Chapter 6: Harm and Hope

Key Concepts:

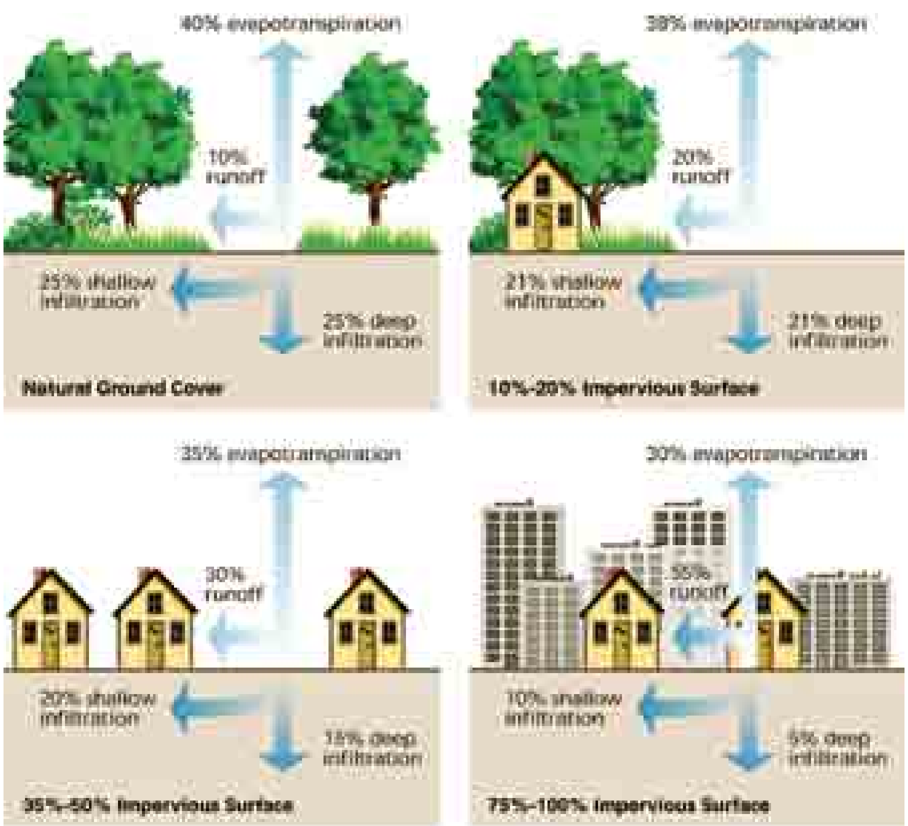
- Human activities can harm or help water quality, the water cycle, and the biological characteristics of water bodies in many ways
- It's up to each of us to help keep water healthy

Cats and caterpillars, turtles and trees... Water affects every living thing, and every living thing affects water. But no species has a greater impact on water in the environment than humans. Our actions can harm or help lakes, streams, wetlands, groundwater, and oceans. We can make it harder or easier for water to meet the needs of other living things. We can affect how well it meets our own needs, too.

In the past, water often seemed so abundant and ubiquitous that people did things like drain wetlands, dam rivers, and pollute lakes without much worry about long-term impacts. Today we realize that water and waterways can be harmed, and water supplies can be degraded or used up altogether. As a result, we have taken actions to reverse harm caused in the past. We also have established limits on the kinds and magnitude of changes we make.

Most human-caused changes in water and waterways fall into three main categories. First, we alter levels of *pollutants* in waterways. Second, we create *water cycle changes* by influencing location and movement of water. Third, we produce *biological changes* by introducing species into water bodies that were not there before, or removing or changing proportions of existing inhabitants.

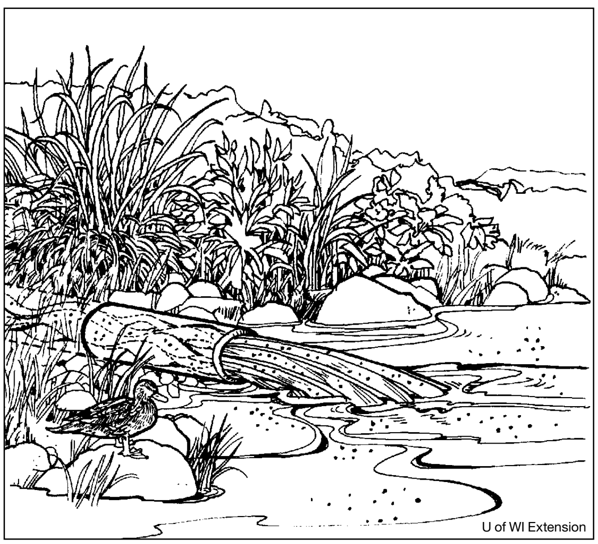
Changes to the Water Cycle as the Built Landscape Changes



In *Stream Corridor Restoration: Principles, Processes, and Practices* (10/98). By the Federal Interagency Stream Restoration Working Group (FISRWG). ©Used with permission.

Pollutants

Many of the most obvious impacts we have on Minnesota's waters have to do with pollutants humans introduce into waterways and watersheds. These include pathogens, nutrients (alone, or as part of organic matter), acids, salts, other chemicals, and thermal pollution (heat). Pollutants introduced to waters through a specific outlet, such as a pipe from an industrial plant, are known as **point source pollution.** Those that enter waters in more dispersed way, such as runoff from a parking lot or farm field or pollutants carried by rain, are called **nonpoint source pollution.** We may tend to notice point source pollution more, because it's concentrated. But most water pollution in Minnesota today is nonpoint source pollution. This runoff can have a huge impact on waterways by carrying sediment, nutrients, toxic chemicals, and other pollutants into them, dramatically altering their chemical, physical, and biological properties.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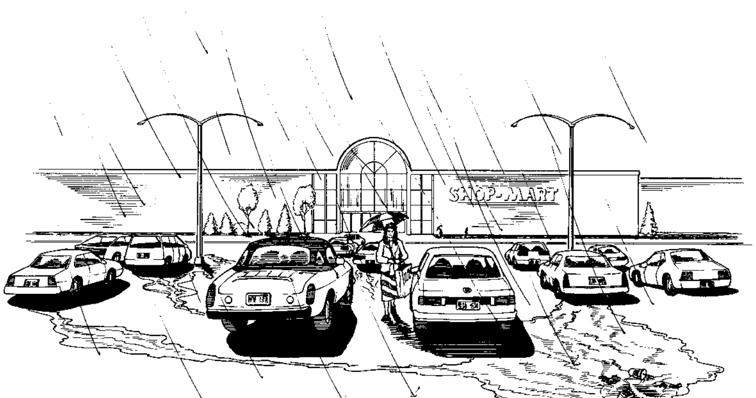
Point source pollution.



Nonpoint source pollution.

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Pathogens

Waterborne diseases are a leading cause of disease and death in many countries. With modern water treatment facilities and wastewater disposal, Minnesota is fortunate to have relatively few problems with pathogens in water. Periodically, problems will occur, however. When septic systems malfunction, adequate wastewater treatment systems are not in place, or other sources of contamination exist, pathogenic bacteria, viruses, and protozoa can pollute lakes and streams and sicken people who ingest the water.

Nutrients

If you've ever fertilized your lawn, garden, or houseplants, you know that plants need three primary nutrients to grow: nitrogen (N), phosphorus (P), and potassium (K)—the N-P-K numbers on the fertilizer label. Plants in lakes and rivers need these nutrients, too. But if lakes and rivers get too much of these nutrients, plants and algae, including particularly troublesome cyanobacteria (blue-green algae), start to proliferate. When the overly abundant plants and microorganisms die, oxygen-using decomposing organisms in the water end up working overtime, and the amount of oxygen dissolved in the water drops. Fish and other animals that depend on oxygen in the water are likely to suffocate. An overabundance of aquatic plants interferes with uses such as swimming, boating, and fishing.

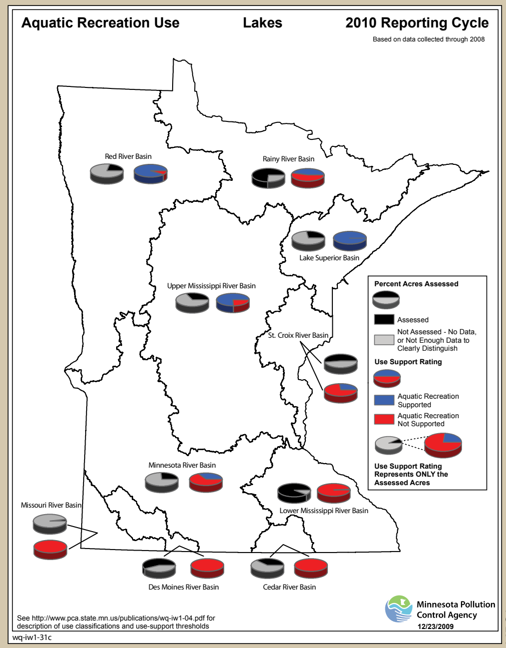
Blue Babies. Nitrate-contaminated groundwater can cause serious health problems in humans. If infants drink it, the nitrate can affect the ability of their blood to transport oxygen. The resulting condition, called methemoglobinemia, or blue baby syndrome, can cause vomiting and diarrhea, inadequate oxygen supply to tissues, and even death. Nitrate in groundwater can also be dangerous for pregnant women and people with compromised immune systems.

How do nutrients end up in Minnesota's lakes and streams? Often, they are carried along with runoff. Runoff occurs when precipitation falls on land and, rather than soaking into the ground where it falls, travels along the surface of the ground to a stream or lake, picking up dissolved nutrients or nutrient-laden materials such as leaves, fertilizer, pet waste, or livestock manure along the way. Another major source of nutrients to waterways has been sewage wastewater. Before cities and towns had wastewater treatment plants, human waste often ended up in waterways. Poorly functioning septic systems or septic systems too close to a lake or river can also release nutrients that contaminate surface water.

When cities began installing wastewater treatment facilities to remove pollutants from wastewater before they could foul surface waters, water conditions improved (see appendix 2 for Minneapolis water treatment case study). Laws regulating the use of phosphorus in cleaning products have also helped to reduce excess plant growth due to the overuse or misuse of fertilizers. One of the hopeful changes in Minnesota's struggle to keep its waters clean is the passage of a law restricting the use of phosphorus in lawn fertilizer. In 2005, Minnesota became one of the first states in the nation to require property owners and managers to test their soil to determine if phosphorus is needed before it can be applied. This law, which also prohibits spilling or spreading fertilizer on impervious surfaces, is helping to prevent nutrients from reaching lakes and streams.

One source of nutrient pollutants in ground and surface water is improper wastewater treatment. According to the Freshwater Society, some 40 percent of septic systems in the state don't meet state standards. Despite laws to the contrary, in some places, raw sewage still flows directly into surface waters. A 2004 report to the Minnesota Legislature estimated that an estimated 60,000 so-called "straight pipe" systems were discharging some 6.75 million gallons of untreated wastewater each day into the state's waterways.

This Is a Test. Scientists characterize the nature and health of a body of water by performing various tests that give insights into its chemical, physical, and biological characteristics. Parameters commonly measured when testing waterways include alkalinity, bacteria, conductivity, dissolved oxygen or biochemical oxygen demand, hardness, nitrate content, pH, phosphate content, temperature, total dissolved solids, and turbidity or transparency.

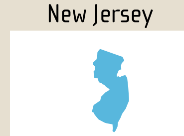


MPCA

Chisago County Staff Photo

Dead Zone

New Jersey



Dead Zone. The ramifications of polluting waters with oxygen-depleting nutrients don't end at the Minnesota border. Nitrogen traveling down the Mississippi River eventually ends up in the Gulf of Mexico, where it stimulate algal blooms that deplete the oxygen bottom-dwelling organisms need to live. Due to nonpoint source pollution from the Mississippi watershed, the plants and animals living in the Gulf of Mexico, such as lobsters, oysters, and fish, have been dying off or have had their reproductive systems altered. The size of the Gulf of Mexico dead zone varies from year to year, with the average being around 6,000 square miles. That's 30 times the size of Mille Lacs Lake, or almost the size of the state of New Jersey—and is visible from space!

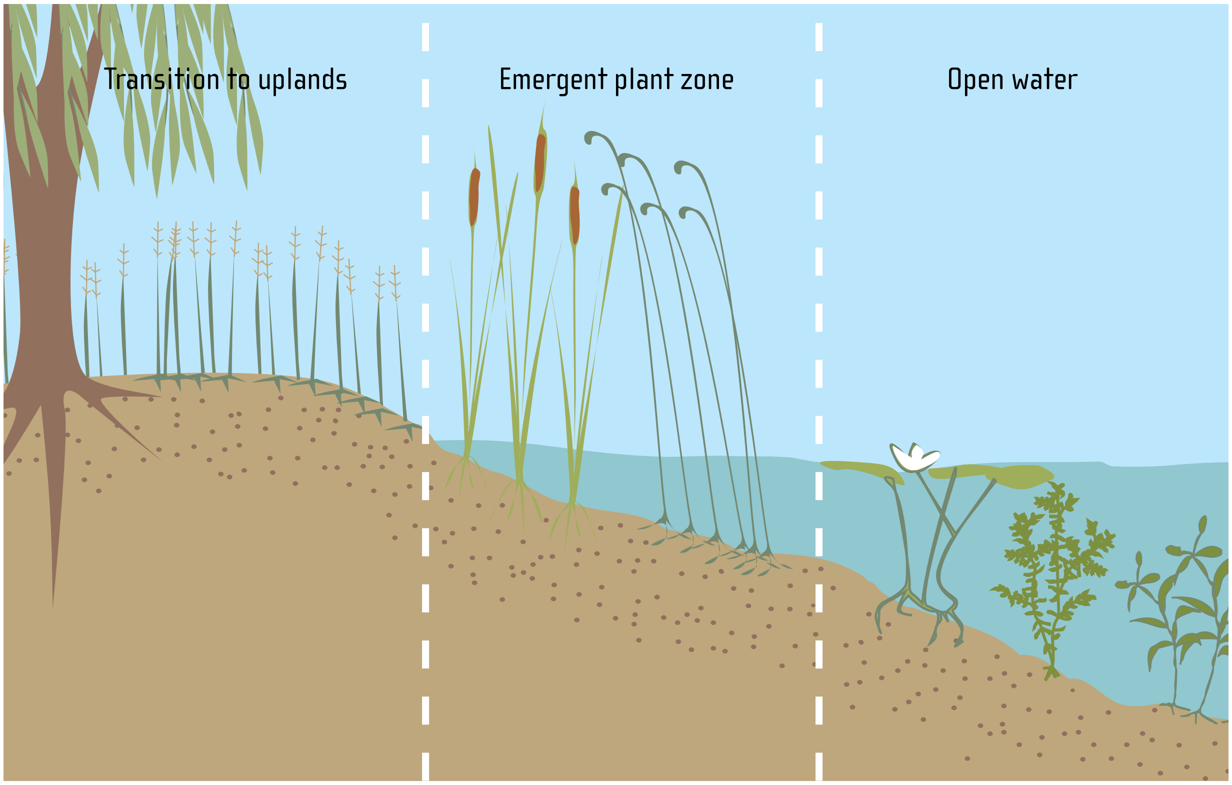
Acid

Natural rain is only mildly acidic due to carbon dioxide in the air, which makes a weak acid. When sulfur dioxide and nitrogen oxides produced by burning of coal and other fossil fuels mix with other substances in the air, they can form sulfuric acid and nitric acid, which are strong acids. Rain and snow can then carry the extra acidity into waterways, lowering the pH in the aquatic habitat in a way that makes it hard for fish and other living things to reproduce properly and in some cases even to survive.

Acidification of lakes became a big issue in the United States in the 1980s. Minnesota was not as susceptible as East Coast states, in part because there were fewer acidifying emissions here, and in part due to geological conditions that help neutralize acids that fall from the sky. In addition, sulfuric acid is consumed in wetlands by natural bacteria that "breathe" sulfate after all oxygen is depleted in the sediment. Nevertheless, Minnesota was the first state in the nation to pass a law protecting waterways from acid deposition and to set an acid deposition standard to protect aquatic life.

These actions and others at the federal level have reduced the threat of acidification. However, scientists are still concerned about the link between acid precipitation and mercury in the food chain. Bacteria in wetlands that consume sulfuric acid also convert mercury pollution into the form that readily enters the food chain. By promoting proliferation of these bacteria, acid deposition may increase the likelihood that the fish we like to catch and eat are contaminated with unsafe levels of mercury.

Freshwater Marsh Cross Section



Chlorides and Road Salt

In the old days, drivers who wanted to travel in wintery conditions would use tactics like installing tire chains and road authorities would add sand to icy roads to give tires more traction and make driving a little safer. As roads and cars have improved, so has the demand to drive faster in the winter and to do so safely. Road salt (most often, sodium chloride) is an inexpensive way for road authorities to melt ice and snow. When the ice melts, the water that runs off of the roadway may look relatively clean, but dissolved in the water is the salt that helped melt the ice in the first place. Modern Minnesota winters mean plenty of salt on the roads, and therefore in the ditches and waterways.

Shingle Creek on the west side of Minneapolis is the first Minnesota stream to be classified as impaired on the basis of its concentrations of chloride. This means that the creek contains a level of chlorides higher than the state and federal chronic standard of 230 milligrams per liter (about 1 teaspoon of salt in 5 gallons of water). Considered a toxic substance, chloride can harm aquatic organisms by disrupting natural processes that help regulate their metabolisms. Once it enters our waters, it's very persistent. It settles to the bottoms of lakes and changes their chemistry, preventing the bottom part of the lake to mix, or turnover, and changing the way the lake supports all of the life found in it. There are also signs of chloride in Shingle Creek watershed's groundwater—during low flow times in August, high levels of chloride show up in Shingle Creek as the groundwater flows into the creek.

Fortunately, we are starting to pay attention to chloride by studying its effects and ways to reduce it in our waters. The Minnesota Pollution Control Agency is now sponsoring voluntary certification courses to train snow removal staff from around the state on the steps they can take to reduce the amount of salt getting into our waters (and save their employers money at the same time.) The suggested changes focus around "anti-icing" instead of deicing. Melting ice with rock salt from the top down is inefficient, but by applying a liquid deicer to roads prior to a storm, it creates a thin layer of melting between the road and ice and allows for better plowing. When traditional rock salt is applied to the road about a third of it bounces of the street into the ditches automatically, wasting the salt and increasing unwanted chlorides in our waters. Switching to a wet salt mix reduces the amount that bounces off the road, melts the ice faster and reduced the overall amount of salt needed to provide a safe traveling surface. Because rock salt only works on warm pavement (over 150° F), another solution is to use different deicers when the road is colder. In the future we may look at other non-chemical solutions like heated roads. Even if we don't install heated roads, simple changes to our current actions can make a huge difference!

Other Chemical Pollutants

Many chemicals from many sources can pollute water bodies. Gasoline and oil from streets, parking lots, and boat motors wash into and contaminate lakes and rivers. Runoff from storm water can carry herbicides and insecticides from lawns and chemicals from cars down storm drains. Heavy metals such as mercury found in power plant air emissions can wash or fall into surface waters and bioaccumulate in fish and other living things. Sodium from road salt can upset the chemical balance of surface waters. Lead fishing tackle and ammunition that end up in lakes, streams, and wetlands can poison wildlife that accidentally eat them. Organic chemicals such as pesticides and herbicides can harm water life, too.

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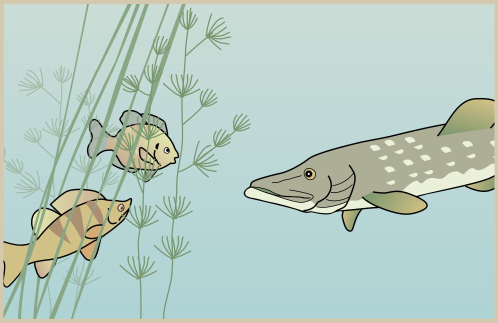
Toxic chemicals found in groundwater include a class of chemicals known as volatile organic compounds, or VOCs. These are chemicals that are manufactured as part of common products such as cleaners, paints, and fuel. The Minnesota Pollution Control Agency monitors groundwater for the presence of VOCs. Other chemicals of concern in groundwater include pesticides and perfluorinated chemicals (PFCs).

Some chemical pollutants, rather than poisoning living things that ingest them, will alter their internal control systems instead. These compounds, known as *endocrine disruptors,* can cause changes in an animal's anatomy or make it hard for animals to reproduce or properly carry on other functions controlled by hormones. For example, male fish begin to show female traits. Endocrine disruptors come from a variety of sources. Some cleaning compounds, plasticizers, pesticides, and other chemicals used in commerce and manufacturing function as endocrine disruptors. Pharmaceuticals also get into the water systems when they are excreted by people, or when unused medications are washed down sinks or toilets. Since most are not removed from the water by wastewater treatment plants, they are released into waterways, where they have the potential to have endocrine-disrupting impacts on fish and other wildlife. Most of the soaps, shampoos, cleaners, supplements and other personal care products we choose to use can also have serious, but largely unstudied, effects on the environment.

The good news about chemical pollution is that we recognize that it is a problem and are doing something about it. Years ago, people didn't think twice about pouring pollutants into waters, figuring they would get diluted or wash away and not be a problem. Now we know better. Since the 1970s, the amount of contamination entering lakes and rivers has been dramatically reduced. As scientists learn about risks from new pollutants, policy makers and regulators are working hard to protect our waters from them as well.



Bioaccumulation. Some pollutants, including mercury and organic pesticides, tend to collect inside the bodies of living things after they are ingested. When other creatures eat plants and animals that have taken up such contaminants from the environment, the pollutants accumulate in even higher concentrations inside them. Animals toward the top of the food chain, such as fish-eating fish, eagles, and mink, can bioaccumulate pollutants at levels high enough to cause health problems. Many lakes in Minnesota have fish consumption advisories—recommendations about how much fish and what types of fish people should eat—because of pollutants that bioaccumulate. Unfortunately, animals cannot avoid consuming mercury as we are able to do.

Half of Minnesota's wetland areas have been drained since 1850.

Matthew Lindon, MPCA

What's THAT? In Minnesota lakes, some things that look like contaminants may simply be the result of natural processes. In late spring, the yellow dust that gathers along shorelines is more likely pine tree pollen than pollution. The dark, "root beer" stain of some northern Minnesota lakes is due to natural chemicals called *tannins* that the water picks up as it travels through wetlands. The oily sheen that shows up on some waters is not human-caused pollution but natural organic materials. The "suds" that sometimes pile up along the shores of fast-flowing streams or on the downwind side of lakes are often composed of naturally occurring organic compounds that have been whipped up by wind or waves.

Thermal Pollution

Water withdrawn from lakes and streams is often used to cool equipment used to generate electricity or manufacture products. If the cooling water is returned directly to the lake or stream it can increase the temperature there. This thermal pollution can have several impacts on waterways. Warm water holds less dissolved gas than cold water does, making it more difficult for fish and other aquatic life forms to obtain the oxygen they need. Heat can speed the growth of bacteria and plants, which also reduces dissolved oxygen and makes it hard for some animals to survive. Heat can also stress animals that have little tolerance for changes in temperature. The added stress can make them more susceptible to disease and predation, or make it harder for them to reproduce. All of Minnesota's fish species are susceptible to harm from thermal pollution, but trout are especially sensitive.

One way we control thermal pollution is to use cooling towers or ponds to allow water used for electrical generation or manufacturing to cool before returning it to the source. In Minnesota, some communities, including downtown St. Paul, use the warm water to help heat buildings in the winter.

Pavement can also create a risk for thermal pollution by heating runoff. Think about how hot a paved parking lot gets in July, then imagine being a rain drop hitting that pavement. This heated runoff water has the greatest effect on spring-fed streams and for waterways near intensely paved areas (areas where much of the ground is covered with pavement or is otherwise impervious). Loss of shading trees along stream banks can also contribute to thermal pollution. In recent years people have worked hard to reduce thermal pollution from these sources by reducing the flow of storm water into rivers and lakes and keeping or planting trees along streams for shade.

Particulates and Solids

Two thousand, seven hundred tons. That's how much of Minnesota soil is lost each day. It washes down the Minnesota River past Mankato as wind and water erode soil and sand from farms, construction sites, roads, and other areas where they are not held in place by vegetation or barriers. Though the Minnesota River bears a larger load than most Minnesota waterways, it's not alone. Many other rivers receive a greater sediment load due to humans, too, leading to a variety of water quality problems. Soil carries with it nutrients and chemicals that pollute the water. Turbid water (water with a lot of sediment in it) makes it difficult for aquatic plants and animals to live and breathe. Sediment plugs fish gills, covers up mussels, impairs drainage systems, and limits transportation.

The problem used to be much worse. As people became aware of the problems caused by erosion and sedimentation, practices changed. Farmers began using measures such as contour plowing, conservation tillage, and buffer strips to hold the soil in place. Cities began requiring erosion control measures such as sediment control fencing, mulching, and catch basin protection to reduce the washing of particulates into surface water. Loggers now use a variety of "best practices," such as strategic stream crossing, to protect water quality. Lakeshore owners are helping by growing native plants, which hold soil in place, at the water's edge. Some city residents are helping out by building rain gardens, special low-lying areas incorporated into landscaping that catch water and allow it to soak into the ground rather than to rush, pollutant-laden, into the storm drain.

Particulates and Lake Pepin. Everything has to go somewhere. For phosphorus and sediment carried downstream by the Minnesota and Mississippi rivers from croplands and cities, that somewhere includes Lake Pepin, a widening in the river near Red Wing. A 2000 sediment-core study by Science Museum of Minnesota researchers showed that Lake Pepin is taking on sediment 10 times faster than in 1830. At current rates, the lake is predicted to be completely filled within 300 years.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Water Cycle Changes

For billions of years water has cycled from sky to earth and back again across the landscape of what is now Minnesota. The cycle has never been constant in space or time. Both location and distribution have shifted through the eons. Minnesota has seen volcanoes and glaciers, up-thrusting and erosion, and water has shaped each resultant landscape.

In recent times, humans have joined the forces altering water's progress through the water cycle and across the landscape by activities such as damming rivers, draining wetlands, and withdrawing groundwater from aquifers that would otherwise provide groundwater to streams, springs, and lakes. We have dramatically altered how water moves across the landscape. Some of those changes have had adverse consequences for the land and the living things it sustains. As a result, within the past few decades, we have reversed some previous modifications made to the water cycle, removing dams and reestablishing wetlands to restore habitat and ecosystem services provided by waterways.

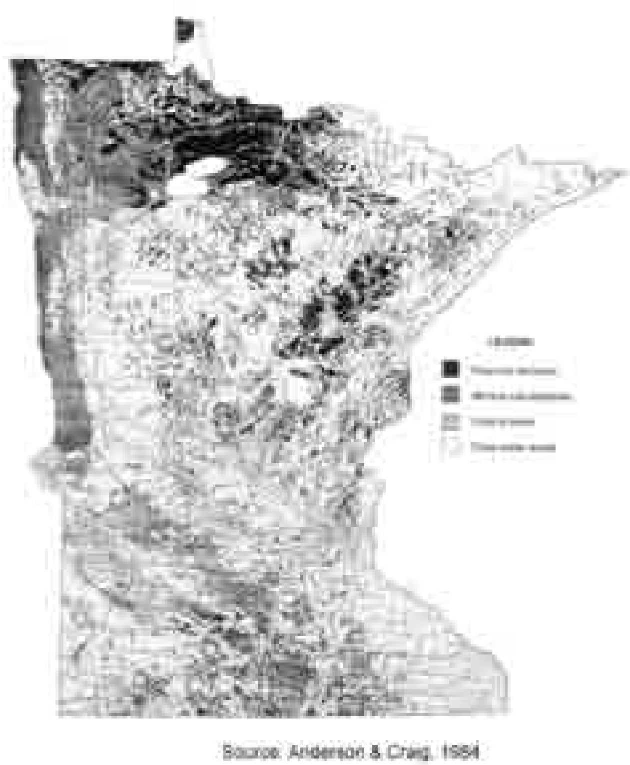
Ditching and Draining

Wetlands were once seen as dangerous, unhealthy places, and a waste of what could be good, productive land. Much effort was put into draining them so they could be used for cropland, houses, schools, and business places. In the late 1800s and early 1900s, thousands of miles of ditches were dug around the state. Well-meaning farmers, struggling to provide food for a growing population, worked hard to drain the water from what many saw as wasted land. In the Twin Cities and other communities, many low-lying areas were drained and filled to make solid ground for homes, schools, roads, and businesses. All told, it has been estimated that half of Minnesota's wetlands were drained or filled in the process of settling this state.

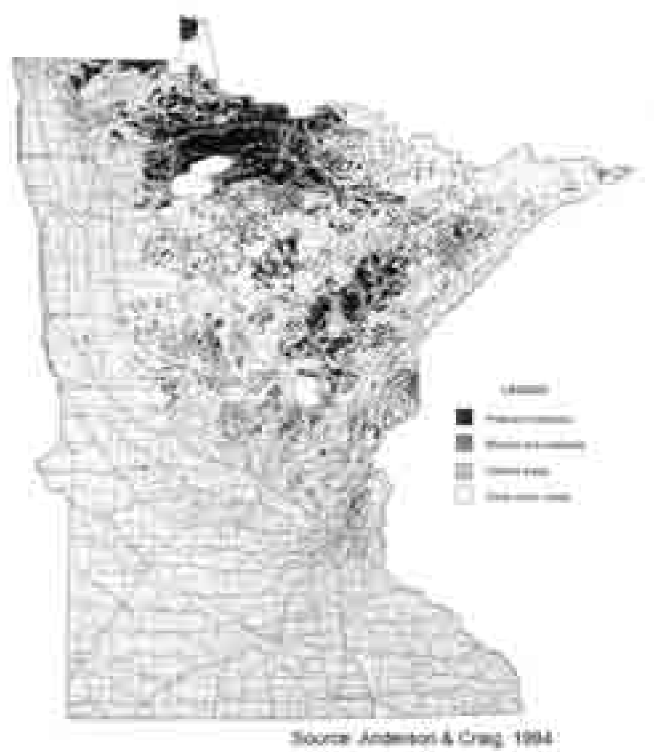
We have dramatically altered how water moves across the landscape.

As is so often true, a change in one part of the environment caused problems in other parts. Lakes and rivers, robbed of the filters that formerly filtered runoff before it reached them, were

Wetlands in Minnesota Prior to European Settlement



Wetlands in Minnesota Today



Used with permission. Anderson, J. P., & Craig, W. J. 1984. *Growing Energy Crops on Minnesota's Wetlands: The Land Use Perspective.* p. 1-95. University of Minnesota, Center for Urban and Regional Affairs, Minneapolis. Publication No. CURA 84-3.

inundated with nutrients and sediments. Valuable habitat for ducks and other wildlife disappeared, and waterfowl began looking elsewhere for places to rest and feed on their migratory journey.

In his book *Streams and Rivers of Minnesota,* Thomas Waters gives the example of Ten-Mile Creek in southwestern Minnesota. In the late 1960s nearly 300 miles of ditches and drain tiles (network of pipes below ground) were installed in the creek's 100-square-mile watershed. The result was not only a gain of good farmland, but also a loss of almost 5,000 acres of wetlands. Wildlife experts estimate that the loss translates into the annual loss of production of some 12,000 ducks and 9,000 muskrats—not to mention the countless other plants and animals that would have made their homes there.

In addition to draining wetlands, ditching also reduces groundwater recharge and causes water to run into rivers more quickly by carving for them a relatively uninhibited path of travel. The result is that rivers are "flashier"—they fill faster in rainstorms—and more sediment is scoured from the riverbanks, increasing erosion and dirtying waters downstream.

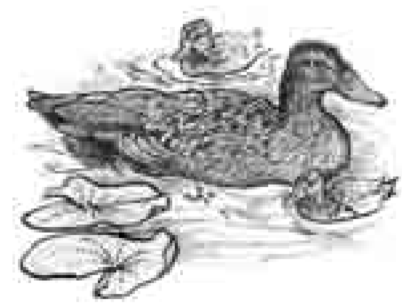
As we became more aware of the importance of wetlands, more emphasis was placed on preserving rather than draining them. In the 1950s a "Save the Wetlands" program set aside wetlands as wildlife habitat. Today people are working around the state to protect and restore wetlands and in some cases filling or plugging drainage ditches.

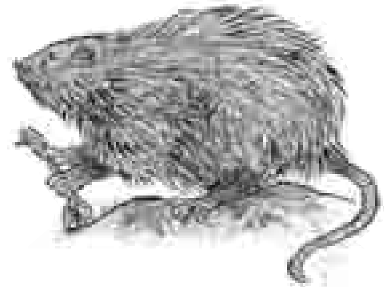

East Side Neighborhood Development Company

Lake Phalen Shopping Center paved over wetland (prior to demolition and restoration).


RWMWD

Lake Phalen Shopping Center site after demolition and wetland restoration.

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Minnesota has more than 21,000 miles of drainage ditches. Ditching and draining is responsible for the loss of hundreds of thousands of acres of small lakes in the state.

Dams, Channels, and Levees

Minnesota has also dramatically altered the natural trajectory of water through the water cycle by damming rivers. Over the years, some 2,500 dams have been installed on Minnesota's lakes and streams.

Dams change rivers by altering the flow of water and causing sediments to collect in the slowed water upstream from the dam. They also affect the free movement of fish and other animals living in the river. In recent years, the Minnesota DNR has been working to remove dams that are no longer needed from rivers around the state. Today Minnesota has approximately 1,300 dams remaining.

Another way people have altered the path Minnesota waters take on their way from cloud to sea is to **channelize** streams—straighten, deepen, and widen them. Close to 22,000 miles of Minnesota streams have been channelized.

Levees are used to protect riverside communities from floodwater and provide public safety. However, they also raise the water level and speed elsewhere, and take away the ecologically important interaction between river and floodplain.

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More than 90 percent of the Minnesota River watershed is being farmed. Much farmland is ditched to deliver water quickly from the surface. Many streams have been straightened, deepened and widened to speed water downstream—a process called channelization. Water is no longer allowed to follow its more meandering, historic course.

Minnesota is home to 69,200 miles of natural streams. It's also home to some 70,000 miles of artificial waterways—ditches that have been carved into the land to dry out soggy areas and make them more suitable for farms, roads, homes, and other uses.

Better Than a Dam Site. In 1908 the Kettle River Power Company built a hydroelectric dam across the Kettle River to power its quarrying operations. As good as the dam may have been for that purpose, it was not very good for the river ecosystem. Fish and mussels couldn't travel upstream. Valuable spawning habitat was destroyed.

By the 1990s the hydropower plant was no longer operational, the Kettle River had been designated a Wild and Scenic River, and the dam had been donated to the Minnesota DNR and declared structurally unsound. In 1995, after a study confirmed the environmental benefits of removing it, the DNR used a wrecking ball and backhoe to remove it. Lake sturgeon and other fish began migrating upstream. Spawning habitat was restored and sediment stopped accumulating behind the dam. Today, a waterfall and rapids uncovered in the process provide beauty and recreational opportunities to residents and visitors alike.


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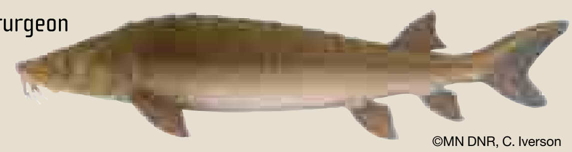
Kettle River with dam and without.

Lake sturgeon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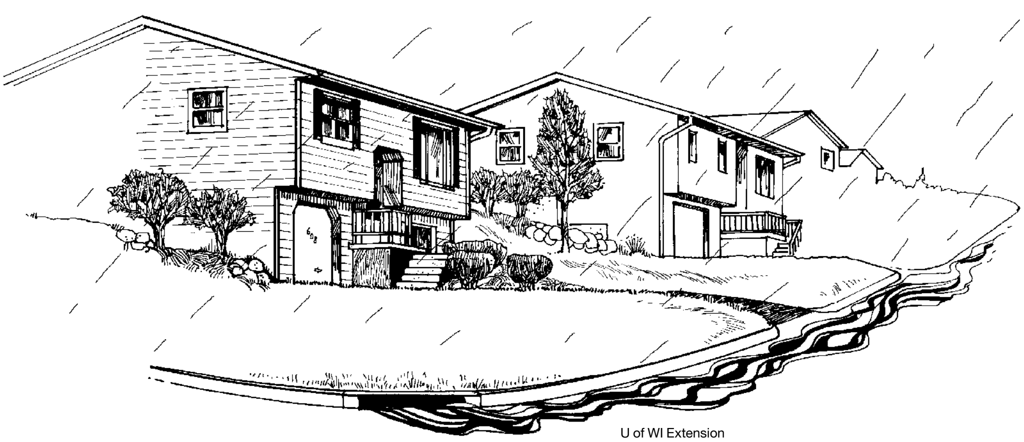
Impervious Surfaces

What happens when rain hits the roof of your house, or the street in front of it? Before your house was built and the lot was developed, much of the rain that fell would soak into the ground. With a surface too dense to permeate, it now runs off, often untreated through a storm sewer, into a lake or river.

The problem with impervious surfaces is that water carries sediments, heat, and other pollutants into lakes and streams when it runs off. Runoff water that runs off is also prevented from replenishing aquifers. Less water is available then for municipal wells and household wells, as well as natural processes like gradually feeding stream flow and providing water to springs.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Slowing the Flow. Some people install features such as rain gardens and rain barrels around homes and businesses to keep a handy supply of water available for various purposes and to keep it from rushing so fast to a stream or lake. On lakeshore property, there is a growing trend toward leaving lakeshores natural rather than growing lawn to the water's edge. This is helping to protect lakes from runoff and nutrients that cloud the water, cause algal blooms, and generally disrupt the balance of nature within them. New engineering techniques have created porous pavement that looks like regular asphalt, but allows water to seep through to the ground. When whole neighborhoods join forces and do these projects together, a significant amount of progress can be made.

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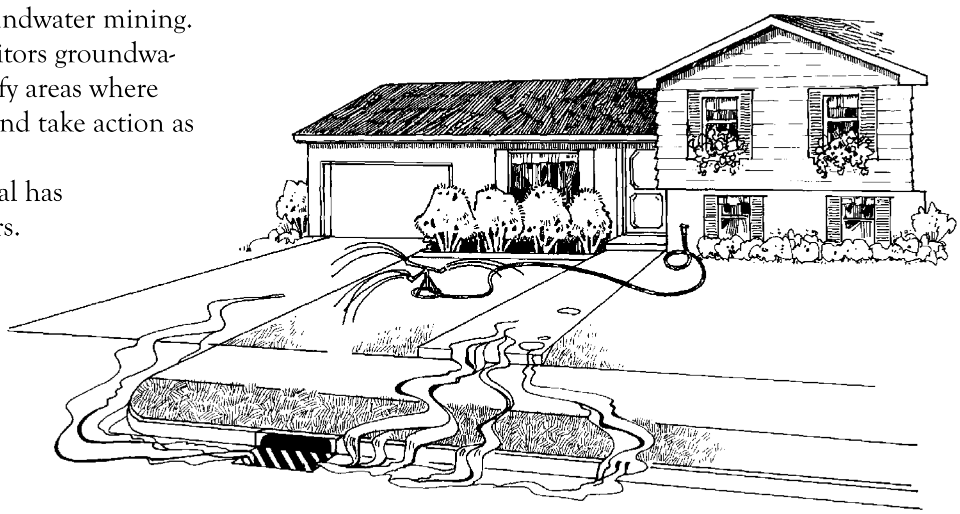
Today, planners and developers are beginning to take into consideration the value of keeping water in its place as they add roads, buildings, and parking lots to undeveloped land. Low-impact development options such as green roofs, rain barrels, pervious pavement, and rain gardens are techniques that are being used more often to prevent water from running quickly into lakes and streams. It all adds up to helping keep both surface and groundwater healthy.

Groundwater Mining

Extensive use of groundwater can result in a long-term lowering of the water table. This phenomenon is known as groundwater mining. The Minnesota DNR monitors groundwater supplies so it can identify areas where overuse may be occurring and take action as needed.

Groundwater withdrawal has grown greatly in recent years. Between 1991 and 2005, groundwater use in Minnesota increased 26% while population increased 18%. Currently, the population is growing quickly in a corridor stretching from St. Cloud through the Twin Cities. With more people comes more demand for water.

Farms and industries around the state are also using more groundwater: During the 1991 to 2005 period, for example, use of groundwater for crop irrigation in the state increased by 65 percent. Water planners are watching carefully to make sure demand for groundwater does not result in overuse. This is important because groundwater is replenished by surface water, and vice versa. In some cases it is better to use water from several sources to lessen impacts on each.



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Lakeshore Development

Lakes throughout Minnesota are experiencing hefty development pressure today. In the Brainerd Lakes area, for example, small fishing cabins and resorts have been replaced by huge homes with expansive lawns. Changing land ownership is making possible the development of more and more lakes to multiple developments as paper companies and other industrial forest landowners sell off their property. These changes can impact water quality and aquatic habitat.

Many lake associations are learning about how their property affects the water. To help protect the lake and the natural beauty that attracted them in the first place, landowners are learning how they can help improve the water quality, and changing their landscaping and other practices correspondingly.

Programs like NEMO (Nonpoint source Education for Municipal Officials) help local decision makers understand how the decisions they make in planning their communities affects their water and how they have many simple, cost-effective options available as they plan and improve their communities.

MN DNR

Global Climate Change

As climate changes, scientists predict we will see dramatic changes in the water cycle in Minnesota. Storms are expected to become more severe. Extended periods of drought and more frequent floods will be more likely. Warming temperatures will speed evaporation, potentially lowering the level of surface waters. Lakes will be more susceptible to oxygen depletion in winter, increasing the chances of fish die-offs. Wetlands may be lost as droughts increase in frequency and/or severity. Some species will be unable to survive in the new conditions.

Some experts think that we are already seeing impacts of global climate change on Minnesota's waters. For example, annual precipitation at Brainerd has increased from 23.03 inches during the period 1921–1950 to 27.62 inches in 1978–2007. And according to the Minnesota Pollution Control Agency, precipitation has increased 20% in some parts of southern Minnesota as well.

MN DNR

Biological Changes

In many instances these actions have been harmful to native species. In other instances they have been beneficial as we work to restore populations formerly depleted by pollution or other human action.

Minnesota's lakes, streams, wetlands, and other bodies of water have long played host to an amazing diversity of, in Charles Darwin's words "endless forms most beautiful and most wonderful"—living things that crawl, swim, float, photosynthesize, eat, die, and give rise to new life. Before humans began to rapidly change the environment, populations of various living things grew and declined in balance with each other, occasionally interrupted by cataclysms and other sudden events. In recent years, human impacts have added new, balance-disrupting forces to the picture, resulting in shifts in the amounts and variety of life in our waters.

More than 20 aquatic invasive species are found in Minnesota waters.

USFWS

A USFWS employee in Missouri holds an Asian carp. The DNR is trying to limit the introduction of Asian Carp to Minnesota.

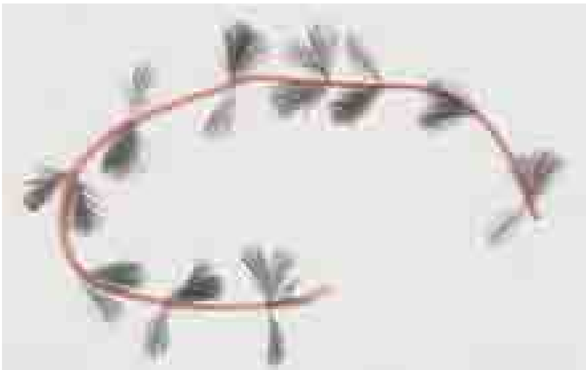
Invasive Species

Imagine getting up one day and finding someone you don't know sitting in your kitchen, eating your cornflakes and drinking your orange juice. You go to use the bathroom, and find it occupied by another mystery guest. Later, when you come home from work or school, the entire house is filled with strangers. During the day they have managed to eat all the food from your refrigerator, take over your bedroom, and break three windows.

Many Minnesota aquatic plants and animals have days—sometimes entire lives—like that. Their native habitat has been invaded by nonnative species, plants or animals that people have intentionally or accidentally brought from other places and displaced the native plants and animals. These species are often from Europe or Asia. Some nonnative species live fairly compatibly with the ones that are already here. Others, called invasives disrupt the balance of nature and reduce native species' ability to thrive. The result in some cases has been a loss of balance in aquatic ecosystems, crowding out of native species, and economic impacts ranging from loss of desirable species to fouling of underwater equipment such as water intake pipes. Minnesota spends millions of dollars each year trying to slow the spread of and reduce the impacts of aquatic invasive species.

Lake Superior alone is home to at least 27 kinds of invasive plants, animals, and other organisms.

Many aquatic species have been intentionally or unintentionally introduced into Minnesota waterways. Some aquatic invasive species affecting Minnesota's waters today include:


MN DNR

Eurasian watermilfoil


MN DNR

common carp


MN DNR

zebra mussel


MN DNR

curly-leaf pondweed


MN DNR

rusty crayfish


MN DNR

purple loosestrife


Jeff Gunderson

spiny water flea


M. Gaden and R. Bergstedt

sea lamprey

MN DNR

bighead carp

Peter Dziuk

flowering rush

David Jude, School of Natural Resources and Environment, University of Michigan

round goby

MN DNR

ruffe

MN DNR

faucet snail

Minnesota Sea Grant

New Zealand mud snail

Public education programs, monitoring programs, and enforcement efforts are working to reduce spread of Eurasian watermilfoil and zebra mussels by encouraging anglers and boaters to remove aquatic plants, animals, and water from watercraft before moving from one body of water to another. Chemical control and physical barriers are attempting to keep the lid on sea lamprey populations.

For more information on the many invasive species found in Minnesota, see www.mndnr.gov

Wild Waters, Troubled Waters.
Even the Boundary Waters Canoe Area Wilderness is not safe from invasive species. Spiny water fleas, tiny crustaceans native to Europe and Asia that were inadvertently brought to Minnesota by ships traveling the Great Lakes, have invaded some waters in the wilderness. The water fleas, which look like a cross between a mosquito and a sewing needle, eat the plankton that form the basis of a lake's food web. They likely invaded the wilderness with the inadvertent assistance of anglers as they clung to fishing lines or other equipment.

Lost or Depleted Species

The many changes we've made in waterways affect their ability to sustain native life forms. As a result, a number of species have been reduced in number or have disappeared altogether from Minnesota's waters, including:

- *skipjack herring*—migrates from the sea, but dams now obstruct
- *ebony shell mussel*—depend on skipjack as host
- *paddlefish*—spawn in gravelly rapids that are altered by dams
- *sturgeon*—spawn in gravelly rapids that are altered by dams
- *blackfin cisco*—crescent stripetail stonefly
- *Blanding's turtles*

In many cases, conservation activities have helped reverse or mitigate the impact of some of the trends that have negatively affected native species in the past. Removal of dams has helped restore sturgeon along stretches of the Red River. A 1999 moratorium on walleye fishing in the Red Lakes helped increase the number of walleye after many years of overfishing. Sea lamprey control efforts have contributed to the recovery of lake trout in Lake Superior after the species nearly disappeared in the 1950s. Improved wastewater treatment in the Twin Cities has allowed mussels to return to formerly uninhabitable parts of the Mississippi River.

A dozen things you can do to care for Minnesota waters:

1. **Dispose of unwanted household chemicals and pharmaceuticals properly.** Don't flush drugs down the toilet! Most counties have household hazardous waste disposal sites. Information on proper pharmaceutical disposal can be found on the Minnesota Pollution Control Agency website.
2. **Examine your boat and remove any plant material clinging to it before moving it from one body of water to another.**
3. **Use rain barrels and rain gardens to capture runoff and reduce impacts to lakes and rivers.** For suggestions on how to create a rain garden using native plants, contact your city or county office.
4. **Check your toilet and sinks for leaks and repair if needed.**
5. **Volunteer to help monitor lakes and rivers** (see online resources listed at the end of this chapter).
6. **Keep lakeshores natural!** If your shoreline is planted in turf grass, consider replanting it with native species. Contact the DNR, the University of Minnesota Extension Service, your soil and water conservation district office, or bluethumb.org for suggestions on what to plant and where to obtain plants.
7. **Don't dump anything into lakes or rivers, onto streets, or down storm drains.** Wash your car on your lawn instead of in your driveway.
8. **Volunteer to start or join a lake or river cleanup in your community.** For more information contact your local lake or river association or the DNR Information Center, 651-296-6157 or 888-646-6367.
9. **Recycle!** Recycling paper uses less water to process than virgin pulp from trees.
10. **Don't water your lawn unless it really needs it.** If you have an automatic sprinkler system, use a rain sensor and adjust settings monthly according to the recommendations of your county soil and water conservation district. Especially make sure you're not watering the sidewalk or street!
11. **Support river-friendly farming.**
12. **Conserve water by using low-flow showerheads and toilets.**

C A R E E R   P R O F I L E

Dennis Lindeke
Assistant Plant Manager,
Metro Council Environmental Services
Cottage Grove

Each day, millions of gallons of wastewater go down the drain in Twin Cities homes and workplaces. Dennis Lindeke is one of the people who makes sure that water is clean when it is released to the area's beautiful river systems.

Before modern wastewater treatment facilities like the one Lindeke manages were built, people were sickened by waterborne diseases, and few game fish swam in this stretch of the Mississippi River. Thanks to modern facilities, waterborne disease is now rare, and you can catch trophy walleye and bass in the corridor between Minneapolis and Hastings.

Lindeke is responsible for maintaining the function of the biological processes that cleanse wastewater. He also works with his staff to keep mechanical equipment in good shape and monitors effluent to make sure it meets strict water quality standards. He says the favorite part of his job is working with people who are dedicated to keeping Minnesota's waterways healthy and clean.

"We are very proud of what we do, day-to-day," he says. "It is really an amazing thing—in a period of about eight hours, we take the pollutants out of the wastewater and discharge very clean water back in to the rivers."

The job gets more challenging every year, however, as wastewater experts learn more about hard-to-remove pollutants such as pharmaceuticals, nutrients, and heavy metals and try to figure out ways to deal with them.

Why would a person choose a career in wastewater treatment? Lindeke does what he does because he cares about the environment. He likes the challenge, too, of needing to know a lot about a lot of different things. People in his position often have engineering or science degrees and use chemistry, biology, math, mechanical and electrical systems, personnel management, writing, and public speaking skills every day.

Related careers:
water treatment plant operator,
chemical engineer

Suggested Project WET Activities and Minnesota Connections

EL = elementary	MS= middle school	HS=high school

Water education involves a variety of teaching strategies

Water Actions (personal action) MS, HS

Water connects all Earth systems

Just Passing Through (erosion) EL, MS

Rainy Day Hike (stormwater pollution) EL, MS

Water is a natural resource

A-maze-ing Water (stormwater pollution) EL, MS

Color Me a Watershed* (watersheds, mapping) HS - Aerial photos of MN major watersheds over time.

Common Water (water users) EL, MS

A Drop in the Bucket (global water distribution) EL, MS, HS

Sum of the Parts (nonpoint source pollution) EL, MS

Water Meter (water conservation) EL, MS

Where are the Frogs? (acid rain) MS

Water resources are managed

Every Drop Counts (water conservation) MS

A Grave Mistake* (groundwater) MS, HS - case studies of Minnesota groundwater contamination.

Humpty Dumpty (ecosystems, parts) EL, MS

Macroinvertebrate* Mayhem (benthic macroinvertebrates & water quality) EL, MS - Example macroinvertebrate species data for Minnesota's three main watersheds.

Money Down the Drain (water conservation) EL, MS

The Pucker Effect (groundwater) MS, HS

Reaching your Limits (water quality) EL, MS

Sparkling Water (wastewater treatment) EL, MS, HS

Water resources exist within social constructs

Dilemma Derby* (water issues, problem solving) MS, HS - MN case studies of historical water issues.)

Hot Water (debate water issues) HS

Whose Problem is it? (water issues, problem solving) MS, HS

* Some Project WET Activities have Minnesota adaptations posted online for Minnesota Project WET Educators in the trained teacher page at www.mndnr.gov/projectwet. Additional adaptations will be added when possible.

Classroom Connections

Research and Protect: Choose a body of water near you. Research past, present, and anticipated future threats. Explore what people have done/are doing to protect it. If there is a need, consider taking it on as a class project. Write an article for the school or local newspaper about the project. Younger students could collect trash around the school grounds to keep it from collecting in local water bodies.

Local Scene? Have students contact city or county environmental staff, soil and water conservation district staff, or watershed district staff to learn what each office is working on and find ways the class or any citizen can become involved in the needs of the community.

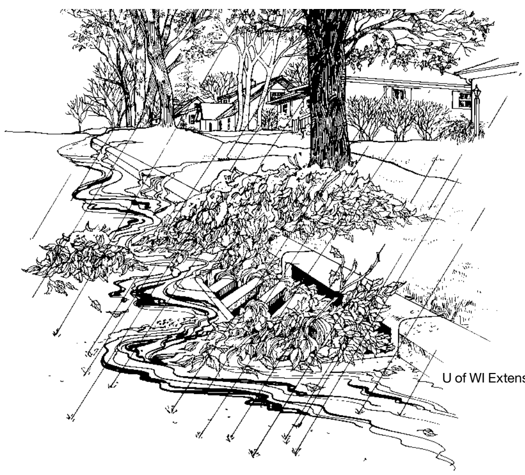
How big of a problem is urban runoff? Practice math skills by calculating the amount of water prevented from soaking in by some familiar impervious spaces—your school building, a typical city street, or the parking lot at the mall. A house with a 1,000-square-foot footprint, for example, sheds more than 600 gallons of water during a one-inch rainstorm.

Drinking Water Reports: Water suppliers that serve the same people year-round must prepare annual water quality reports (consumer confidence reports) for their customers. The reports tell where drinking water comes from, what's in it, and how you can help protect it. Water suppliers send out CCRs to homes and some post them online, however, citizens can request a copy from their local water utility. Have your students contact your local water supplier to get a copy of the local Consumer Confidence Report and learn about their tap water.

Observing Water Samples: For younger students, brainstorm a list of six places you can find water in your community (including running out of the faucet). On your own, reuse plastic peanut butter jars to collect samples of water for each and put the jars on display in your classroom. How do the samples differ? Are some cleaner than others? If so, why?

Out and About

Investigating Storm Sewers: Many storm sewers empty directly into rivers and lakes. After researching where the drains in the vicinity of your school drain, get permission to stencil messages near the drains reminding people not to dump harmful chemicals down them where they can wash into drains. Write an article for your local newspaper explaining the importance of keeping pollutants out of storm sewers.


U of WI Extension

Rain Garden: With students in the lead, design and install a rain garden at your school. Talk to your local watershed district or county environmental services staff to see if they can help you with planning or planting costs (many offices have cost-share programs and free raingarden planning advice.) Invite local media to tell your story so others can learn what you did and why you did it.

Stewardship and Service: Look at the list of things you can do to care for Minnesota waters. Choose one of these practices as the focus of a service-learning project. Develop and carry out a plan to encourage residents of your community to adopt the practice.

Visit with Local Water Officials: Visit a nearby soil and water conservation district or watershed district project with a staff member from the organization who can tell you what happened/is happening and why.

How much is Impervious? Map and calculate impervious surfaces on school grounds. Where does the runoff water go? What would be the advantage of slowing it down? What could you do to make that happen? (e.g., rain barrels, rain gardens)

Save Water = Save Money: Help your school save water and money while learning lots about measurement and calculation by doing a school water audit. Search “school water audit” online for example audits.

A few excellent resources:

1. Water Footprint Calculator, Water Footprint Network. http://www.waterfootprint.org/?page=files/WaterFootprintCalculator. The water footprint is an indicator of direct and indirect water use of a consumer or producer. The water footprint of an individual, community or business is defined as the total volume of freshwater that is used to produce the goods and services consumed by the individual or community or produced by the business.

2. Water Data for the Nation, United States Geological Survey. http://waterdata.usgs.gov. This website allows you to look up real-time data on streamflow, groundwater table levels, precipitation, etc. for specific points in MN.

3. Water on the Web http://www.waterontheweb.org/. Water on the Web helps college and high school students understand and solve real-world environmental problems using advanced technology. The program includes two sets of curricula, data from many lakes and rivers nationwide, extensive online primers, data interpretation and Geographic Information System Tools, and additional supporting materials.

4. Storm drain stenciling guide, University of MN Extension Service. http://www.cleanwatermn.org/app_themes/cleanwater/pdfs/GetInvolved_InNeighborhood/StormDrainStencilingGuide.pdf A simple guide on how to storm drain stencil with your students.

5. Minnesota Water, Let's Keep it Clean website, Metro WaterShed Partners. http://cleanwatermn.org/ This website provides public stormwater pollution prevention education materials and products.

6. Find your local watershed district at http:///www.mnwatershed.org, your soil and water conservation district at http://www.maswcd.org, or a list of who to contact at all levels of government, local, state and federal at http://shorelandmanagement.org/contact/index.html. See appendix 3 for a summary of Minnesota local and state water contacts.

7. Minnesota Pollution Control Agency water website, MPCA. http://www.pca.state.mn.us/water/index.html Find out more about the MPCA's programs to help protect our water by monitoring its quality, setting standards and controlling what may go into it.

8. MN Water Conservation Resources Website, MN DNR. http://www.dnr.state.mn.us/waters/watermgmt_section/appropriations/conservation.html This website contains links to water conservation resources and information like water conservation toolboxes for water suppliers and citizens, summary of residential water use, and water efficiency tools.

9. Minnesota Shoreland Management Resource Guide, MN Sea Grant and University of MN's Water Resources Center. http://shorelandmanagement.org/index.html. This website provides easy access to information about sustainable shoreland practices to improve management of Minnesota's lakes and rivers. The Website contains scientific and technical background, camera-ready quick and easy answers (FAQs), highlights of citizen action, and contact information for Minnesota counties.

Want More? See www.mndnr.gov/projectwet for resources and information:

Academic standards correlations to Project WET activities
Educational materials/classroom resources for Project WET teachers
Out and About—field trip ideas
Citizen science/service learning opportunities
Useful websites
Suggested books