Chapter 3: Minnesota Waters—Wetlands and Groundwater

Key Concepts:

- Minnesota's wetlands and groundwater aquifers are numerous and varied
- Wetlands provide valuable functions in the water cycle: temporary storage, runoff filtration, unique habitats
- All of Minnesota is underlain by groundwater, held between grains of soil or in cracks within rocks and unconsolidated materials
- By studying wetlands and aquifers, we can learn things that help us keep them healthy—and keep us healthy, too!

LAKES AND RIVERS may be the most conspicuous bodies of water in Minnesota. However, plenty of water is to be found in two other less obvious but very important places: wetlands and groundwater.

Wetlands

Neither land nor lake, **wetlands** are defined as places where the soil is waterlogged at least part of each year. Characteristic suites of plants thrive in wetlands, and many wetland types are identified in part because of the plants that are present in them.

Minnesota is far soggier than most states. Before European settlers started draining the land for agriculture and urban development, 18.6 million acres of our spongy state were covered with wetlands. Today, some 9.3 million acres of wetlands dot the surface of the state. Most of those are found in the northwest, where vast acres of bogs and fens (types of peatlands) stretch for many miles.

Varieties of Wetlands

Wetlands vary widely from place to place, depending on the amount and chemical characteristics of the water present, the nature of the soils and topography, and the climate. Each wetland setting provides habitat for certain types of plants and animals.

Minnesota is far soggier than most states.

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Seasonal wetlands are wet in spring after the snow melts but are drier during summer. Seasonal wetlands make great breeding grounds for frogs and other amphibians and resting places for waterfowl on their way north in the spring. In summer they may be dry enough to grow crops.

MN DNR

Wet meadows have soil that is often saturated with water—but not so much that water would often be above the ground surface. This category includes sedge meadows and some prairies. Wet meadows are wet in spring but tend to dry out over the summer because more water is used by plants in the warmer months. Sedges give wet meadows a “grassy” look.

MN DNR

Shallow marshes are nonforested wetlands where water may be up to 6 inches deep during the growing season. They are richly covered with emergent plants (which grow in standing water with stems emerging above the water surface) such as cattails, bulrushes, and arrowhead.

MN DNR

Deep marshes are similar to shallow marshes but soggier—6 inches to more than 3 feet deep during the growing season. They, too, feature abundant water-loving plants, including wild rice, bulrushes, and water lilies.

USFWS

Shallow open water areas provide important habitat for waterfowl and other living things. They are too deep and too permanent to host emergent plants, except around the edges, but aquatic vegetation such as pondweed, water lilies, and coontail will grow here. Prairie potholes are one example of this type of wetland. They dot much of the western Minnesota landscape, but many have now been drained for farming.

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A **shrub swamp** is a wetland in which woody plants such as willow and alder thrive. Shrub swamps make superb habitat for many types of wildlife.

MN DNR

A **wooded swamp** is a wetland with trees. Because trees are sensitive to fluctuations in water level, and because water in wetlands can fluctuate dramatically, swamps may have dead as well as living trees. Wooded swamps often have open tree canopies and enough light reaches the ground to allow ferns, mosses, and other plants to grow in the moist soil. Hardwood swamps contain species such as black ash, red maple, and balsam poplar. Coniferous swamps may be thick with tamarack and cedar.

MN DNR

Bogs, a type of peatland, are wetlands in which partially decayed remnants of sphagnum moss, sedges, reeds and/or other wetland plants have formed a deep, spongy layer of organic material called peat. The water and soil in peat bogs are acidic. Plants found in bogs include sedges, cottongrass, and round-leaved sundew. Minnesota is home to a remarkable million acres of peatlands—more than any other state except Alaska. If you're interested in seeing one big bog, check out the 500-square-mile peatland in Big Bog State Recreation Area near Waskish.

MN DNR

Fens, another type of peatland, but with non-acidic water, are interspersed within the big bogs. They occur wherever groundwater interacts with the water at the surface to reduce the overall acidity of the peat. Plants found in fens include pitcher plant, bladderwort, and buckbean. Calcareous fens are a subcategory of fen that is very rare. Most calcareous fens are found in prairie settings apart from the other extensive peatlands.

Rare, Right Here. One of the rarest habitat types in the world is right in Minnesota's backyard. Known as calcareous fens, these odd wetlands form where groundwater constantly seeps to the ground surface with oxygen-poor, mineral-laden cold water. When the groundwater meets the oxygen in the air, reactions occur that lock nutrients away from the plants and that leave films of mineral deposits on the surface of the peat and on the plants themselves. Not surprisingly, it takes specialized plants to deal with those conditions. Those that can adapt, such as fen orchid, sterile sedge, grass of Parnassus, valerian, and small white lady's slipper, form communities that exist nowhere else. Calcareous fens are so rare—and the plants within them often so threatened—that Minnesota law specifically protects them.

Want to visit a calcareous fen? Three of the state's calcareous fens are located at DNR Scientific and Natural Areas: Seminary Fen SNA, Savage Fen SNA and Gully Fen SNA. Learn more at the DNR website.

Meadow Fern

Wanbun Fern

MN DNR

Fen Orchid

A Valuable Role

In the past, many people considered wetlands a waste of good land and a breeding ground for mosquitoes and other things they perceived as pests. In reality, wetlands play a huge and valuable role in the balance of nature and in keeping the natural systems we humans and other living things rely on healthy and whole. Wetlands:

- help control flooding by serving as a holding basin for water from heavy rains or snowmelt
- help slow runoff, reducing the loss of soil as water rushes toward streams and lakes, improving water quality
- provide valuable habitat and breeding grounds for amphibians, fish, other animals, and plants
- retain water on the landscape and release it slowly to other water bodies—reducing flooding when it's wet and providing moisture when it's dry
- contain plants that use up nutrients and keep them out of downstream lakes, resulting in less plant and algae growth
- have basins that trap sediment that has eroded from uplands, reducing sediment loads to streams and lakes
- add beauty and diversity to the landscape provide food for animals, including us! (Think cranberries and wild rice.)

What else do wetlands do? Add your own items to this list.

Groundwater

Out of every 100 drops of water that fall as rain or snow in Minnesota, as many as 20 can manage to seep down below the roots of plants and become **groundwater.** In sufficient quantities, the groundwater fills all of the spaces between soil particles and saturates the soil. Fill a drinking glass with sand. Now begin to pour water into the glass until it is half "full" of water. The sand in the bottom of the glass is saturated and while the top half may be wet, it is not saturated. The very upper surface of this saturated layer in the ground is called the **water table.** If you have ever gone to the beach at your favorite lake and dug a hole in the sand until there is water in the bottom of your hole, you have discovered the water table at that spot.

When precipitation is plentiful, water levels rise because more water is stored. Stored water, known as groundwater, moves from aquifers to lakes and streams through seeps, springs, and (thanks to humans) wells. Groundwater helps both natural systems and humans survive dry times. Minnesota is relatively rich in groundwater. However, the water beneath the surface of our state is not evenly distributed. The depth and abundance of groundwater varies from place to place.

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What Is an Aquifer?

"Aquifer" comes from the Latin root words for "water bearer." Literally, an aquifer is water-bearing rock or sediment. An aquifer stores water and water flows through it because it is permeable. We can withdraw groundwater from an aquifer for human use, or it can seep out into lakes, streams, or wetlands naturally.

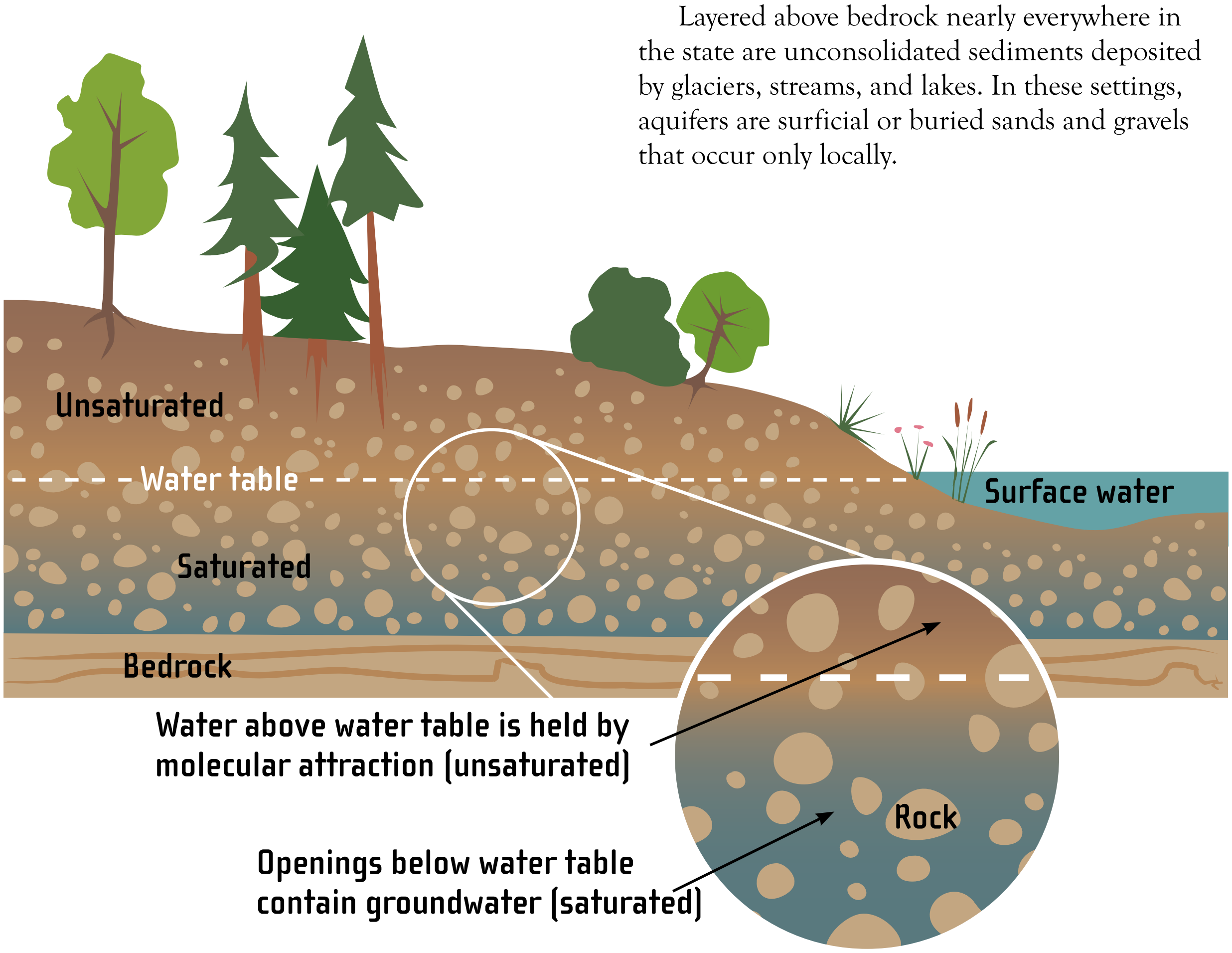
Minnesotans extract more than 120 billion gallons of water each year from underground aquifers for household and industrial use.

Minnesota's Aquifers

Minnesota has bedrock aquifers and unconsolidated aquifers. Bedrock aquifers include a range of rock types, including igneous, metamorphic, and sedimentary, that have formed throughout geologic history. Water is stored in fractures or within pore spaces in what appears to be solid rock (e.g., St. Peter sandstone). Loose unconsolidated materials (sand, gravel, clay) deposited by glaciers, glacial meltwater, and present-day streams and lakes lie above the bedrock. Water in these unconsolidated aquifers is stored in pore spaces and may be much easier to find and withdraw.

In the southeastern part of the state, and underlying the Twin Cities, the bedrock aquifers include thick, continuous layers of sandstone and limestone that yield reliable, sufficient quantities of groundwater for municipal and private wells. Under most of the rest of Minnesota, the bedrock is igneous and metamorphic rock that has tight pore spaces and low permeability. Interconnected fractures may store enough water for human consumption. However, it may be hard to get much groundwater from these bedrock aquifers, and the water from them may be very high in dissolved minerals.

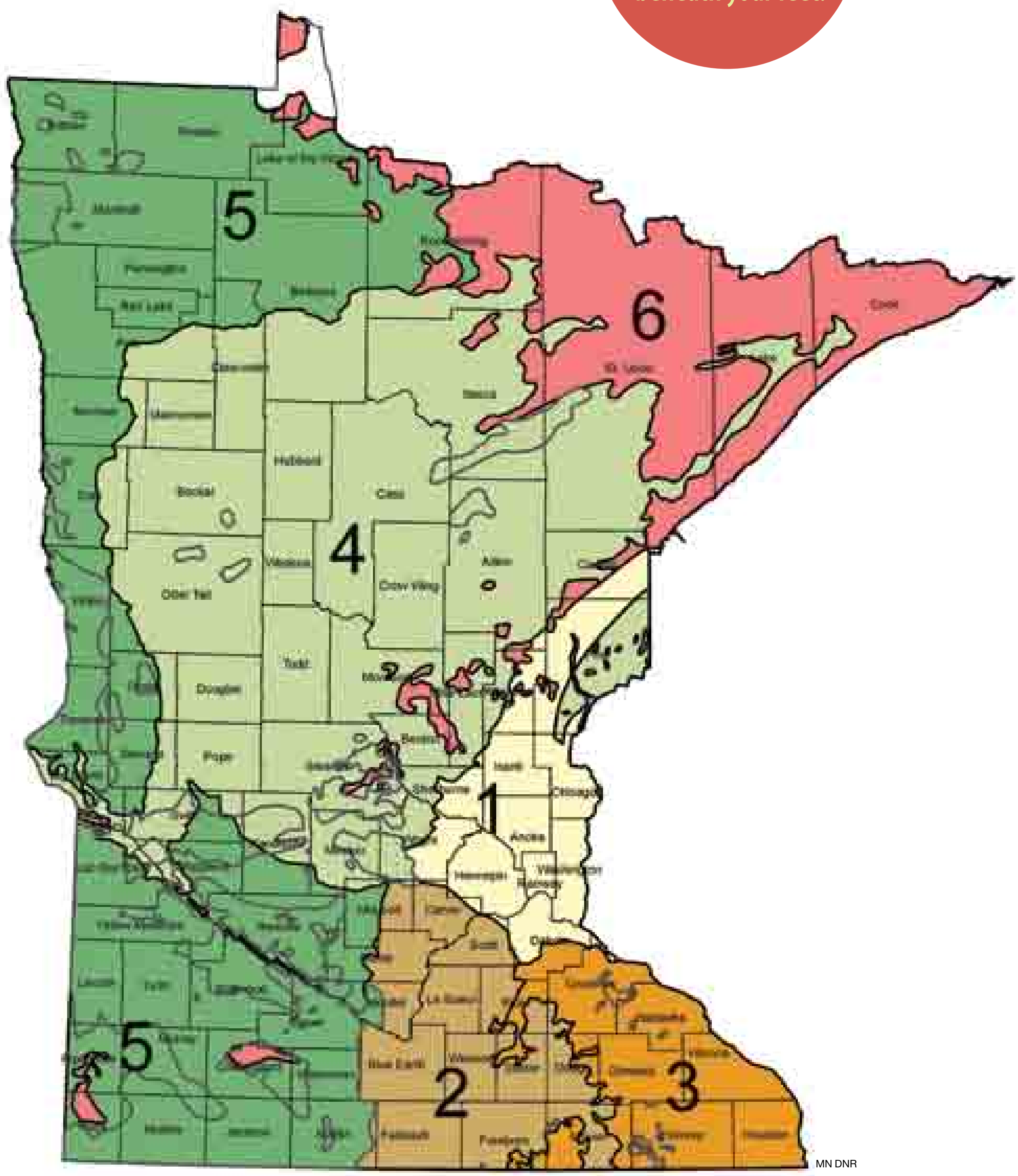
Layered above bedrock nearly everywhere in the state are unconsolidated sediments deposited by glaciers, streams, and lakes. In these settings, aquifers are surficial or buried sands and gravels that occur only locally.



Groundwater Provinces

Minnesota's bedrock and unconsolidated aquifers can be combined to make up six groundwater provinces—areas in which the source and availability of groundwater are similar. The six provinces are 1) Metro, 2) South-Central, 3) Southeastern, 4) Central, 5) Western, and 6) Arrowhead. They are defined by the nature of the bedrock and unconsolidated aquifers.

Wherever you are in Minnesota, there's groundwater beneath your feet.



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Groundwater on the Move

Water moving into an aquifer is called recharge; water moving out of an aquifer is called discharge. Recharge is greater where there is more precipitation and where the soil at the surface is more permeable. An area with sandy soils in central Minnesota might receive 30 inches of rain, and as many as 6 inches of it might end up recharging the water table aquifer. An area with clayey soils in western Minnesota might receive 20 inches of rain, and in some years none of it will get past the plant roots into the aquifer beneath. Groundwater recharge occurs through streambeds and lake beds whenever the water levels in the surface water are higher than the water levels in the groundwater system.

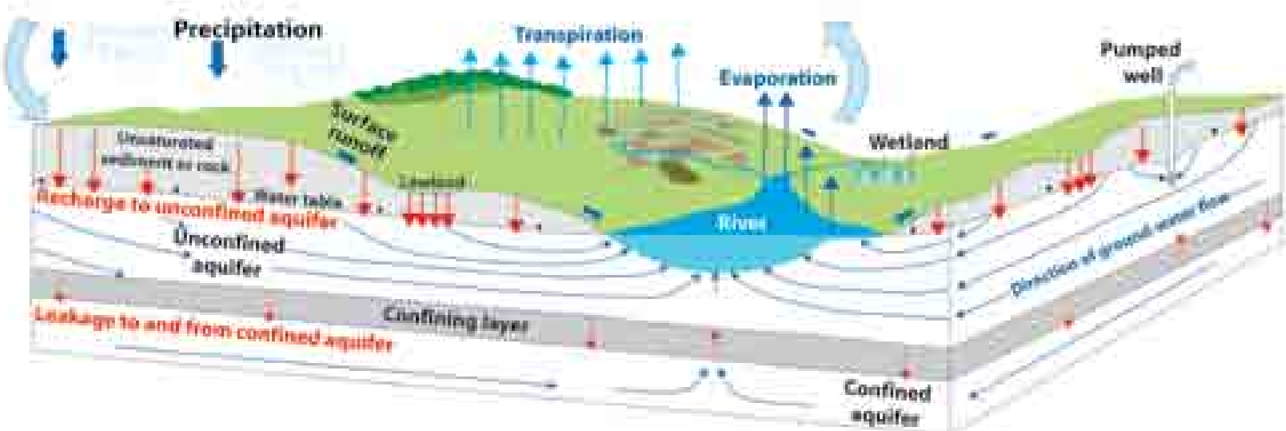
Water moves horizontally through an aquifer from areas of high head (high pressure) to areas of low head (low pressure). The rate at which the water moves through the aquifer depends on the permeability or interconnectedness of the pores or fractures. This rate is expressed in units of length over time (e.g., feet per day). In highly permeable aquifers such as coarse sand and gravel, water can move many feet per day. In a deposit of tight clay or shale where the space between the particles is much smaller, water may only move a few inches in a century. Such formations are not considered aquifers because they do not produce water. They are referred to instead as aquitards and generally restrict or confine the flow of groundwater.

Whether they are made of bedrock or unconsolidated material, there are two specific types of aquifers: unconfined (water table) aquifers, and confined aquifers.

Unconfined aquifers are directly connected with surface water and the overall water table mimics the surface of the land. Groundwater flows from areas of high topography to areas of lower topography where it generally flows out to surface water features such as lakes, streams, or wetlands.

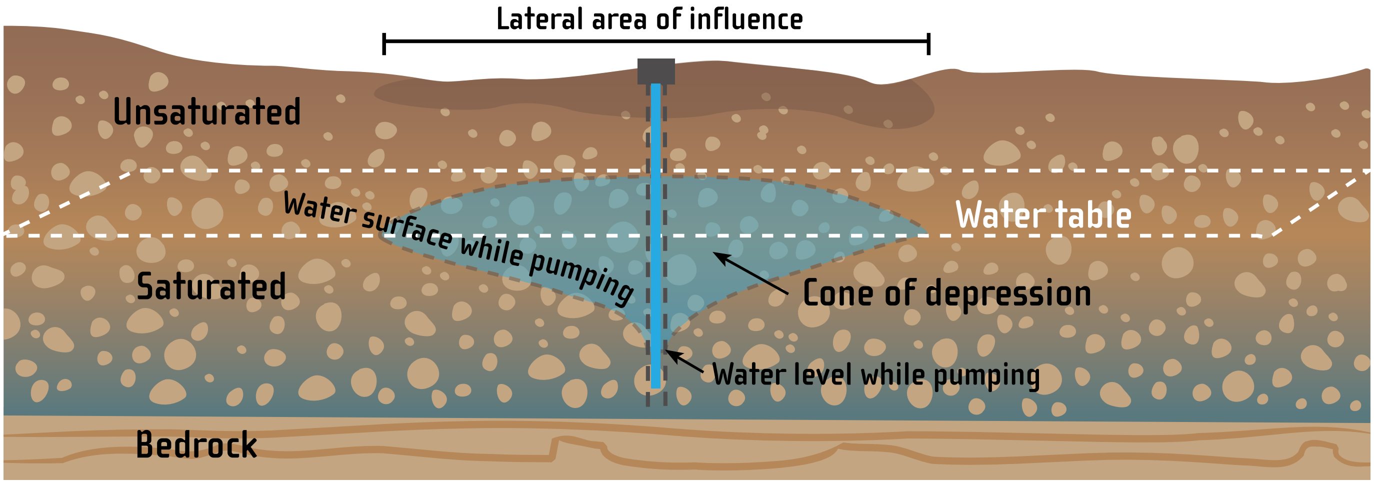
A **confined aquifer** is located beneath an **aquitard** or confining unit. The water that is stored in a confined aquifer is under pressure; if a well is installed, the water level in the well will rise above the top of aquifer to a level that equals the pressure in the aquifer. This elevation is called the pressure head. In a confined aquifer, water moves from areas of high head to areas of low head, which does not necessarily follow the topography of the land. Hydrologists use groundwater maps and conceptual models to determine the direction of groundwater flow.

More than 70 percent of Minnesotans use groundwater for drinking, bathing, washing clothes, and other household uses.



Source: USGS

If water is withdrawn from an aquifer at a high rate—say to provide water for irrigating extensive farm fields, or to provide drinking water for a city—the resulting low pressure will form a cone of depression around the well. The cone of depression will grow and draw more water from the area until there is enough water moving toward the well to match the pumping rate. The size of the cone is determined by the pumping rate of the well and the ability of the aquifer to move water (transmissivity.) As the water level in the aquifer is lowered around the well, it can potentially impact water levels in nearby wells and surface water features.



Caves. We've seen how water shapes the surface of the land, carving valleys and streambeds as it moves toward the ocean. Less visible but just as real is how it shapes what lies beneath. When water moves through limestone, dolomite, or sandstone underground, it can dissolve some of the rock, creating spaces known as caverns or caves. Throughout most of Minnesota, many such layers that existed have either been scraped off by glacial action or been buried by thick glacial sediments. But in southeastern Minnesota, which was not blanketed by the most recent glaciers, the layers of rock susceptible to cavern-carving still lie close to the surface. Signs that caves might be found in a particular area include springs, disappearing streams, and sinkholes.

Disappearing stream.

CAREER PROFILE

Jennifer Olson
Water Resources Specialist,
Emmons & Olivier Resources, Inc.
Oakdale

Can we build roads, houses, office buildings, and industrial parks and still protect the environment? Helping make sure water resources stay safe during development is something geologist Jennifer Olson does every day. When people decide to make a change to the landscape, they call on a water resource specialists like Olson or someone like her to look at the water resource in the area and help plan ways to protect it.

You might think Olson's job would involve getting her feet wet. But most days you're more likely to find her at a computer than in a creek. When a new project is proposed, she looks up information about water resources in the area, teams with colleagues to put together a water protection plan, then works with government agencies and others to turn the plan into reality.

"I've always been an environmentalist at heart, starting back when I was a little girl," Olson says. "I remember reading stories in National Geographic and thinking I wanted to do something that would make a positive impact on the environment."

To get where she is today, Olson pursued a college degree in hydrogeology and environmental geology. That gave her a solid understanding of science and of how water and land interact. She recommends that others interested in following in her footsteps get a good education both in science and in the social aspects of water resources. Also important, she says, is "a willingness to try new things, and a dedication to making a difference."

Related careers:
hydrologist,
engineer,
planner

Suggested Project WET Activities and Minnesota Connections

EL = elementary	MS= middle school	HS=high school

Water is essential for all life to exist.

Life in the Fast Lane (wetland species needs) EL

People of the Bog (bogs, decomposition) MS, HS

Water connects all Earth systems.

Capture Store and Release (wetlands) EL

Get the Groundwater Picture (groundwater) MS, HS

Great Stony Book (geology) MS

Wetland Soils in Living Color (wetlands and geology) EL, MS, HS

Water resources are managed.

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

The Pucker Effect (groundwater) 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

Charting Wetland Types: Work in small groups or as a class to develop "compare and contrast" charts for various wetland types. Based on research, have students identify traits that wetlands share, and traits that distinguish them from one another. Make observations on how and why they vary.

How Much Water Can it Hold? Use sponges to demonstrate the water-holding capacity of a wetland. Provide groups of students with a dry sponge on a plate and a water dropper. (Use a variety of sponges with different characteristics if possible.) Invite students to add water drop by drop to the sponge until it begins to pool on the plate. How many drops were they able to add before the sponge's capacity was reached? Where was the water? Why did it stay there instead of flowing through onto the plate? (Review traits of water from Chapter 1.)

Local Groundwater: Ask your local watershed district or soil and water conservation district for information about aquifers in your area. Is there an aquifer under your school? What is its name? What kind of aquifer is it? Where does it get its water? Where does water go when it leaves the aquifer?

Pore Space: Fill jar with rocks and ask students how much space is left. Pour in sand to fill up the spaces between the rocks and ask the same question again. Then pour in water, to show there is still pore space available. Help students see that groundwater exists in pore spaces between soils and rocks.

Where Does it Flow? Ask students where they think the water that lands on your school ultimately flows: into the Red River of the North, the Great Lakes, the Mississippi River, or the Missouri River. Use maps to figure out the correct answer.

Water Observations: For very young students, take a variety of items, such as a piece of plastic, a wooden plank, a pan with some rocks, and a pan with soil. Add a cup or two of water to each sample and have the students observe what happens to the water—does it run off? Form puddles? Soak in? Erode the objects? Have the students continue to observe changes for a day or two.

Out and About

Wetland Walk: Take a walk to a wetland near you. Discuss: What type of wetland is it? Where does the water in the wetland come from? Where does it go? What kinds of plants and animals live there? How does the wetland benefit your students and their families?

Perc Test: Have students contact a local septic system installer who performs "perc" tests (percolation tests) to demonstrate and explain his or her findings and why it's important to perform such a test before building on a site.

Groundwater Treasure Hunt: If you live in an area where the water table is fairly close to the surface, take a shovel out onto your school property and dig a hole until you hit water. (Be sure to check with the power company first!) If you have time, try various spots: high spots, low spots, spots near a drainage ditch or pond. Is water always the same distance below the surface? Are there any springs nearby? What would happen if you tried this another day? Be sure to get permission first, and fill in your holes when you are done!

A few excellent resources:

1. *WOW! Wonders of Wetlands,* ECI & The Watercourse (1995). Project WET's K–12 wetland activity guide, features more than 70 pages of background material followed by more than 40 activities. Available through http://projectwet.org or the Minnesota Project WET coordinator.

2. MN County Atlas Program, DNR. www.mndnr.gov (search "county atlas") This website offers maps and reports of the characteristics and pollution sensitivity of MN's groundwater.

3. Volunteer Water Monitoring Programs, Minnesota Pollution Control Agency. http://www.pca.state.mn.us/water/volunteer-monitoring.html This website provides information on several volunteer monitoring programs active throughout Minnesota, including lake monitoring, stream monitoring and wetland monitoring.

4. *America's Wetlands: Guide to Plants and Animals* by Marianne D. Wallace (2004). This book includes illustrations and descriptions to help identify wetland types, plants, and animals throughout the USA. The book provides a list of common and scientific names, detailed species information and maps.

5. Groundwater Flow Models, MN DNR and other local government agencies. An interactive classroom tool that is designed to show the flow of water and toxins though differing gradients. This "giant ant farm" can be used in front of the classroom and is easily used by students themselves. Used to demonstrate flowage through confined and unconfined aquifers as well as the effects of pumping on these aquifers. Contact the Project WET Coordinator to check out the model.

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