with the objectives of the CWA.

Designated uses are also important because they inform the water quality criteria that states and authorized Tribes must adopt to protect their designated uses. These criteria are essential when implementing key CWA requirements, such as effluent limitations for point source dischargers in NPDES permits under CWA Section 402, and TMDLs for waters not meeting applicable WQS under CWA Section 303(d).

Determining the designated uses that appropriately reflect the potential for a waterbody involves balancing—within the boundaries established by the CWA and 40 CFR Part 131—environmental, scientific, technical, economic, and social considerations, as well as public input on the desired condition for the waterbody. The EPA can assist the state or authorized Tribe in evaluating these considerations when determining the appropriate designated uses for their waters.

8 40 CFR 131.2, 131.3(b), 131.5(a)(2), 131.6(c), and 131.11(a).

9 CWA Section 303(c)(1) and 40 CFR 131.20(b).

Basic Information about Nonpoint Source

On this Page:

- Overview
- Nonpoint Source vs Point Source
- What You Can do to Prevent Nonpoint Source Pollution
- Factsheets

Overview

NPS pollution generally results from land runoff, precipitation, atmospheric deposition, drainage, seepage or hydrologic modification. NPS pollution, unlike pollution from industrial and sewage treatment plants, comes from many diffuse sources. NPS pollution is caused by rainfall or snowmelt moving over and through the ground. As the runoff moves, it picks up and carries away natural and human-made pollutants, finally depositing them into lakes, rivers, wetlands, coastal waters and ground waters.

Nonpoint source pollution can include:

- Excess fertilizers, herbicides and insecticides from agricultural lands <https://epa.gov/nps/nonpoint-source-agriculture> and residential areas <https://epa.gov/nps/nonpoint-source-urban-areas>
- Oil, grease and toxic chemicals from urban runoff <https://epa.gov/nps/nonpoint-source-urban-areas> and energy production
- Sediment from improperly managed construction sites, crop and forest lands, and eroding streambanks <https://epa.gov/nps/nonpoint-source-hydromodification-and-habitat-alteration>
- Salt from irrigation practices and acid drainage from abandoned mines <https://epa.gov/nps/abandoned-mine-drainage>
- Bacteria and nutrients from livestock, pet wastes and faulty septic systems
- Atmospheric deposition and hydromodification <https://epa.gov/nps/nonpoint-source-hydromodification-and-habitat-alteration>

States report that nonpoint source pollution is the leading remaining cause of water quality problems. The effects of nonpoint source pollutants on specific waters vary and may not always be fully assessed. However, we know that these pollutants have harmful effects on drinking water supplies, recreation, fisheries and wildlife.

Nonpoint Sources vs. Point Sources

The term "nonpoint source" is defined to mean any source of water pollution that does not meet the legal definition of "point source" in section 502(14) of the Clean Water Act:

> The term "point source" means any discernible, confined and discrete conveyance, including but not limited to any pipe, ditch, channel, tunnel, conduit, well, discrete fissure, container, rolling stock, concentrated animal feeding operation, or vessel or other floating craft, from which pollutants are or may be discharged. This term does not include agricultural storm water discharges and return flows from irrigated agriculture.

Illustrations of nonpoint and point source pollution along with elements of the hydrologic cycle.
Developed by the EPA, Office of Water, Nonpoint Source Program

Download the above diagram in a screen-reader compatible format: Sources of Pollution Diagram (pdf) <https://www.epa.gov/system/files/documents/2024-11/508_final-nps-diagram_11-18-24.pdf> (2.13 MB, November 2024)

What You Can Do to Prevent Nonpoint Source (NPS) Pollution

In Urban Environments

- Keep litter, pet wastes, leaves and debris out of street gutters and storm drains—these outlets drain directly to lake, streams, rivers and wetlands.
- Apply lawn and garden chemicals sparingly and according to directions.
- Dispose of used oil, antifreeze, paints and other household chemicals properly—not in storm sewers or drains. If your community does not already have a program for collecting household hazardous wastes, ask your local government to establish one.
- Clean up spilled brake fluid, oil, grease and antifreeze. Do not hose them into the street where they can eventually reach local streams and lakes.
- Control soil erosion on your property by planting ground cover and stabilizing erosion-prone areas.
- Encourage local government officials to develop construction erosion and sediment control ordinances in your community.
- Have your septic system inspected and pumped, at a minimum every three to five years, so that it operates properly. Purchase household detergents and cleaners that are low in phosphorous to reduce the amount of nutrients discharged into our lakes, streams and coastal waters.

Forestry

- Use proper logging and erosion control practices on your forest lands by ensuring proper construction, maintenance, and closure of logging roads and skid trails.
- Report questionable logging practices to state and federal forestry and state water quality agencies.

Agriculture

- Manage animal manures to minimize losses to surface water and ground water.
- Reduce soil erosion and nutrient loss by using appropriate conservation practice systems and other applicable best management practices.
- Use planned grazing systems on pasture and rangeland.
  Dispose of pesticides, containers, and tank rinsate in an approved manner.
- Work with conservation partners locally including Soil and Water Conservation Districts to understand local strategies.

Fact Sheet: Introduction to Clean Water Act (CWA) Section 303(d) Impaired Waters Lists

What is a 303(d) list of impaired waters?

The goal of the Clean Water Act (CWA) is “to restore and maintain the chemical, physical, and biological integrity of the Nation’s waters” (33 U.S.C §1251(a)). Under section 303(d) of the CWA, states, territories, and authorized tribes, collectively referred to in the Act and here as “states,” are required to develop lists of impaired waters. The term "303(d) list" is short for the list of impaired and threatened waters (e.g., stream/river segments, lakes) that all states are required to submit for EPA approval during even-numbered years. The main program result of this process is EPA’s national tracking system for impaired waters.

A state’s 303(d) impaired waters list is comprised of all waters where the state has identified that required pollution controls are not sufficient to attain or maintain applicable water quality standards. The law requires that states establish a prioritized schedule for waters on the lists, and develop Total Maximum Daily Loads (TMDLs) for the identified waters based on the severity of the pollution and the sensitivity of the uses to be made of the waters, among other factors (40C.F.R. §130.7(b)(4)).

A TMDL is a calculation of the maximum amount of a pollutant that a waterbody can receive and still safely meet water quality standards, and an allocation of that load among the various sources of the pollutant. States provide to EPA a long-term plan for completing TMDLs within 8 to 13 years from the first listing of the waterbody. EPA policy allows states to remove waterbodies from their 303(d) list after they have developed a TMDL or made other changes to correct water quality problems.

How do states identify impaired waters?

Regulations say states must evaluate "all existing and readily available information" in developing their 303(d) lists (40 C.F.R. §130.7(b) (5)). Usually due to a lack of resources, most state water quality agencies are able to monitor only a limited percentage of their waters consistently enough to detect water quality problems. Many state agencies use data collected from outside organizations and the public to compile their lists. There are usually quality requirements for data collection and submission before state agencies will consider the data.

How do states submit lists?

In addition to the 303(d) impaired waters list, the CWA requires each state report every two years on the health of *all* its waters, not just those that are impaired. Information from this report, known as the 305(b) report or "biennial water quality report," has historically been used to develop the "threatened and impaired waters" (303(d)) list. Most states compile the data and findings from the 305(b) report and add information from other sources to produce the 303(d) list. EPA recommends that states combine the threatened and impaired waters list with the 305(b) report to create an "Integrated Report," due April 1 of even-numbered years.

Once states submit their 303(d) list to EPA, EPA then has 30 days to approve or disapprove the 303(d) lists. If EPA disapproves a state list, EPA has 30 days to develop a new list for the state; although historically, EPA has rarely established an entire list for a state. Sometimes EPA partially disapproves a list because of omission and adds waters to the state's list.

National Summary of Top 303(d) Listing Impairments

EPA’s Assessment and TMDLs Tracking and Implementation System (ATTAINS) provides state-reported data on the condition of monitored surface waters. ATTAINS is the primary result of long-term state and EPA collaboration on tracking, characterizing, and mapping of 303(d)-listed waters. Below is an excerpt showing the top15 causes of impairment for 303(d) listed waters in ATTAINS. Note that one body of water may have single or multiple listed impairment causes.

Causes of Impairment for 303(d) Listed Waters

Description of this table

NOTE: Click on a cause of impairment (e.g. pathogens) to see the specific state-reported causes that are grouped to make up this category. Click on the "Number of Causes of Impairment Reported" to see a list of waters with that cause of impairment.

Cause of Impairment Group Name	Number of Causes of Impairment Reported
Pathogens	10,249
Mercury	7,966
Metals (other than Mercury)	7,164
Nutrients	6,900
Sediment	6,477
Organic Enrichment/Oxygen Depletion	5,989
pH/Acidity/Caustic Conditions	3,756
Polychlorinated Biphenyls (PCBs)	3,286
Cause Unknown - Impaired Biota	3,254
Turbidity	3,062
Temperature	3,025
Pesticides	1,558
Salinity/Total Dissolved Solids/Chlorides/Sulfates	1,470
Cause Unknown	1,237
Noxious Aquatic Plants	998

How does the 303(d) listing process help to improve water quality?

For many states, identifying waters on a 303(d) list is the first step towards achieving water quality goals. Listing a waterbody on a 303(d) list requires states to review their water quality standards, evaluate available monitoring data and determine if adequate controls are in place for point and nonpoint sources of pollutants. States use this information to identify those waters not meeting the applicable water quality standards (referred to as "impaired waters") or having declining trends (referred to as "threatened waters"), after pollution controls are in place. By identifying threatened waters, states take a more proactive "pollution prevention" approach to water quality management.

In many respects, the 303(d) list acts as a "trigger" signaling the need for immediate management actions to address water quality impairments. Section 303(d) of the CWA also requires states to identify those water quality-limited waters needing TMDLs and to organize its list of waters in a prioritized schedule for TMDL development. Using the impaired waters listing process, states have readily available data and determinations on current water quality impairments, and therefore are able to set management priorities for addressing such impairments accordingly. A 303(d) list effectively influences and guides many appropriate courses of action for restoring and protecting the waters of the U.S.

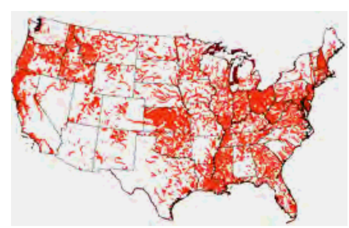
Program Results through 303(d) Listings of Impaired Waters

- **Guidance to States**
  - EPA first provided guidance for states developing 303(d) lists in the 1992 issuance of Guidance for Water Quality-Based Decisions: The TMDL Process*.*
  - EPA continues to provide guidance to states through various Integrated Reporting Guidances (issued for reporting cycles 2002, 2004, 2006, 2008 and 2010), with the 2006 Integrated Reporting Guidance providing the most comprehensive level of detail on using the 5 categories.
  - Additionally, EPA recognizes unusual listing challenges, such as in listing and addressing waters impaired due to atmospheric sources of mercury, and has developed specific guidance appropriate to these challenges (see: Listing Waters Impaired by Atmospheric Mercury).

- **Timely Submission and Review of 303(d) Lists/Integrated Reports**
  Over the past two years, EPA has worked with states to anticipate and address potential issues with the 303(d) list early on in an effort to streamline the 303(d) list submission process. EPA saw a substantial jump in the number of 303(d) List/Integrated Report submissions for the 2008 Integrated Report Cycle. Over three times as many lists were received by the deadline month compared with the 2006 Cycle. Similarly, EPA has made considerable progress in the amount of time the Agency takes in issuing a final action (approve/disapprove) on a State's list.

- **National Information about 303(d) Listed Waters Online**
  EPA has consolidated several years of states' 303(d) listing into the ATTAINS data system, providing publicly available information on over 40,000 tracked waters and user-friendly access to data at scales from local to statewide to national.

- **National GIS (Mapped) Data on Geo-Referenced Impaired Waters Online**
  EPA indexes state spatial data to the National Hydrography Dataset Plus (NHD*Plus*) to provide a nationally consistent reference layer. The indexed data is housed in EPA's Reach Address Database (RAD). EPA provides access to a static national shapefile of 303(d) listed waters, as well as dynamic access to individual state or watershed-level shapefile downloads as new data become available. The spatial data downloads can be related to tabular data extracted from ATTAINS via the WATERS Expert Query tool.



Additional Resources:

- ◊ For more information on **CWA Section 303(d) lists** visit: http://www.epa.gov/owow/tmdl/overview.html
- ◊ For more information on **EPA's 303(d) Listing Guidance, including the recommended "Integrated Reporting"** for reporting under Sections 303(d) and 305(b) visit: http://www.epa.gov/owow/tmdl/guidance.html#2
- ◊ For a national summary or state-by-state data on listed threatened and impaired waterbodies visit **EPA's Assessment and TMDL Tracking and Implementation System (ATTAINS)**: http://www.epa.gov/waters/ir/index.html
- ◊ For tabular state data on 303(d) listed impaired waterbodies visit **EPA's WATERS Expert Query Tool**: http://www.epa.gov//waters/tmdl/expert_query.html
- ◊ For **Geographic Information Systems (GIS) Downloads** visit EPA's Reach Address Database (RAD): http://epamap32.epa.gov/radims/ or visit the WATERS Data Download page: http://www.epa.gov/waters/data/downloads.html
- ◊ For more information on the TMDL Program Results Analysis Project visit: http://www.epa.gov/owow/tmdl/results or contact the project leader at norton.douglas@epa.gov

Overview of Identifying and Restoring Impaired Waters under Section 303(d) of the CWA

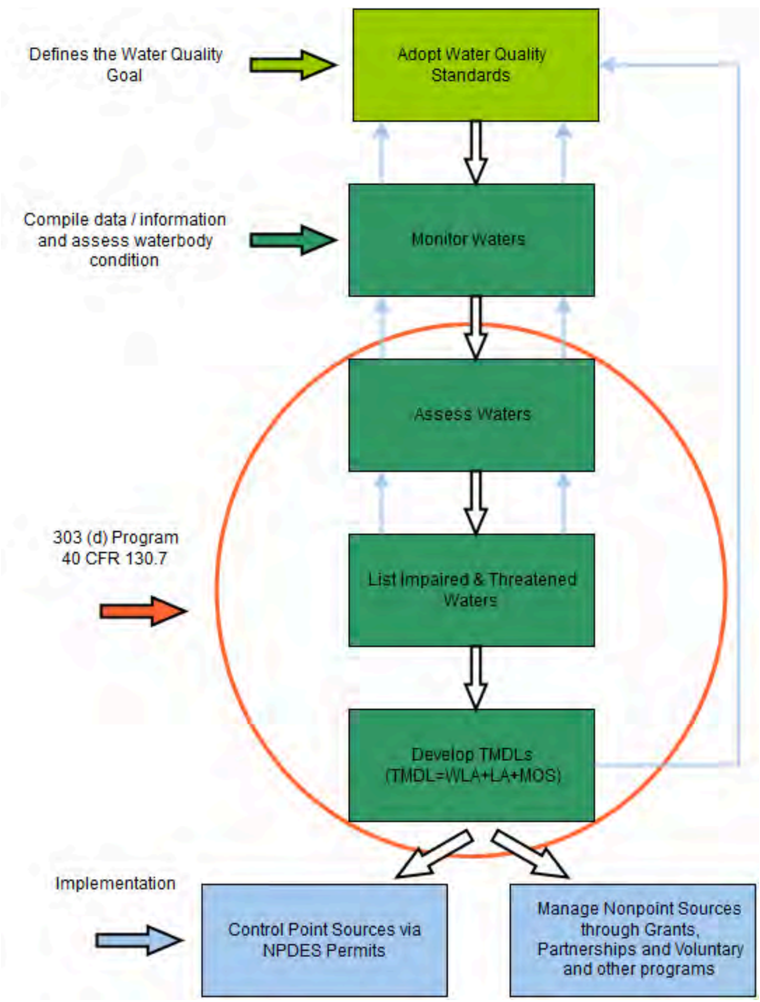
The Impaired Waters and Total Maximum Daily Load (TMDL) Program is an important component of the Clean Water Act's (CWA) framework to restore and protect our Nation's waters. The program is comprised primarily of a two part process. First, states identify waters that are impaired or in danger of becoming impaired (threatened) and second, for these waters, states calculate and allocate pollutant reduction levels necessary to meet approved water quality standards.

What is Section 303(d) of the Clean Water Act?

The goal of the Clean Water Act (CWA) is "to restore and maintain the chemical, physical, and biological integrity of the Nation's waters" (33 U.S.C §1251(a)). Under section 303(d) of the CWA, states, territories and authorized tribes, collectively referred to in the act as "states," are required to develop lists of impaired waters. These are waters for which technology-based regulations and other required controls are not stringent enough to meet the water quality standards set by states. The law requires that states establish priority rankings for waters on the lists and develop Total Maximum Daily Loads (TMDLs) for these waters. A TMDL includes a calculation of the maximum amount of a pollutant that can be present in a waterbody and still meet water quality standards.

How does the 303(d) Impaired Waters and TMDL Program Fit into the Clean Water Act?

As part of the CWA, states must establish water quality standards (WQS) for waters within their borders. Such standards designate the use of the particular waterbody (e.g., recreation or protection of aquatic life), establish water quality criteria to protect the waterbody, and adopt requirements to protect and maintain healthy waters.



Water Quality-Based Approach of the Clean Water Act

Under Section 303(d) of the Act, states are required to evaluate all available water quality-related data and information to develop a list of waters that do not meet established WQS (impaired) and those that currently meet WQS, but may exceed it in the next reporting cycle (threatened). States then must develop a TMDL for every pollutant/waterbody combination on the list. An essential component of a TMDL is the calculation of the maximum amount of a pollutant that can occur in waterbody and still meet WQS. Within the TMDL the state allocates this loading capacity among the various point sources and non-point sources. Permits for point sources are issued through EPA's National Pollutant Discharge Elimination System, or NPDES program.

States are required to update and resubmit their impaired waters list every two years. This process ensures that polluted waters continue to be monitored and assessed until applicable water quality standards are met.

For additional information:

- Overview of Listing Impaired Waters <https://epa.gov/tmdl/overview-listing-impaired-waters-under-cwa-section-303d>
- Overview of TMDLs <https://epa.gov/tmdl/overview-total-maximum-daily-loads-tmdls>

Key Topic #2: NPS in a Growing World and Your Role in It

Learning Objectives

1. **Explain** how population growth, urban expansion, and agricultural intensification contribute to increased non-point source pollution globally and locally.
2. **Compare** the effects of land use types (e.g., urban, suburban, agricultural) on runoff volume and pollutant loading.
3. **Identify** common products or practices in daily life that contribute to non-point source pollution through indirect pathways (e.g., fertilizers, car washing, pet waste).
4. **Illustrate** the concept of a personal environmental footprint as it relates to NPS pollution, using tools such as footprint calculators.

Land Use

What are the trends in land use and their effects on human health and the environment?

- Definition of Land Use
- Effects of Land Use Changes
- ROE Indicators

Definition of Land Use

"Land use" is the term used to describe the human use of land. It represents the economic and cultural activities (e.g., agricultural, residential, industrial, mining, and recreational uses) that are practiced at a given place. Public and private lands frequently represent very different uses. For example, urban development seldom occurs on publicly owned lands (e.g., parks, wilderness areas), while privately owned lands are infrequently protected for wilderness uses.

Land use differs from land cover in that some uses are not always physically obvious (e.g., land used for producing timber but not harvested for many years and forested land designated as wilderness will both appear as forest-covered, but they have different uses).

Effects of Land Use Changes

Land use changes occur constantly and at many scales, and can have specific and cumulative effects on air and water quality, watershed function, generation of waste, extent and quality of wildlife habitat, climate, and human health.

EPA is concerned about different land use activities because of their potential effects on the environment and human health. Land development and agricultural uses are two primary areas of concern, with a wide variety of potential effects.

Land Development

- Land development creates **impervious surfaces** through construction of roads, parking lots, and other structures. Impervious surfaces:
  - Contribute to nonpoint source water pollution <https://epa.gov/nps/basic-information-about-nonpoint-source-nps-pollution> by limiting the capacity of soils to filter runoff.
  - Affect peak flow and water volume, which heighten erosion potential and affect habitat and water quality.
  - Increase storm water runoff, which can deliver more pollutants to water bodies that residents may rely on for drinking and recreation.[1] Storm runoff from urban and suburban areas contains dirt, oils from road surfaces, nutrients from fertilizers, and various toxic compounds.
  - Affect ground water aquifer recharge.
- **Point source discharges** from industrial and municipal wastewater treatment facilities can contribute toxic compounds and heated water.
- Some **land development patterns**, in particular dispersed growth such as "suburbanization," can contribute to a variety of environmental concerns. For example:
  - Increased air pollution due to vehicle use results in higher concentrations of certain air pollutants in developed areas that may exacerbate human health problems such as asthma.[2]
  - Land development can lead to the formation of "heat islands," domes of warmer air over urban and suburban areas that are caused by the loss of trees and shrubs and the absorption of more heat by pavement, buildings, and other sources. Heat islands can affect local, regional, and global climate, as well as air quality.[3]

Agricultural Uses

- Agricultural land uses can affect the **quality of water and watersheds**, including:
  - The types of crops planted, tillage practices, and various irrigation practices can limit the amount of water available for other uses.
  - Livestock grazing in riparian zones can change landscape conditions by reducing stream bank vegetation and increasing water temperatures, sedimentation, and nutrient levels.
  - Runoff from pesticides, fertilizers, and nutrients from animal manure can also degrade water quality.
- Agricultural land use may also result in **loss of native habitats** or increased wind erosion and dust, exposing humans to particulate matter and various chemicals.[4]
- Some land uses can accelerate or exacerbate the **spread of invasive species**. For example:
  - Certain agricultural land use practices, such as overgrazing, land conversion, fertilization, and the use of agricultural chemicals, can enhance the growth of invasive plants.[5] These plants can alter fish and wildlife habitat, contribute to decreases in biodiversity, and create health risks to livestock and humans.
  - Introduction of invasive species on agricultural lands can reduce water quality and water availability for native fish and wildlife species.

Research is beginning to elucidate the connections between land use changes and infectious disease. For example, some studies indicate that spread of vector-borne disease may be influenced by land use and/or other environmental change.[6]

Other studies indicate that fragmentation of forest habitat into smaller patches separated by agricultural activities or developed land increases the “edge effect” and promotes the interaction among pathogens, vectors, and hosts.[7]

In some cases, changes in land use may have positive effects, such as increasing habitat (as a result of deliberate habitat restoration measures) and reclamation of previously contaminated lands for urban/suburban development.

ROE Indicators

The ROE presents two indicators providing information about land use trends: Land Use and Urbanization and Population Change. Available indicators in this area are limited because numerous circumstances (including lack of data; varying approaches to data classification and management, and difficulty in delineating land use) create significant challenges and limitations in tracking trends in and effects of land use.

- **Lack of data:**
  - No indicators are available to assess the effects that trends in land use have on human health, as effects have not been shown or quantified on a national basis. Researchers have conducted site-specific studies on individual land uses, but little is known about overall national trends in land use and potential impacts on human health.
  - An additional challenge is that a variety of state and local laws, regulations, and practices govern the use of land. There are few state-level efforts to organize land use data; most activities occur over specific local, usually urbanizing, geographic areas.

    This means that land use records are not maintained statewide or nationally, as they are in other nations. This contributes to challenges in tracking and monitoring land use changes. It also means that efforts to coordinate land use across jurisdictions are difficult to develop.

- **Varying approaches to data classification and measurement:** Estimates of the extent of various land uses differ across data sources, and each source uses different classifications, measurement approaches, methodologies for analysis and interpretation, and sampling time frames. The data are collected by many different agencies that manage land for many different purposes.

  Some data collection efforts arise out of specific interests, such as tracking changes in the extent of agricultural land or farmland, or understanding how much land is used for timber production. These data collection efforts tend to develop their own classifications and categorization, making it difficult to integrate the data over time, across inventories, or as a national picture.

- **Difficulty in delineating land use:** Finally, the difficulty of actually delineating land use presents a challenge in developing data to determine trends. Land use is generally a function of laws, policies, or management decisions that may not always be possible to infer by examining the ground via surveys. Analysis of zoning maps or property records at the local level may be necessary to understand land use.

EPA
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EPA 841-F-03-003

Protecting Water Quality *from* URBAN RUNOFF

Clean Water Is Everybody's Business

In urban and suburban areas, much of the land surface is covered by buildings and pavement, which do not allow rain and snowmelt to soak into the ground. Instead, most developed areas rely on storm drains to carry large amounts of runoff from roofs and paved areas to nearby waterways. The stormwater runoff carries pollutants such as oil, dirt, chemicals, and lawn fertilizers directly to streams and rivers, where they seriously harm water quality. To protect surface water quality and groundwater resources, development should be designed and built to minimize increases in runoff.

The most recent National Water Quality Inventory reports that runoff from urbanized areas is the leading source of water quality impairments to surveyed estuaries and the third-largest source of impairments to surveyed lakes.

Did you know that because of impervious surfaces like pavement and rooftops, a typical city block generates more than 5 times more runoff than a woodland area of the same size?

How Urbanized Areas Affect Water Quality

Increased Runoff

The porous and varied terrain of natural landscapes like forests, wetlands, and grasslands traps rainwater and snowmelt and allows them to filter slowly into the ground. In contrast, impervious (nonporous) surfaces like roads, parking lots, and rooftops prevent rain and snowmelt from infiltrating, or soaking, into the ground. Most of the rainfall and snowmelt remains above the surface, where it runs off rapidly in unnaturally large amounts.

Storm sewer systems concentrate runoff into smooth, straight conduits. This runoff gathers speed and erosional power as it travels underground. When this runoff leaves the storm drains and empties into a stream, its excessive volume and power blast out streambanks, damaging streamside vegetation and wiping out aquatic habitat. These increased storm flows carry sediment loads from construction sites and other denuded surfaces and eroded streambanks. They often carry higher water temperatures from streets, roof tops, and parking lots, which are harmful to the health and reproduction of aquatic life.

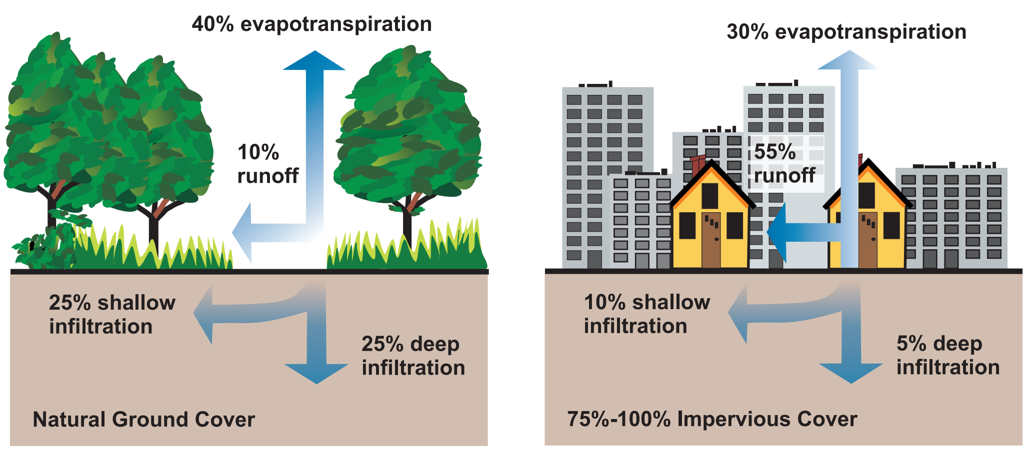
The loss of infiltration from urbanization may also cause profound groundwater changes. Although urbanization leads to great increases in flooding during and immediately after wet weather, in many instances it results in lower stream flows during dry weather. Many native fish and other aquatic life cannot survive when these conditions prevail.

Increased Pollutant Loads

Urbanization increases the variety and amount of pollutants carried into streams, rivers, and lakes. The pollutants include:

- Sediment
- Oil, grease, and toxic chemicals from motor vehicles
- Pesticides and nutrients from lawns and gardens
- Viruses, bacteria, and nutrients from pet waste and failing septic systems
- Road salts
- Heavy metals from roof shingles, motor vehicles, and other sources
- Thermal pollution from dark impervious surfaces such as streets and rooftops

These pollutants can harm fish and wildlife populations, kill native vegetation, foul drinking water supplies, and make recreational areas unsafe and unpleasant.



Relationship between impervious cover and surface runoff. Impervious cover in a watershed results in increased surface ruunoff. As little as 10 percent impervious cover in a watershed can result in stream degradation.

Managing Urban Runoff

What Homeowners Can Do

To decrease polluted runoff from paved surfaces, households can develop alternatives to areas traditionally covered by impervious surfaces. Porous pavement materials are available for driveways and sidewalks, and native vegetation and mulch can replace high maintenance grass lawns. Homeowners can use fertilizers sparingly and sweep driveways, sidewalks, and roads instead of using a hose. Instead of disposing of yard waste, they can use the materials to start a compost pile. And homeowners can learn to use Integrated Pest Management (IPM) to reduce dependence on harmful pesticides.

In addition, households can prevent polluted runoff by picking up after pets and using, storing, and disposing of chemicals properly. Drivers should check their cars for leaks and recycle their motor oil and antifreeze when these fluids are changed. Drivers can also avoid impacts from car wash runoff (e.g., detergents, grime, etc.) by using car wash facilities that do not generate runoff. Households served by septic systems should have them professionally inspected and pumped every 3 to 5 years. They should also practice water conservation measures to extend the life of their septic systems.

Controlling Impacts from New Development

Developers and city planners should attempt to control the volume of runoff from new development by using low impact development, structural controls, and pollution prevention strategies. Low impact development includes measures that conserve natural areas (particularly sensitive hydrologic areas like riparian buffers and infiltrable soils); reduce development impacts; and reduce site runoff rates by maximizing surface roughness, infiltration opportunities, and flow paths.

Controlling Impacts from Existing Development

Controlling runoff from existing urban areas is often more costly than controlling runoff from new developments. Economic efficiencies are often realized through approaches that target "hot spots" of runoff pollution or have multiple benefits, such as high-efficiency street sweeping (which addresses aesthetics, road safety, and water quality). Urban planners and others responsible for managing urban and suburban areas can first identify and implement pollution prevention strategies and examine source control opportunities. They should seek out priority pollutant reduction opportunities, then protect natural areas that help control runoff, and finally begin ecological restoration and retrofit activities to clean up degraded water bodies. Local governments are encouraged to take lead roles in public education efforts through public signage, storm drain marking, pollution prevention outreach campaigns, and partnerships with citizen groups and businesses. Citizens can help prioritize the clean-up strategies, volunteer to become involved in restoration efforts, and mark storm drains with approved "don't dump" messages.

Related Publications

Turn Your Home into a Stormwater Pollution Solution!

www.epa.gov/nps

This web site links to an EPA homeowner's guide to healthy habits for clean water that provides tips for better vehicle and garage care, lawn and garden techniques, home improvement, pet care, and more.

National Management Measures to Control Nonpoint Source Pollution from Urban Areas

www.epa.gov/owow/nps/urbanmm

This technical guidance and reference document is useful to local, state, and tribal managers in implementing management programs for polluted runoff. Contains information on the best available, economically achievable means of reducing pollution of surface waters and groundwater from urban areas.

Onsite Wastewater Treatment System Resources

www.epa.gov/owm/onsite

This web site contains the latest brochures and other resources from EPA for managing onsite wastewater treatment systems (OWTS) such as conventional septic systems and alternative decentralized systems. These resources provide basic information to help individual homeowners, as well as detailed, up-to-date technical guidance of interest to local and state health departments.

Low Impact Development Center

www.lowimpactdevelopment.org

This center provides information on protecting the environment and water resources through integrated site design techniques that are intended to replicate preexisting hydrologic site conditions.

Stormwater Manager's Resource Center (SMRC)

www.stormwatercenter.net

Created and maintained by the Center for Watershed Protection, this resource center is designed specifically for stormwater practitioners, local government officials, and others that need technical assistance on stormwater management issues.

Strategies: Community Responses to Runoff Pollution

www.nrdc.org/water/pollution/storm/stoinx.asp

The Natural Resources Defense Council developed this interactive web document to explore some of the most effective strategies that communities are using around the nation to control urban runoff pollution. The document is also available in print form and as an interactive CD-ROM.

For More Information

U.S. Environmental Protection Agency
Nonpoint Source Control Branch (4503T)
1200 Pennsylvania Avenue, NW
Washington, DC 20460
www.epa.gov/nps

February 2003

EPA
United States Environmental Protection Agency

EPA 841-F-05-001

Protecting Water Quality *from* AGRICULTURAL RUNOFF

Clean Water Is Everybody's Business

The United States has more than 330 million acres of agricultural land that produce an abundant supply of food and other products. American agriculture is noted worldwide for its high productivity, quality, and efficiency in delivering goods to the consumer. When improperly managed however, activities from working farms and ranches can affect water quality.

In the 2000 *National Water Quality Inventory,* states reported that agricultural nonpoint source (NPS) pollution is the leading source of water quality impacts on surveyed rivers and lakes, the second largest source of impairments to wetlands, and a major contributor to contamination of surveyed estuaries and ground water. Agricultural activities that cause NPS pollution include poorly located or managed animal feeding operations; overgrazing; plowing too often or at the wrong time; and improper, excessive, or poorly timed application of pesticides, irrigation water, and fertilizer.

Pollutants that result from farming and ranching include sediment, nutrients, pathogens, pesticides, metals, and salts. Impacts from agricultural activities on surface water and ground water can be minimized by using management practices that are adapted to local conditions. Many practices designed to reduce pollution also increase productivity and save farmers and ranchers money in the long run.

What Is Nonpoint Source Pollution?

Nonpoint source (NPS) pollution, unlike pollution from point sources such as industrial and sewage treatment plants, comes from many diffuse sources. Polluted runoff is caused by rainfall or snowmelt moving over and through the ground. As the runoff moves, it picks up and carries away natural and human-made pollutants, finally depositing them into watersheds through lakes, rivers, wetlands, coastal waters, and even our underground sources of drinking water.

Did you know that runoff from farms is the leading source of impairments to surveyed rivers and lakes?

There are many government programs available to help farmers and ranchers design and pay for management approaches to prevent and control NPS pollution. For example, over 40 percent of section 319 Clean Water Act grants have been used to control NPS pollution from working farms and ranches. Also, many programs funded by the U.S. Department of Agriculture and by states provide cost-share, technical assistance, and economic incentives to implement NPS pollution management practices. Many local organizations and individuals have come together to help create regional support networks to adopt technologies and practices to eliminate or reduce water quality impacts caused by agricultural activities.

Sedimentation

The most prevalent source of agricultural water pollution is soil that is washed off fields. Rain water carries soil particles (sediment) and dumps them into nearby lakes or streams. Too much sediment can cloud the water, reducing the amount of sunlight that reaches aquatic plants. It can also clog the gills of fish or smother fish larvae. In addition, other pollutants like fertilizers, pesticides, and heavy metals are often attached to the soil particles and wash into the water bodies, causing algal blooms and depleted oxygen, which is deadly to most aquatic life. Farmers and ranchers can reduce erosion and sedimentation by 20 to 90 percent by applying management practices that control the volume and flow rate of runoff water, keep the soil in place, and reduce soil transport.

Nutrients

Farmers apply nutrients such as phosphorus, nitrogen, and potassium in the form of chemical fertilizers, manure, and sludge. They may also grow legumes and leave crop residues to enhance production. When these sources exceed plant needs, or are applied just before it rains, nutrients can wash into aquatic ecosystems. There they can cause algae blooms, which can ruin swimming and boating opportunities, create foul taste and odor in drinking water, and kill fish by removing oxygen from the water. High concentrations of nitrate in drinking water can cause methemoglobinemia, a potentially fatal disease in infants, also known as blue baby syndrome. To combat nutrient losses, farmers can implement nutrient management plans that help maintain high yields and save money on fertilizers.

Animal Feeding Operations

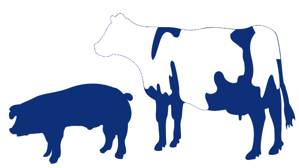
By confining animals in small areas or lots, farmers and ranchers can efficiently feed and maintain livestock. But these confined areas become major sources of animal waste. An estimated 238,000 working farms and ranches in the United States are considered animal feeding operations, generating about 500 million tons of manure each year. Runoff from poorly managed facilities can carry pathogens such as bacteria and viruses, nutrients, and oxygen-demanding organics and solids that contaminate shellfishing areas and cause other water quality problems. Ground water can also be contaminated by waste seepage. Farmers and ranchers can limit discharges by storing and managing facility wastewater and runoff with appropriate waste management systems.

Livestock Grazing

Overgrazing exposes soils, increases erosion, encourages invasion by undesirable plants, destroys fish habitat, and may destroy streambanks and floodplain vegetation necessary for habitat and water quality filtration. To reduce the impacts of grazing on water quality, farmers and ranchers can adjust grazing intensity, keep livestock out of sensitive areas, provide alternative sources of water and shade, and promote revegetation of ranges, pastures, and riparian zones.

Irrigation

Irrigation water is applied to supplement natural precipitation or to protect crops against freezing or wilting. Inefficient irrigation can cause water quality problems. In arid areas, for example, where rainwater does not carry minerals deep into the soil, evaporation of irrigation water can concentrate salts. Excessive irrigation can affect water quality by causing erosion, transporting nutrients, pesticides, and heavy metals, or decreasing the amount of water that flows naturally in streams and rivers. It can also cause a buildup of selenium, a toxic metal that can harm waterfowl reproduction. Farmers can reduce NPS pollution from irrigation by improving water use efficiency. They can measure actual crop needs and apply only the amount of water required. Farmers may also choose to convert irrigation systems to higher efficiency equipment.



Pesticides

Insecticides, herbicides, and fungicides are used to kill agricultural pests. These chemicals can enter and contaminate water through direct application, runoff, and atmospheric deposition. They can poison fish and wildlife, contaminate food sources, and destroy the habitat that animals use for protective cover. To reduce contamination from pesticides, farmers should use Integrated Pest Management (IPM) techniques based on the specific soils, climate, pest history, and crop conditions for a particular field. IPM encourages natural barriers and limits pesticide use and manages necessary applications to minimize pesticide movement from the field.

Farm Bill Conservation Funding

In May 2002 President Bush signed the Farm Bill, providing up to $13 billion for conservation programs for six years. This Farm Bill represents an 80 percent increase above current levels of funding available for conservation programs designed to prevent polluted runoff. For more information, visit www.usda.gov/farmbill.

Related Publications and Web Sites

National Management Measures to Control Nonpoint Source Pollution from Agriculture
epa.gov/nps/agmm

This technical guidance and reference document is for use by state, local, and tribal managers in the implementation of nonpoint source pollution management programs. It contains information on effective, readily available, and economically achievable means of reducing pollution of surface and ground water from agriculture.

Agricultural Nonpoint Source Pollution Management Web Site
epa.gov/nps/agriculture.html

This web site features a collection of links to helpful documents, federal programs, partnerships and nongovernmental orrganizations that convey advice and assistance to farmers and ranchers for protecting water quality.

National Agriculture Compliance Assistance Center
epa.gov/agriculture or call toll-free: 1-888-663-2155

EPA's National Agriculture Compliance Assistance Center is the "first stop" for information about environmental requirements that affect the agricultural community.

Animal Feeding Operations (AFO) Web Sites
AFO Virtual Information Center: epa.gov/npdes/afovirtualcenter
Overview of regulations and helpful links: epa.gov/npdes/afo

Funding Sources

Searchable Catalog of Federal Funding Sources for Watershed Protection
epa.gov/watershedfunding

Agricultural Management Assistance Database
www.nrcs.usda.gov/programs/ama

Clean Water Act Section 319(h) funding (epa.gov/nps/319hfunds.html) is provided to designated state and tribal agencies to implement approved nonpoint source management programs.

Environmental Quality Incentives Program (www.nrcs.usda.gov/programs/eqip) offers financial, technical, and educational assistance to install or implement structural, vegetative, and management practices designed to conserve soil and other natural resources.

Conservation Reserve and Conservation Reserve Enhancement Programs (www.fsa.usda.gov/dafp/cepd/default.htm) implemented by the U.S. Department of Agriculture provide financial incentives to encourage farmers and ranchers to voluntarily protect soil, water, and wildlife resources.

For More Information

U.S. Environmental Protection Agency
Nonpoint Source Control Branch (4503T)
1200 Pennsylvania Avenue, NW
Washington, DC 20460

epa.gov/nps

Revised March 2005

Key Topic #3: The role of the Individual/Community in NPS issues and solutions

Learning Objectives

1. **Describe** the role that individuals, families, and local communities can play in reducing NPS pollution through behavior change and local initiatives.
2. **Identify** examples of community-based solutions to NPS pollution (e.g., storm drain marking campaigns, rain garden installations, stream cleanups).
3. **Compare** the effectiveness of individual vs. collective actions in mitigating NPS pollution at the watershed scale.
4. **Demonstrate** how to design or participate in a local outreach or monitoring project that addresses NPS pollution, such as conducting a stormwater audit or organizing a pollution prevention campaign.
5. **Interpret** the benefits and limitations of volunteerism, citizen science, and public- private partnerships in addressing NPS issues.

Overview

Individuals play a significant role in nonpoint source (NPS) pollution, as their everyday actions can contribute to the problem. While NPS pollution is often associated with diffuse sources like agricultural runoff and urban stormwater, individual behaviors such as improper disposal of waste, overuse of lawn chemicals, and improper vehicle maintenance can all contribute to the problem.

Here's a breakdown of how individuals contribute to NPS pollution:

1. Improper Waste Disposal:
    - **Littering:** Discarded trash can be carried by wind or stormwater into waterways.
    - **Improper disposal of household chemicals:** Pouring chemicals like oil, paint, or cleaning products down the drain or on the ground can contaminate soil and water.
    - **Pet waste:** Animal waste left on the ground can be washed into storm drains and pollute nearby water bodies.
2. Excessive Use of Lawn and Garden Chemicals:

- **Fertilizers and pesticides:**

  Over-application of these products can lead to runoff that pollutes nearby water sources with excess nutrients and chemicals.
- **Improper application:**
  Applying these chemicals before rain or in excessive amounts can increase runoff and contamination.

3. Poor Vehicle Maintenance:
    Leaking oil, antifreeze, and other vehicle fluids can be washed into storm drains and pollute water.
    Disposing of used oil, antifreeze, and other automotive fluids improperly can contaminate the environment.
4. Erosion and Sedimentation:
    <u>Construction activities:</u>
    Improper management of construction sites can lead to soil erosion and runoff, contributing to sedimentation of waterways.
    <u>Bare soil:</u>
    Areas of bare soil on residential properties can easily erode during rain, carrying sediment into nearby water bodies.
5. Inadequate Septic Systems:
    - **Failing septic systems:** Malfunctioning septic systems can release untreated sewage into the ground and potentially contaminate groundwater.

How Individuals Can Help:

- **Properly dispose of waste:** Recycle, compost, and dispose of trash and chemicals properly.
- **Use lawn and garden chemicals responsibly:** Apply them sparingly and only when necessary, following label instructions.
- **Maintain vehicles properly:** Fix leaks promptly and dispose of used fluids properly.
- **Control erosion:** Plant vegetation, use mulch, and manage construction activities to minimize soil erosion.
- **Ensure septic systems are functioning correctly:** Have them inspected and pumped regularly.
- **Participate in community cleanups:** Help remove litter and debris from local waterways.
- **Promote awareness:** Educate others about the impact of NPS pollution and encourage responsible practices.

By taking these steps, individuals can significantly reduce their contribution to nonpoint source pollution and help protect water quality.

Nonpoint Source: Urban Areas

Introduction:

Urbanization increases the variety and amount of pollutants carried into our nation's waters. In urban and suburban areas, much of the land surface is covered by buildings, pavement and compacted landscapes. These surfaces do not allow rain and snow melt to soak into the ground which greatly increases the volume and velocity of stormwater runoff. In addition to these habitat-destroying impacts, pollutants from urban runoff include:

- Sediment
- Oil, grease and toxic chemicals from motor vehicles
- Pesticides and nutrients from lawns and gardens
- Viruses, bacteria and nutrients from pet waste and failing septic systems
- Road salts
- Heavy metals from roof shingles, motor vehicles and other sources
- Thermal pollution from impervious surfaces such as streets and rooftops

These pollutants can harm fish and wildlife populations, kill native vegetation, foul drinking water, and make recreational areas unsafe and unpleasant.

Low Impact Development

The term *low impact development* (LID) refers to systems and practices that use or mimic natural processes that result in the infiltration, evapotranspiration or use of stormwater in order to protect water quality and associated aquatic habitat. EPA currently uses the term green infrastructure to refer to the management of wet weather flows that use these processes, and to refer to the patchwork of natural areas that provide habitat, flood protection, cleaner air and cleaner water. At both the site and regional scale, LID/GI practices aim to preserve, restore and create green space using soils, vegetation, and rainwater harvest techniques. LID is an approach to land development (or re-development) that works with nature to manage stormwater as close to its source as possible. LID employs principles such as preserving and recreating natural landscape features, minimizing effective imperviousness to create functional and appealing site drainage that treat stormwater as a resource rather than a waste product. There are many practices that have been used to adhere to these principles such as bioretention facilities, rain gardens, vegetated rooftops, rain barrels and permeable pavements. By implementing LID principles and practices, water can be managed in a way that reduces the impact of built areas and promotes the natural movement of water within an ecosystem or watershed. Applied on a broad scale, LID can maintain or restore a watershed's hydrologic and ecological functions.

Key Topic #4: Strategies to Evaluate NPS Sources, Issues, and Solutions

Learning Objectives

1. **Identify** tools and techniques used to assess non-point source pollution, including watershed mapping, stormwater flow tracing, and visual assessment methods.
2. **Explain** how monitoring data (e.g., water quality indicators such as turbidity, E. coli, nutrients) can be used to evaluate the presence and severity of NPS pollution.
3. **Describe** the challenges in monitoring, quantifying, and managing NPS pollution compared to point source pollution.
4. **Apply** simple field protocols to evaluate land use and physical features (e.g., slope, impervious cover, vegetative buffers) that influence runoff and pollutant transport.
5. **Interpret** basic maps, aerial imagery, or field data to locate potential sources of NPS pollution in a given watershed.
6. **Recommend** appropriate solutions based on identified issues in a mock or real-world NPS pollution scenario, drawing on field evidence or data interpretation.

Resource Title	Source	Located on
Nonpoint Source Monitoring	*TechNOTES Introduction, U.S. EPA, 2016*	Page 113
Designing Water Quality Monitoring Programs for Watershed Projects, *excerpts*	*TechNOTES 2, U.S. EPA, July 2005*	Page 114-119
Exploring Your Data, The First Step, *excerpts*	*TechNOTES 1, U.S. EPA, July 2005*	Page 120-122
Surface Water Flow Measurement for Water Quality Monitoring Projects, *excerpts*	*TechNOTEs 3, U.S. EPA, March 2008*	Page 123-124
Lag Time in Water Quality Response to Land Treatment, *excerpts*	*TechNOTES 4, U.S. EPA, September 2008*	Page 125-127
Using Biological and Habitat Monitoring Data to Plan Watershed Projects, *excerpts*	*TechNOTES 5, U.S. EPA, September 2008*	Page 128-130
Pollutant Load Estimation for Water Quality Monitoring Projects, *excerpts*	*TechNOTES 8, U.S. EPA, April 2013*	Page 131-132
Land Use and BMP Tracking for NPS Watershed Projects, *excerpts*	*TechNOTES 11, U.S. EPA, August 2014*	Page 133-139
Explanatory Variables: Improving the Ability to Detect Changes in Water Quality in Nonpoint Source Watershed Studies, *excerpts*	*TechNOTES 12, U.S. EPA, August 2014*	Page 140-141
How to Read a Topographic Map and Delineate a Watershed	*USDA-NRCS-Minnesota, 2020*	Page 142-145

Nonpoint Source Monitoring

(https://www.epa.gov/nps/nonpoint-source-monitoring-technotes)
See original document above for embedded references.

Through the National Nonpoint Source Monitoring Program (NNPSMP), states monitor and evaluate a subset of watershed projects funded by the Clean Water Act Section 319 Nonpoint Source Control Program. The program has two major objectives:

1. To scientifically evaluate the effectiveness of watershed technologies designed to control nonpoint source pollution
2. To improve our understanding of nonpoint source pollution

NNPSMP TechNOTES is a series of publications that EPA published between 2005 and 2014 that describes this unique research and monitoring effort. TechNOTES offer:

- guidance on data collection,
- implementation of pollution control technologies and monitoring design,
- case studies that illustrate principles in action.

Designing Water Quality Monitoring Programs for Watershed Projects
Excerpts

Designing Water Quality Monitoring Programs for Watershed Projects

(https://www.epa.gov/polluted-runononpoint-source-monitoring-technical-notes) See original document above for embedded references.

Define Goals

Monitoring is carried out to support watershed projects for a number of reasons, including the following (USEPA, 1997a):

- To identify water quality problems, use impairments, causes, and pollutant sources
- To assess permit compliance
- To assist program development and management
- To respond to emergencies
- To validate or calibrate models
- To conduct research
- To develop TMDLs and load/wasteload allocation
- To assess use support status
- To track trends
- To track management measure implementation
- To assess the effectiveness of watershed projects

Relevant monitoring goals are to track management measure implementation, look for trends, and assess watershed project effectiveness. Land treatment monitoring goals might include the following:

- To find out when and where management measures are implemented and operational
- To determine whether management measures are working as planned
- To determine the degree of pollution control achieved by the management measures
- To measure the pollutant contributions from areas where management measures are not implemented
- To discover unplanned activities that could affect project success

Trend analysis and watershed effectiveness monitoring goals might include the following:

- To document pre-implementation water quality conditions
- To measure changes in water quality due to implementation of management measures
- To develop information to guide changes in the implementation plan if water quality goals are not achieved
- To measure the pollutant removal efficiencies of specific management measures
- To measure water quality changes in subwatersheds
- To document changes in pollutant load at the watershed outlet

Review Available Information and Monitoring Efforts

A good watershed monitoring program must be based on a thorough understanding of the system(s) being monitored. Collecting and evaluating all available information and data from other monitoring efforts lays an important foundation for such an understanding. Currently available information should be reviewed before new data are collected to assess its potential use in characterizing the watershed and achieving monitoring goals.

Existing data can also be helpful in designing the management measure implementation plan. For example, stream data for relatively homogenous watersheds might be helpful in assessing pollutant delivery coefficients for current land uses. Comparing these coefficients with literature values might provide a crude indication of the extent to which management improvements could reduce pollutant delivery.

When reviewing historical data, it is important to explore any relationships that might exist between water quality data and land use or land management data. Abrupt changes in water quality parameter values could be related to the addition of or improvement to a point source discharge such as a wastewater treatment plant, changes in impervious surface percentage, increases or decreases in livestock herd sizes, changes in agricultural crop production or livestock types, hydromodification or bridge construction, urbanization, or other land use or land management changes.

Design the Monitoring Program

The specifics of a successful monitoring program depend on the monitoring goals, the availability of existing data and monitoring efforts, the time frame for yielding results, the variability of the system monitored, the types of variables tracked, funding, and the priorities of program managers.

A no-frills monitoring program that meets established goals should be the base, to which enhanced capabilities are added as resources and management allow. Even with generous budgets, no monitoring should be conducted without carefully considering the use of the data to be collected.

Statistical Design

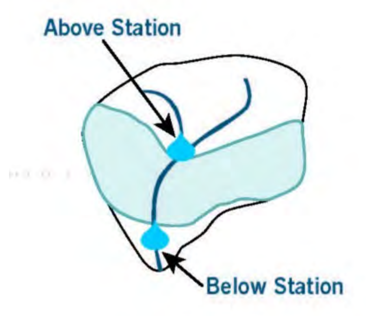
The statistical design must be chosen before other monitoring details (e.g., scale, number of sampling sites, monitoring station type, sampling frequency) can be determined. search sampling can be used to characterize a watershed and locate major pollutant sources; and probability sampling should be used to evaluate watershed projects. Types of probability sampling include simple random sampling, stratified random sampling, two-stage sampling, cluster sampling, systematic sampling, and double sampling

When evaluating the effectiveness of watershed projects, the emphasis should be on testing a hypothesis rather than estimating parameters. For example, the null hypothesis might be that phosphorus loads to the lake will not change between pre-implementation and post-implementation conditions. The goal for the monitoring design would be to test the null hypothesis and, if the null hypothesis is rejected, to conclude with some level of confidence that a change occurred.

The types of monitoring designs are as follows:

- Single-watershed before/after (not recommended)
- Above/below watersheds
- Side-by-side watersheds (not recommended)
- Paired watersheds (very good, but expensive)
- Trend monitoring (>10 years monitoring)

Above/Below Watersheds



In this design monitoring stations are placed above and below the area in which management measures are implemented. Also known as a nested design, this can be treated as a paired-watershed approach if monitoring is done before and after management measures are implemented (USDA, 1996). This design is not as vulnerable to year-to-year climate variations as is single watershed monitoring; it is fairly easy to find a situation where treatment can be implemented between stations; and it is possible to attribute changes in water quality to specific causes, as long as management measures and other land use variables are monitored in both watersheds.

One disadvantage is that the water quality at the above station and that at the below station are not independent because upstream concentrations usually affect downstream concentrations. This might confound statistical analysis of the data. If both pre-implementation and post-implementation monitoring are used, some of these problems can be addressed by a paired-watershed analysis. A paired t-test of the differences between paired above and below samples is appropriate for this design (USDA, 1996).

Watershed-level monitoring is the primary mechanism for evaluating the effectiveness of a watershed project because the projects are implemented at this scale. Watersheds can range in size from a few acres to several thousand acres depending on the project goals and setting. As a general rule, larger watersheds are slower to respond to treatment because of the pollutant transport mechanisms involved. This, however, might not be the case where biological monitoring is conducted, particularly in watersheds where habitat restoration is a key component of the implementation plan.

Variables

The basic monitoring program to assess watershed project effectiveness must focus on the pollutant sources identified in the watershed, the key pollutants from these sources, the water resources affected by these sources and pollutants, measures of designated use support in the affected water resources, and any biological and habitat issues of concern.

Logistical factors, including site access and conditions, personnel availability, and travel times, also influence the selection of water quality variables to monitor. Some water quality constituents, such as soluble reactive phosphorus, have short (24-hour) holding times and require refrigeration while waiting for pickup. In contrast, samples for total phosphorus analysis can be held for as long as 7 days under proper conditions. Samples for bacteria analysis can rarely be collected by automated sampling equipment because of sterility issues and have even shorter allowable holding times (6 hours) between collection and analysis. Trade-offs between the expense and personnel effort to accommodate such constraints and the value of the resulting information must be considered when selecting variables to monitor.

In the end, monitoring data will be used to make statements about the effectiveness of the watershed project. Precipitation, air temperature, and other weather variables are also typically tracked to aid in data analysis and interpretation.

Number of Samples

For many urban streams
it might be desirable to sample every storm event, whereas weekly sampling might be sufficient for rural streams. Storm event samples are often composited into weekly samples for laboratory analysis. Monthly or quarterly sampling could be adequate for some lakes, whereas reservoirs with short hydraulic residence times might require weekly sampling.

Monitoring of management measure effectiveness requires a greater sampling frequency than does trend monitoring. Trend monitoring, however, is typically carried out over a far longer period, bringing total sample counts near to those for effectiveness monitoring.

Trend Analysis

to support trend analysis, a sufficient number of samples must be collected to adequately represent seasonality or other sources of variability evident in the data. In general, a monthly sampling frequency (or taking more frequent samples that can be aggregated to monthly median values, for example) is generally the minimum frequency for sampling streams or rivers in nonpoint source situations. Sampling programs to support trend analysis should operate continuously for the entire project period, using consistent methods, locations, and schedules.

Timing

The sampling time chosen depends on the monitoring goals, the target population, and the anticipated relationship between management measure implementation and measured water quality. If seasonal impacts are expected, sampling should occur during the identified season(s). To determine the general conditions of the water resource, sampling should occur throughout the year, perhaps by weekly sampling.

For nonpoint source load estimation, sampling must occur during high-flow events because that is typically when the greatest pollutant loads occur. Some variables such as dissolved oxygen and temperature display diurnal patterns, and sampling time should be based on the portion of the pattern that is of interest. Biological monitoring is often done quarterly or on some other seasonal basis. In some climates summer sampling is impossible because there is no flow, while winter sampling might be precluded by freezing of the water resource.

Specific types of monitoring include:

- **Load Estimation**
- **Biological Monitoring**
- **Land Treatment**

Handling Noise in the Data

To cut through the noise to find the meaning or signal, a monitoring program to measure the effectiveness of a watershed project must be designed to include recognition of the variability described here. A number of obstacles and constraints must be overcome in most watershed monitoring programs, including the following:

- Lack of control over activities that affect water quality
- Hydrologic variation across seasons and between years
- Incremental change brought on by a land treatment program
- Lag time in the response of natural systems to change
- Surprises, disasters, and other unusual events

Keeping these issues in mind during the design and operation of a monitoring program will increase the probability of success.

Quality Assurance and Quality Control Plan

Quality assurance and quality control practices should be an integral part of the development, design, and implementation of a watershed evaluation project to minimize or eliminate problems associated with the methodologies, data quality, and coordination of sampling and analysis efforts (USEPA, 1997a).

Data Management, Analysis, and Reporting

While conducting a watershed evaluation project, it is important to document all data collected and used. All collected data should be validated with error checking, stored in a logically based and safe filing system with backups, and analyzed using proven approaches. Both hard and computerized copies of data should be maintained because each type of storage is susceptible to damage or loss. Both hard and computer copies should be housed separately from originals, and data should be backed up daily as long as new data are being acquired.

Table 1. Selected pollutants and watershed source characteristics and activities to monitor.

Pollutant Type	Potential Source Characteristics and Activities to Monitor
Suspended sediment (upland erosion)	Cropland tillage, planting, harvesting, construction, logging, erosion control BMPs, precipitation
Suspended sediment (instream erosion)	Streamflow, stream morphometry, riparian zone management, precipitation
Phosphorus (P)	Manure applications, livestock populations, manure and fertilizer management, soil test P, wastewater treatment plant discharge
Nitrogen (N)	Fertilizer applications, legume cropping, manure and fertilizer management, groundwater movement, wastewater treatment plant discharge
Herbicides	Herbicide application rates and timing, precipitation
E. coli (rural)	Livestock populations, grazing practices, riparian zone management, pasture fencing, wildlife populations and seasonal patterns
E. coli (urban)	Pet populations, wildlife/waterfowl activity, septic system maintenance/failure, sewer maintenance, illicit discharge/connections, combined sewer overflow, wastewater treatment plant discharge
Heavy metals	Vehicle traffic, highway infrastructure, street sweeping, stormwater management structures and activities, wastewater treatment plant and industrial discharge
Stormwater flow	Impervious cover, stormwater management facilities, precipitation, combined sewer overflow discharge

Table 2. Relationship of water quality and land use/land treatment variables. "Weekly" and "Annual" variables represent different metrics to be assessed on different time scale.

Water Quality Monitoring Variable	Primary Source	~Weekly Land Use/Treatment Monitoring Variables	~Annual Land Use/Treatment Monitoring Variables
Suspended sediment	Cropland erosion	• Date of tillage operations • Form of tillage (e.g., no-till, mulch-till, reduced-till, and conventional tillage) • Crop canopy development (percentage of soil surface covered by plant foliage) • Cover crop density	• Acreage (and percentage) of land under reduced tillage • Acreage (and percentage) served by terrace systems • Acreage (and percentage) of land converted to permanent cover • Linear feet (and percentage of linear feet) of watercourse protected with riparian buffers (specify buffer width)
Total N	Agricultural cropland	• Manure and fertilizer application rates • Manure and fertilizer forms • Date of manure and/or fertilizer application • Manure and fertilizer application methods	• Number (and percentage) and acreage (and percentage) of farms implementing comprehensive nutrient management plans (CNMP) • Annual fertilizer and manure N applications per acre • Legume acreage • Crop N needs and basis
Stream flow	Urban	• Operation and maintenance of stormwater system • Functioning of stormwater diversions or treatment devices	• Percentage impervious cover • Acreage (and percentage) served by stormwater runoff collection system • Number and area of rain gardens or other infiltration practices • Annual inspection results

Key Topic #5: Legislation, Regulations, and Voluntary Measures

Learning Objectives

1. **Summarize** major U.S. policies and programs that address non-point source pollution, including the Clean Water Act (especially Sections 303 and 319) and Total Maximum Daily Loads (TMDLs).
2. **Differentiate** between regulatory and voluntary approaches to controlling NPS pollution and identify examples of each.
3. **Describe** how federal and state agencies support local communities in managing NPS pollution through funding, education, and technical assistance.
4. **Simulate** a decision-making process where students must select appropriate policy or program tools to manage a fictional watershed's NPS challenges.

Resource Title	Source	Located on
Nonpoint Source Program	*U.S. EPA*	Page 147-149
Overview of TMDLs	*U.S. EPA*	Page 150-153
Stormwater Runoff	*Chesapeake Bay Program*	Page 154-159
Mississippi River Gulf of Mexico Watershed Nutrient Task Force New Goal Framework	*U.S. EPA, December 3, 2014*	Page 160-163
Deepwater Horizon – BP Gulf of America Oil Spill	*U.S. EPA*	Page 164-166
How China is designing flood-resistant cities, *VIDEO*	*Vox, How China is Designing flood-resistant cities*	Page 167
Managing stormwater to improve Canadian cities' safety and resilience	*National Research Council, Government of Canada, 2022*	Page 168-170

Nonpoint Source Program

Available Assistance: Financial, Technical, Planning, Coordination, Facilitation

Statute: Clean Water Act and Safe Drinking Water Act

Program Type: Non-regulatory

EPA Contact(s):

- Robert Goo | Office of Wetlands, Oceans, and Watersheds | 202-566-1201 | goo.robert@epa.gov
- Ellie Flaherty | Office of Wetlands, Oceans, and Watersheds | 202-566-2456 | flahety.ellie@epa.gov

Main Website(s): Polluted Runoff: Nonpoint Source (NPS) Pollution

Helping states, territories, and tribes perform a wide variety of activities to prevent nonpoint source pollution from degrading water quality.

On this page:

About the Program

The 1987 amendments to the Clean Water Act established the Section 319 Nonpoint Source (NPS) Program to address NPS pollution. NPS pollution is caused when rainfall or snowmelt, moving over and through the ground, picks up and carries natural and human-made pollutants, depositing them into lakes, rivers, wetlands, coastal waters, and groundwaters. Increased precipitation from extreme weather will compound NPS pollution.

Types of Assistance

The NPS program provides grant money to states, territories, and tribes to support a wide variety of activities including technical assistance, financial assistance, education, training, technology transfer, demonstration projects, and monitoring to assess the success of specific NPS implementation projects. Receiving a NPS grant to implement projects for improving water quality first requires an EPA-approved watershed-based plan. More information about the NPS program is available in the National Nonpoint Source Program highlights report.

Program in Action

- Drinking Water Supplies: Restoration and Protection Activities in the Upper Branch of the Delaware River Protects New York City's Drinking Water Supply (pdf) (New York).
- Recreation: Urban and Rural Nonpoint Source BMPs Improve Water Quality in the Upper San Antonio River (pdf) (Texas).
- Fisheries: Sasco Brook Improves Due to Bacteria Source Reductions (pdf) (Connecticut).
- Wildlife: Community Partnerships Restore the Water Quality of Mill Creek (pdf) (Alabama).

How This Program Helps Build Resilience

NPS pollution is presently the dominant source of water quality pollution, causing harmful effects on drinking water supplies, recreation, fisheries, and wildlife. To address multiple pollutants and their risks, the NPS program promotes the use of watershed planning to protect and restore water resources (see Handbook for Developing Watershed Plans to Restore and Protect Our Waters). Watershed plans outline best management practices (BMPs) for implementation. BMPs can include bioretention systems, floodplain and stream restoration or stabilization, wetland creation, reforestation, and agricultural conservation approaches like cover crops and riparian buffers. In addition to improving water quality, nature-based practices can also create climate change adaptation and natural hazard mitigation co-benefits (e.g., resilience to droughts, floods, fires, urban heat islands, landslides, erosion, and harmful algal blooms). If plan priorities align, a partnership between hazard or risk reduction plans with watershed or water quality improvement plans could emerge. The annual number of projects implementing practices with climate/hazard mitigation co-benefits is reported as part of the Office of Water Climate Adaptation Implementation Plan. Over 300 Section 319 funded projects with potential climate co-benefits were reported in FY23.

The following success stories document specific examples of water quality improvements that remove stressors and therefore enhance the resilience of water bodies. More success stories about restoring water bodies impaired by NPS pollution can be found in an online database.

Connections to Other EPA, Federal, or Non-Governmental Efforts

The Federal Emergency Management Agency (FEMA) and the EPA have a Memorandum of Agreement that provides a collaborative framework for jointly working on activities related to both hazard mitigation and environmental management to create more resilient communities. The NPS program is currently working with FEMA's hazard mitigation assistance programs, which provide funding for eligible mitigation measures that help reduce disaster losses. Hazard mitigation actions or projects can also provide water quality improvements as a side benefit of reducing hazard risks. However, hazard mitigation projects are more likely to improve water quality if they are coordinated with other state or community water quality goals, strategies, or planned action items.

This information was pulled from EPAs website @ https://www.epa.gov/climate-change-water-sector/nonpoint-source-program.

Overview of Total Maximum Daily Loads (TMDLs)

On this page:

- What is a TMDL?
- What triggers the need for a TMDL?
- Who is responsible for developing a TMDL?
- How are TMDLs developed?
- Public participation in TMDL development
- What are the components of a TMDL document?
- What happens after the TMDL is approved by EPA?

What is a TMDL?

A TMDL is the calculation of the maximum amount of a pollutant allowed to enter a waterbody so that the waterbody will meet and continue to meet water quality standards for that particular pollutant. A TMDL determines a pollutant reduction target and allocates load reductions necessary to the source(s) of the pollutant.

Pollutant sources are characterized as either point sources that receive a wasteload allocation (WLA), or nonpoint sources that receive a load allocation (LA). For purposes of assigning WLAs, point sources include all sources subject to regulation under the National Pollutant Discharge Elimination System (NPDES) program, e.g. wastewater treatment facilities, some stormwater discharges and concentrated animal feeding operations (CAFOs). For purposes of assigning LAs, nonpoint sources include all remaining sources of the pollutant as well as natural background sources. TMDLs must also account for seasonal variations in water quality, and include a margin of safety (MOS) to account for uncertainty in predicting how well pollutant reductions will result in meeting water quality standards.

Expressed mathematically, the TMDL equation is:

TMDL = ΣWLA + ΣLA + MOS

Where **WLA** is the sum of wasteload allocations (point sources), **LA** is the sum of load allocations (nonpoint sources and background) and **MOS** is the margin of safety.

Each pollutant causing a waterbody to be impaired or threatened is referred to as a waterbody/pollutant combination, and typically a TMDL is developed for each waterbody/pollutant combination. For example, if one waterbody is impaired or threatened by three pollutants, three TMDLs might be developed for the waterbody. However, in other cases, a single TMDL document may be developed to address several waterbody/pollutants combinations. Neither the CWA nor EPA's regulations define or limit the scale of TMDLs. Some states have been developing TMDLs on a watershed-scale basis. Such state TMDLs may also cover multiple watersheds.

What triggers the need for a TMDL?

According to the Clean Water Act, each state must develop TMDLs for all the waters identified on their Section 303(d) list of impaired waters, according to their priority ranking on that list.

Who is responsible for developing a TMDL?

As a general matter, states are responsible for developing TMDLs and submitting them to EPA for approval. Even if third parties assist in the development of the TMDL or its supporting analysis, such TMDLs must still be submitted to EPA by the states.

Under the CWA, the EPA reviews and either approves or disapproves the TMDL. If EPA disapproves a state TMDL, EPA must develop a replacement TMDL.

How are TMDLs developed?

The objective of a TMDL is to determine the loading capacity of the waterbody and to allocate that load among different pollutant sources so that the appropriate control actions can be taken and water quality standards achieved. The TMDL process is important for improving water quality because it serves as a link in the chain between water quality standards and implementation of control actions designed to attain those standards.

TMDLs are developed using a range of techniques, from simple mass balance calculations to complex water quality modeling approaches. The degree of analysis varies based on a variety of factors including the waterbody type, complexity of flow conditions and pollutant causing the impairment.

All contributing sources of the pollutants (point and nonpoint sources) are identified, and they are allocated a portion of the allowable load that usually contemplates a reduction in their pollution discharge in order to help solve the problem. Natural background sources, seasonal variations and a margin of safety are all taken into account in the allocations.

The approach normally used to develop a TMDL for a particular waterbody or watershed consists of five activities:

- Selection of the pollutant(s) to consider.
- Estimation of the waterbody's assimilative capacity (i.e., loading capacity).
- Estimation of the pollutant loading from all sources to the waterbody.
- Analysis of current pollutant load and determination of needed reductions to meet assimilative capacity.
- Allocation (with a margin of safety) of the allowable pollutant load among the different pollutant sources in a manner such that water quality standards are achieved.

TMDLs should clearly identify the links between the waterbody use impairment, the causes of impairment, and the pollutant load reductions needed to meet the applicable water quality standards.

Public participation in TMDL development

EPA’s regulations require public involvement in developing TMDLs, however, the level of citizen involvement in the TMDL process varies by state.

Local citizens sometimes know more about what is happening in their watersheds than state agencies, and this knowledge can be a valuable aspect of TMDL development. The public often contributes useful data and information about an impaired waterbody. The public can often offer insights about their community that may ensure the success of one pollutant reduction strategy over another. Citizen information and participation can improve the quality of TMDLs that are developed and can ultimately speed cleanup of impaired waters or secure protection of threatened waters. Public/stakeholder roles in the TMDL process can include:

- Providing data and information to the states.
- Reviewing and commenting on impaired water list.
- Reviewing and commenting on draft TMDLs.
- Assisting in the development of TMDLs.

What are the components of a TMDL document?

EPA issued review guidelines for TMDL submissions in *Guidelines for Reviewing TMDLs under Existing Regulations Issued in 1992*. Below is a TMDL Review Checklist with the minimum recommended elements that should be present in a TMDL document.

- Identification of Waterbody, Pollutant of Concern, Pollutant Sources and Priority Ranking.
- Applicable WQS and Numeric Water Quality Target.
- Loading Capacity.
- Load Allocations and Waste Load Allocations.*
- Margin of Safety.
- Consideration of Seasonal Variation.
- Reasonable Assurance for PS/NPS.
- Monitoring Plan to Track TMDL Effectiveness.
- Implementation Plan.
- Public Participation.

What happens after the TMDL is approved by EPA?

TMDL wasteload allocations (those pollutant allocations assigned to point sources) are generally implemented through EPA's National Pollutant Discharge Elimination System (NPDES) permits under CWA section 402. This section of the Act requires that point source discharges be controlled by including water quality-based effluent limits in permits issued to point source entities. Under EPA's permitting regulations, water quality-based discharge limits in NPDES permits must be "consistent with the assumptions and requirements" of wasteload allocations in EPA-approved TMDLs.

Non-point source load reduction actions are implemented through a wide variety of programs at the state, local and federal level. These programs may be regulatory, non-regulatory or incentive-based e.g., a cost-share program. In addition, waterbody restoration can be assisted by voluntary actions on the part of citizen and/or environmental groups. The EPA section 319 program provides grant money to the states to fund specific projects aimed at reducing the nonpoint source pollution.

Although states are not explicitly required under section 303(d) to develop TMDL implementation plans, many states include some type of implementation plan with the TMDL. When developed, TMDL implementation plans may provide additional information on what point and nonpoint sources contribute to the impairment and how those sources are being controlled, or should be controlled in the future.

This information was sourced from EPAs website @ https://www.epa.gov/tmdl/overview-total-maximum-daily-loads-tmdls#1.

Key Topic #6: Your Best Management Practices for NPS

Learning Objectives

1. **Identify** common BMPs used to reduce NPS pollution in urban, suburban, and agricultural environments (e.g., rain gardens, cover crops, buffer strips, pervious pavement).
2. **Explain** how selected BMPs reduce pollutant loads or improve stormwater infiltration, using diagrams or real-world examples.
3. **Compare** the costs, benefits, and feasibility of different BMPs in various land use contexts (e.g., a schoolyard vs. a farm vs. a residential street).
4. **Demonstrate** how to plan or assess a BMP using a field checklist, photo documentation, or a site sketch (e.g., rain garden layout or runoff path).
5. **Recommend** appropriate BMPs for a hypothetical site based on land use, soil conditions, and observed pollution risks.

Resource Title	Source	Located on
BMPs used to reduce NPS pollution in urban environment, *excerpts*	*National Management Measures to Control Nonpoint Source Pollution from Urban Areas, US EPA, 2005*	Page 172-184
Agricultural Nonpoint Source Pollution, Hydromodification, *excerpts*	*U.S. EPA, 2005*	Page 185-186
Economics of Water Quality Protection from Nonpoint Sources: Theory and Practice, *Abstract excerpt*	*Ribaudo et al, Resource Economics Division, Economic Research Service, U.S.D.A. Agricultural Economic Report No. 782, 1999*	Page 187
Estimating Benefits and Costs of Stormwater Management: *chart and graphic*	*Environmental Finance Center, Sacramento State, 2019*	Page 188-189
Case Study-Burnsville rain gardens	*Minnesota Stormwater Manual, 2005*	Page 190-193
Case studies for stormwater and rainwater harvest and use/reuse	*Minnesota Stormwater Manual, 2012*	Page 194-200
Home NPS BMPs: Reducing Nonpoint Source Pollution at Home, *summary*	*Rodrigue, Paul, USDA NRCS and U.S. EPA*	Page 201-202
Steps to Help Control NPS Pollution, *excerpts*	*Mississippi Department of Environmental Quality*	Page 203

Home NPS BMPs: Reducing Nonpoint Source Pollution at Home

Nonpoint source (NPS) pollution is the leading cause of water quality problems in the U.S.. It's caused by pollutants carried by rainfall or irrigation runoff, which can come from various sources like agricultural runoff, urban streets, and construction sites.

Homeowners can significantly contribute to preventing NPS pollution by implementing Best Management Practices (BMPs) around their homes.

Here are some key NPS BMPs homeowners can use:

1. Managing Runoff:
   - Direct downspouts: Divert roof runoff onto grassed areas or into rain barrels instead of paved surfaces or storm sewers.
   - Install rain gardens or permeable pavement: These features help infiltrate stormwater into the ground, reducing runoff and promoting groundwater recharge.
   - Reduce impervious surfaces: Limit concrete and asphalt walkways and driveways. Consider using alternatives like gravel, stone, or permeable pavers.
   - Plant trees and native vegetation: Trees and native plants help slow down runoff, absorb excess water, and filter pollutants.

2. Smart Lawn and Garden Care:
   - Fertilize and apply pesticides sparingly: Use these chemicals only when necessary and follow recommended application rates. Avoid applying them before rain events.
   - Choose drought-resistant and native plants: These plants require less water, fertilizer, and pesticides, reducing environmental impact.
   - Compost yard waste: Recycling grass clippings and leaves through composting reduces fertilizer needs and keeps waste out of storm drains.
   - Mow properly: Follow recommended mowing heights and avoid excessive watering.
   - Control soil erosion: Plant ground cover and stabilize erosion-prone areas to prevent soil runoff.

3. Responsible Waste Management:
   - Dispose of hazardous materials properly: Never pour oil, antifreeze, paint, or other household chemicals down storm drains or into the trash. Utilize local hazardous waste collection programs.
   - Clean up spills: Absorb spills of fluids like oil and grease with absorbent material and dispose of it properly.
   - Manage pet waste: Promptly clean up pet waste to prevent it from washing into storm drains and contaminating waterways.
   - Maintain septic systems: If you have a septic system, have it inspected and pumped regularly to ensure proper function and prevent pollution.

4. Vehicle Care:
   - Wash cars on pervious surfaces: Use a commercial car wash or wash your car on a lawn to prevent soapy water from entering storm drains.

- Address leaks promptly: Repair any leaks from your vehicle to prevent fluids from entering the storm drain system.
- Recycle used automotive fluids: Dispose of used oil and other fluids at designated recycling stations.

By implementing these simple BMPs, homeowners can make a significant difference in protecting water quality and reducing NPS pollution.

Steps to help control NPS pollution

Summarized from: https://www.mdeq.ms.gov/water/surface-water/nonpoint-source-pollution-program/steps-tohelp-control-nps-pollution/

- Collect litter and animal waste before they wash into storm drains.
- Apply fertilizer at the recommended rate when heavy rain isn't likely to wash it away.
- Recycle grass clippings and leaves by mulching or composting. If you can't compost, collect and dispose of yard waste according to local provisions. Do not put in storm drain.
- If you change your own oil, take the used oil to a recycling station. Check with your local service stations for such facilities. Never dump oil into a storm drain.
- Home septic tanks should be located, constructed and installed according to regulations. Maintenance and prompt correction of problems are important.
- Direct roof runoff onto a grassed area. Roof drains should not be connected to a sanitary or storm sewer system.
- Watch for soil erosion around your home. Seed, install sod or plant ground cover to protect the site.
- Use porous surfaces such as flagstone, gravel, stone, and interlocking pavers rather than concrete and asphalt.
- If you're concerned about the effects of runoff leaving a nearby construction site, contact the local governing body responsible for erosion and sediment control in your area.
- Be active! Join a civic or environmental group and participate in stream cleanup activities. Give talks, man booths, join the Adopt-A-Stream Program… spread the word.

You couldn't live long without clean water. Nothing can. Do your part to protect our waters.