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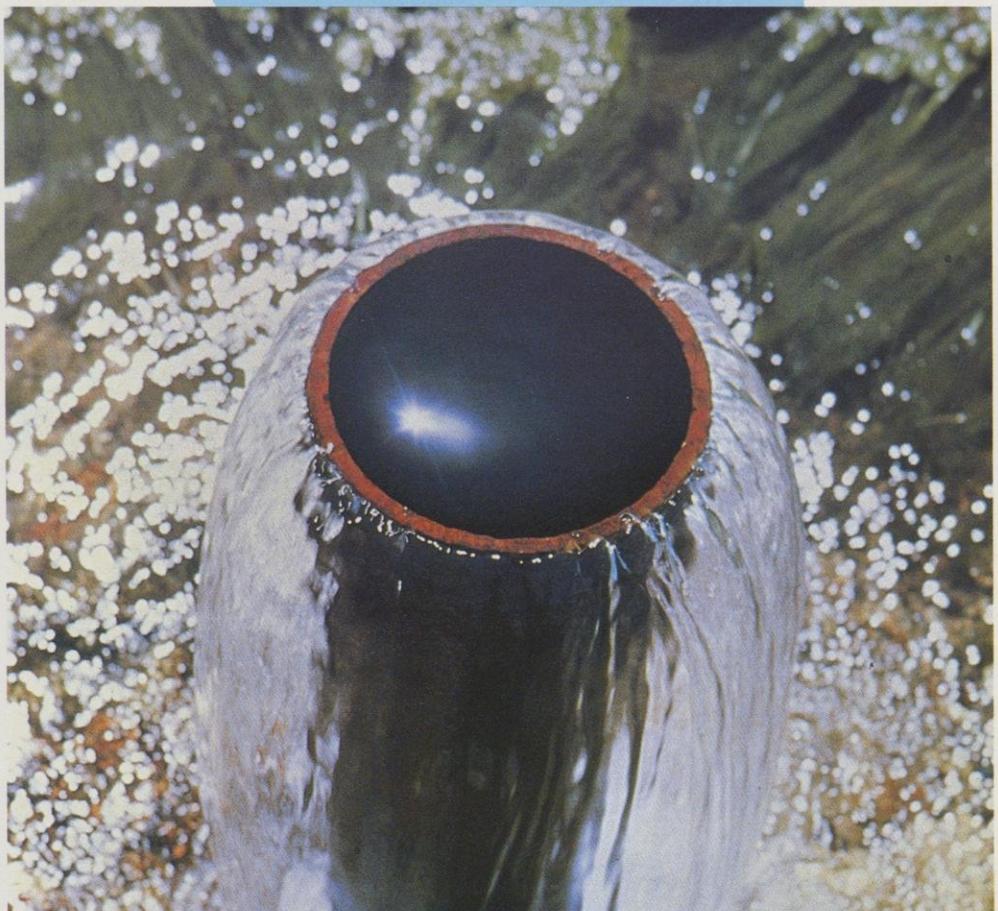
Groundwater



Protecting Wisconsin's buried treasure

CONTENTS

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FRONT COVER: Photo of a flowing artesian well in Door County by Ken Bradbury.

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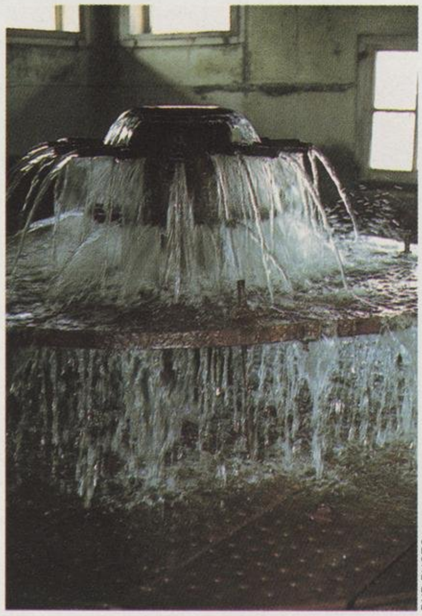


DNR PHOTO

Walk on water? Difficult if you're not divine. Yet it's something you do every day.

Under the sidewalk, below the garden path, beneath the baseball diamonds, hiking trails, the front lawn and the back 40, there is water: *groundwater* — about two quadrillion (2,000,000,000,000,000) gallons, give or take a pint, under Wisconsin alone. If that water were solid gold, it'd be one heck of a buried treasure.

Maybe standing above all that liquid is making you wish life preservers were standard equipment on humans. May we suggest a glass of water to keep your head above...you know.

Open the tap and fill your cup. It's probable that you're sipping groundwater drawn from a private or public well: Nearly 75 percent of Wisconsinites rely on groundwater for drinking. It's a plentiful and cheap source of potable water.

Perhaps a juicy cheeseburger and crisp french-fried potatoes would hit the spot. Before you take a bite, remember that nearly every drop of water used to irrigate Wisconsin crops, plus a great deal used in milk and beef production, comes from groundwater reserves. Agriculture, manufacturing, brewing and a host of other industries depend on reliable, pure groundwater.

Wisconsin's famed lakes, rivers, streams and wetlands attract people from all over the world, so it's no surprise that tourism is an important part of our economy. Without groundwater, however, some of those water bodies wouldn't be as appealing and others would cease to exist. You can't fish, swim, ski, sail or canoe on mud or dry land.

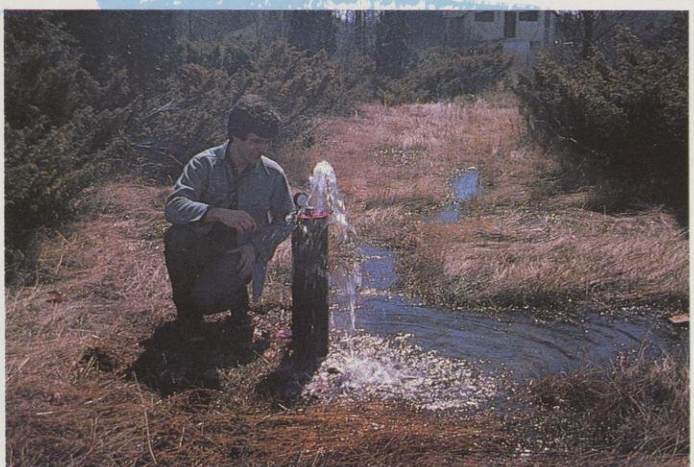
As you go about your daily activities — taking out the garbage, preparing supper, filling the car's gas tank — consider the liquid treasure buried below your feet. It's a vulnerable resource, susceptible to hazards such as leaking underground gasoline tanks, chemicals misapplied on farm fields, and poorly constructed, mismanaged landfills.

Protecting groundwater from these and other dangers is everybody's responsibility. In 1983, Wisconsin Natural Resources published "Groundwater: Wisconsin's buried treasure" to introduce this valuable resource. We've returned to the subject in "Groundwater: Protecting Wisconsin's buried treasure" to let you know what is being done to safeguard groundwater and what you can do to help. Each of us in Wisconsin is a beneficiary of the groundwater treasure; we must learn to be its guardian.

Look for the water drop, your guide to the truth about 10 common groundwater myths!

GROUNDWATER
Wisconsin's
buried treasure

Using groundwater



KEN BRADBURY

Freed by a well, water once trapped in layers of rock and soil spurts to the surface. Wisconsin has a plentiful supply of groundwater, but it's distributed unequally across the state.

Wisconsin is water-rich...

Welcome to Wees-kan-san — Chippewa for "gathering of waters." Each year about 29 trillion gallons of water fall as rain or snow on Wisconsin's 36 million acres. Some is consumed, some returned to the atmosphere by evaporation or transpiration by plants and the rest flows into rivers, lakes and streams or seeps into the soil.

If you could somehow pour all the water below ground on top, you'd need to trade in your ranch house for a houseboat: Wisconsin's bountiful groundwater could cover the whole state to a depth of 30 feet!

Every day, Wisconsinites withdraw about 570 million gallons of this seemingly endless resource from private and public wells. Our wells seldom go dry because groundwater is replenished at the rate of six to 10 inches per year.

So why be concerned about groundwater? There's plenty, more than we could possibly use, right? There'll always be pure, clean groundwater for drinking and food processing, for livestock and paper production, for beer-making, car-washing, two showers a day, ice cubes, soda, mineral water, swimming pools and birdbaths, right?

Read on.

...but the quality and quantity of groundwater varies from place to place

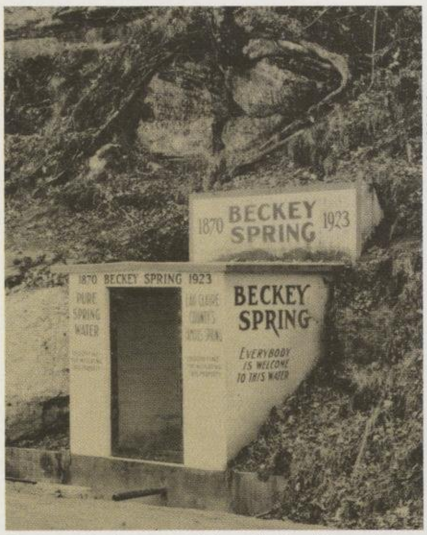
In Wisconsin, there's a difference in groundwater abundance from west to east and areas in between. The difference is caused mostly by geology, as you'll discover later in this publication. But here's an example to tide you over:

Cities and towns in the north central and northeastern third of Wisconsin receive the most precipitation in the state. But they are underlain by crystalline bedrock, a type of rock formation notorious for yielding only small quantities of water. Even though there may be plenty of surface water, finding spots here that hold enough groundwater to supply large-capacity wells can be difficult.

Shallow wells can be affected by seasonal changes in the amount of rainfall and may go dry during times of drought. Deeper wells often tap aquifers, or layers of water-bearing rock, where the quantity of water remains relatively constant.

At last estimate, there were about 700,000 private wells operating in the state. Even though there are areas where soil or rock yield water very slowly, you can drill a hole just about anywhere in Wisconsin and find a dependable water supply.

The supply may be dependable, but that doesn't mean it's drinkable. Groundwater can be contaminated in a number of ways. Leachate from poorly constructed landfills trickles into groundwater. Pesticides may pass through the soil and into the groundwater in low but sometimes toxic concentrations. Improperly managed fertilizer and farm animal wastes increase nitrate levels in rural wells. Septic systems built too close together can cause nitrate problems in subdivision wells. Naturally-occurring contaminants such as radium may render groundwater unfit to drink. Road salt can taint the groundwater supply. Drop by drop, gasoline and fuel oil stored in rusting underground storage tanks pollute this abundant resource all over the state.



ICONOGRAPHIC COLLECTION, STATE HISTORICAL SOCIETY OF WISCONSIN

Beckey Spring near Eau Claire (French for clear water) refreshed Chippewa Valley residents for many years.

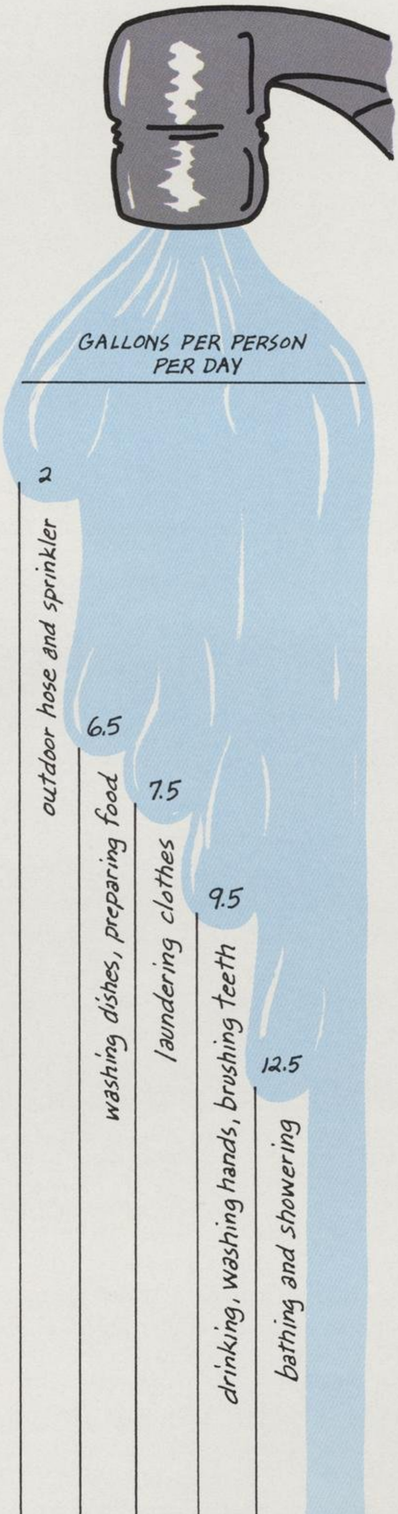
Stricter laws and improvements in technology have advanced the state of groundwater protection; you'll read about them here. And you'll find out how you can take action at home as well.

On the home front

About three-fourths of Wisconsin's residents draw nearly 222 million gallons of groundwater daily at home to slake thirsts, scrub pots, boil spaghetti, rinse hair, soak socks and fill balloons.

Per person, that's 63 gallons of groundwater per day.

How do you use Wisconsin's ample buried treasure? Take a look at the faucet.



GEORGINE PRICE

Sixty-three gallons of groundwater per person per day may not seem like much, considering the depth of our underground coffers. To some folks, conserving water seems about as sensible as spitting into the Pacific Ocean to raise the water level. What difference does it make?

There are hidden costs for excessive water use. Your community may have to install new wells or water and sewer pipes to accommodate increasing demand. Pumping more water requires more energy, which costs more money. Treating wastewater to stringent standards of purity strains every budget, private or municipal. You can take a real bath on your property taxes when the bill for new sewers arrives!

The less water you use, the fewer new water-related facilities you or your community will need to build and the longer good, pure groundwater will remain affordable. (On page 25, you'll find details on drinking water quality and tips for water conservation.)

Thirsty cities

It's used to fight fires, clean streets, fill the local pool, sprinkle golf courses and parks, drench dry boulevard trees, supply commercial customers and satisfy the needs of thirsty residents at home or at innumerable bubblers (drinking fountains, to non-Wisconsinites) around town. Ninety-seven percent of Wisconsin's cities and villages count on groundwater to provide basic water-related services often taken for granted.


ROBERT QUEEN

Groundwater makes a big splash in cities and villages statewide.

Wisconsin's municipal groundwater tab: A cool 275 million gallons per day. The top counties and main users: Dane County (Madison) 42 million gallons per day; La Crosse County (La Crosse), 20 million gallons per day; Rock County (Janesville and Beloit), 19 million gallons per day.

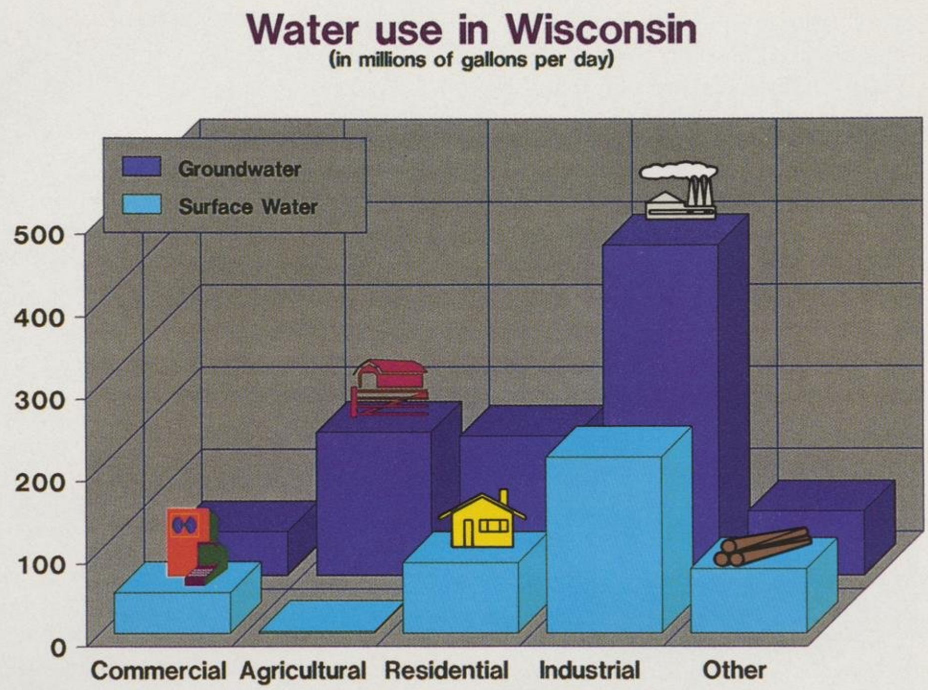
Average daily cost to a family of four in 1989: Less than 50 cents.

A fluid economy

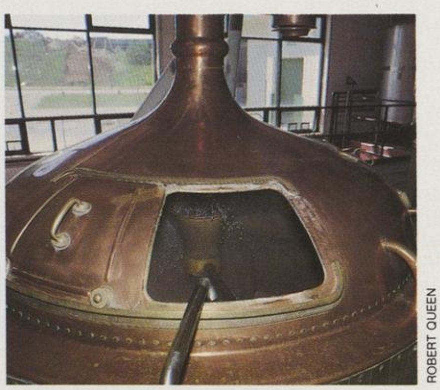
Water is vital to the health of Wisconsin's economy. It's part of countless manufacturing processes, from metal fabrication to paper production to leather tanning. When water purity isn't critical to the final product, companies located near larger bodies of water have the option of using surface water. But some of our most important industries — fruit and vegetable processing, cheesemaking, dairy farming, meat processing and brewing — need pure, clean groundwater to make the goods for which Wisconsin is nationally renown.

We'd never be able to remain leaders in producing canned snap beans and sweet corn or in cheese and butter production without groundwater. There's no way Wisconsin breweries could have produced 15,066,979 barrels of beer in 1988 without ample groundwater resources.

The big operators aren't the only ones who need this valuable resource. Consider your local laundromat and car wash, the soft-drink bottlers, restaurants, health clubs, hairdressers....



data from "Water Use in Wisconsin, 1985"
U.S. Geological Survey and Wisconsin DNR



The beverage that made Wisconsin famous couldn't be brewed without good groundwater. This vat at Middleton's Capital Brewery is being filled with water to begin the next batch of beer.

Commercial and industrial companies draw over 40 million gallons of groundwater each day from their own wells and use about 150 million gallons more provided by municipal water systems. Groundwater supplies nearly one-third of Wisconsin's business and industrial water needs — an important partner in Wisconsin's economic stability and future.

Wet and wild

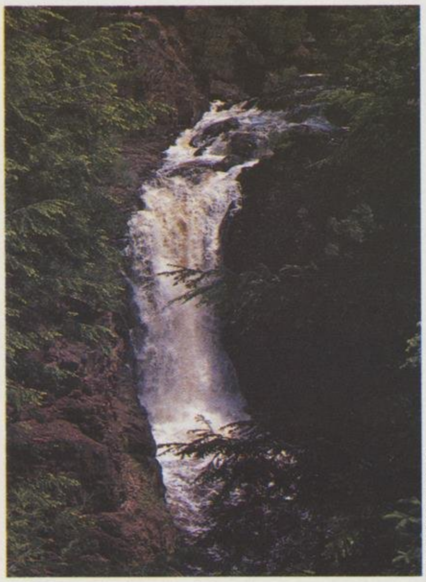
2,444 trout streams.
5,002 warmwater streams.
14,949 inland lakes.
5,331,392 acres of wetlands.

These figures add up to a $4 billion boost to Wisconsin's economy, provided by thousands of tourists who visit the state each year to enjoy, among other things, our fabulous water resources. What they don't see is our most fabulous water resource of all: Groundwater.

After seeping through the soil and rock, groundwater discharges in low places where the water table meets the land surface — streams, lakes and wetlands. That favorite fishing hole or secret pond, the expanse of cattails perfect for observing herons and singing along with the frogs, those wild rapids waiting to devour the raft

or roll the kayak — most are replenished by groundwater.

It's Wisconsin's invisible natural resource.



GERARD STEPHANEK

Copper Falls near Mellen: Like most rivers in Wisconsin, the Bad River is replenished with groundwater. Here it plunges over hard basalt, creating a spectacular sight.

Aquaculture?

Take a short test: A dairy cow producing 100 pounds of milk daily slurps 45 gallons of water each day to wet her whistle. There are roughly 1,840,000 cows in the state. How much water will they drink in a year?

If you said 30,222,000,000 gallons, you pass. For extra credit, how much of that water was groundwater?

Ninety-six percent? Good guess!

Wisconsin's dairy and cattle farms use about 90 million gallons of groundwater a day to water stock, maintain a high level of sanitation in the milkhouse and all-around cleanliness on the farm. Dairy farmers know that bringing a quality product to market means starting with quality materials — wholesome, nutritious feed and pure, clean water.

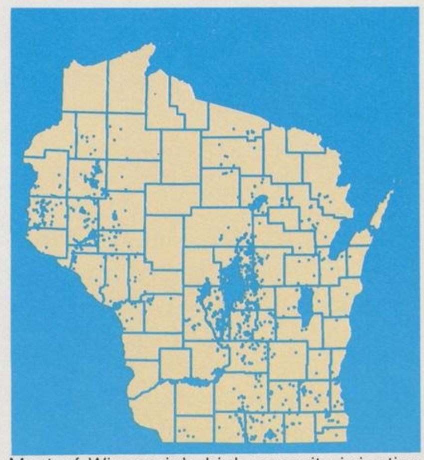
DNR PHOTO

Wisconsin's irrigated acreage has nearly doubled in the past 20 years. Irrigation may ensure a successful crop, but excessive watering can leach fertilizers and pesticides into groundwater.

The demand for groundwater on the farm continues to rise as increasing numbers of farmers install irrigation systems to make the risky business of farming more certain. In 1969, 105,526 acres of Wisconsin farmland were irrigated; by 1987, that figure rose to 284,637 acres.

Irrigation equipment withdraws about 84 million gallons per day during the growing season, almost all of it groundwater.

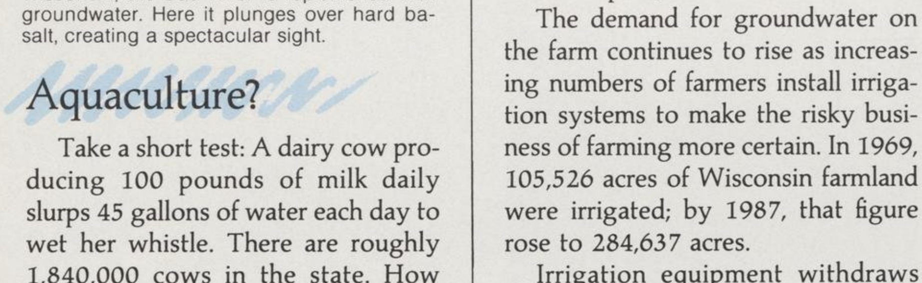
Much of Wisconsin's irrigated acreage is in the relatively flat 10-county Central Sands area, where the potato is king. The tuber grows well in the sandy, loose soil, which needs less plowing and seedbed preparation than heavier soils and makes for an easy harvest. Water quickly seeps into this permeable soil and drains away almost as fast, allowing the plant roots to breathe and preventing rot. But the sandy soil doesn't hold water well, so irrigation is almost essential to ensure a good crop.



UNITED STATES GEOLOGICAL SURVEY

Most of Wisconsin's high-capacity irrigation wells are clustered in the 10-county Central Sands area and other areas with permeable sand and gravel aquifers.

While irrigation has helped formerly marginal lands turn a profit, there is a cost. Increased irrigation can speed soil erosion as windbreaks come down to accommodate wide-swinging spray arms. Irrigation encourages cropping on the same piece of land year after year, instead of using a cover crop and allowing the land to rest periodically. Perhaps the most dangerous in the long run: excessive irrigation may leach nutrients, fertilizers and pesticides into the groundwater. ■



GROUNDWATER Wisconsin's buried treasure

Understanding the resource

The water cycle

Water might be called our most recycled resource. The water you showered in this morning, for example, may have contained the same water molecules that caused a dinosaur's hide to glisten in the prehistoric sun or carried the *Nina, Pinta* and *Santa Maria* across the Atlantic. The distribution of the earth's total supply of water changes in time and space, but the quantity has remained constant.

Uneven water distribution is governed by a phenomenon known as the hydrologic cycle, which is kept in motion by solar energy and gravity.

Pick a bursting cloud as the start of the cycle. As the rain it sheds falls to earth, some flows downhill as runoff into a stream, lake or ocean. Some evaporates; some is taken up by plants. The rest trickles down through surface soil and rock formations, traveling through pore spaces and open cracks. This water eventually reaches the top of a water-saturated layer of soil or rock called the water table. The water contained in the saturated layer below the water table is called groundwater.

Groundwater seeps from upland to lowland areas and is released, or discharged, in lakes, streams and wetlands — low places where the water table meets the land surface. The sun releases energy, causing evaporation from surface waters. The process that returns water to the atmosphere from water and land surfaces and by the activity of living plants is called evapotranspiration. When water vapor accumulates in the atmosphere and clouds begin to form, the hydrologic cycle begins anew.

Wisconsin receives an average of 30 to 32 inches of precipitation per year. Seventy-five percent of that precipitation evaporates or transpires through plants and never reaches surface or groundwaters. The six to 10 inches that do not evaporate immediately or get used by plants run off into surface waters or soak into the ground, depending on local topography, soil, land use and vegetation. For every one inch of water that runs off the land to a stream or lake in gently rolling Dane County, two inches seep down to the water table; in the sandy plains of Portage County, nine inches are able to seep into the ground for each inch running off the land.

All groundwater moves continually toward an area of discharge, but the rates of movement vary greatly.

The reason for this variability is a matter of geology. The size of the cracks in rocks, the size of the pores between soil and rock particles and whether the pores are connected contribute to the rate of movement to, through and out of the saturated zone.

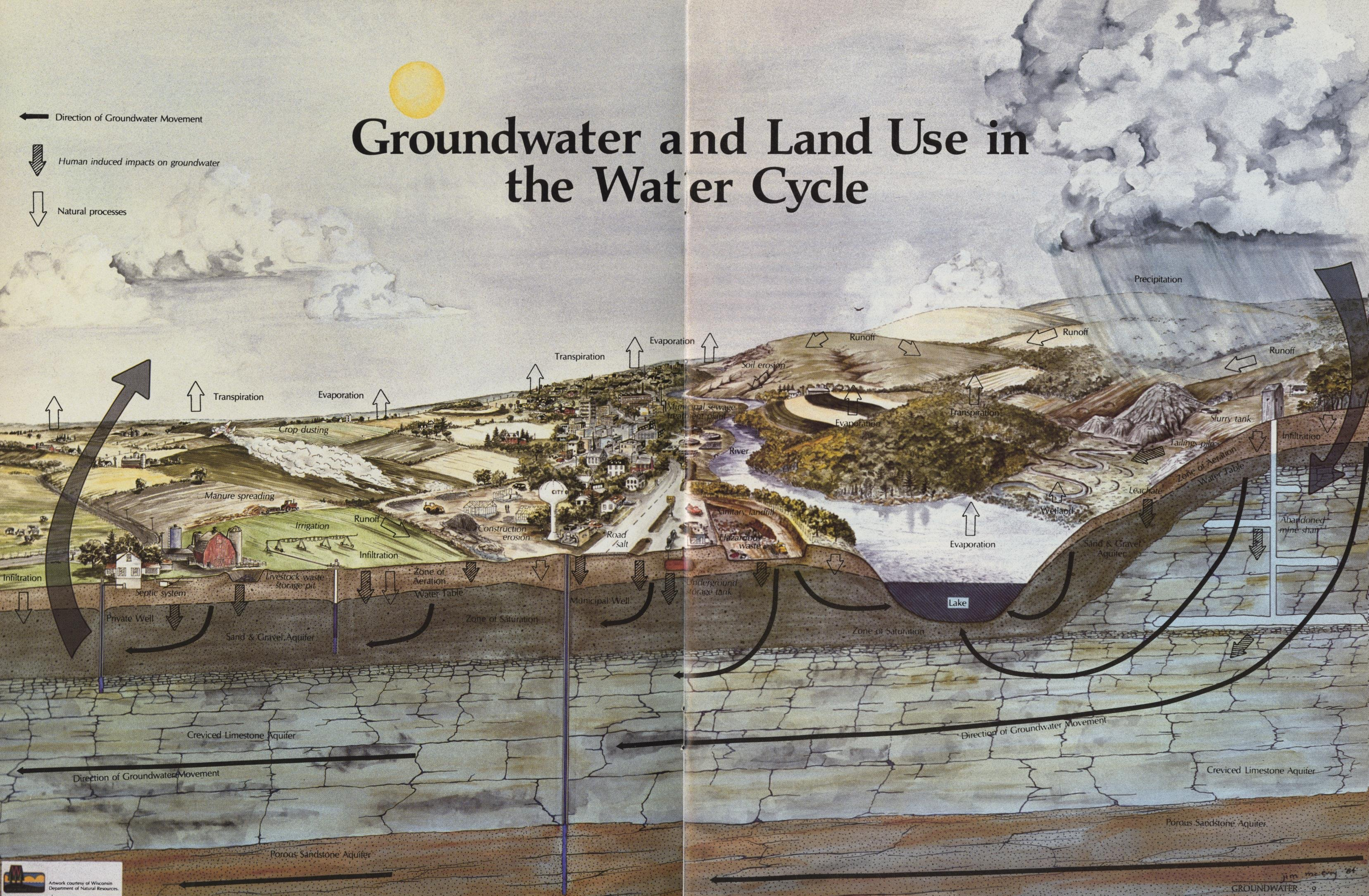
Water generally moves more quickly into, through and out of coarse sand, sometimes as much as several feet per day. Openings between the grains are large and interconnected, resulting in high permeability. Very fine-grained material like clay has many pores where water can be stored, but the pores are so small that moving water through or out is difficult. Clay formations are relatively impermeable — water may move only a few inches a year. Permeability in limestone, on the other hand, primarily depends not on pore spaces but on the size, frequency and distribution of fractures and cracks.

Groundwater on the move

As groundwater moves through the water cycle, it follows the slope of the water table. In Wisconsin, the natural movement is from upland recharge areas to lowland discharge areas. Most precipitation seeping into the soil moves only a few miles to the point where it is discharged; in the vast majority of cases, it stays within the same watershed.

Perhaps you've wondered why some streams continue to flow during dry periods and in winter, when there's no rainfall. Winter stream flow is largely groundwater discharge (called base flow), which remains at a relatively constant temperature year 'round — about 50° F. Streams, and most lakes and wetlands, are constantly replenished during the winter by groundwater from the surrounding uplands. The water table steadily lowers during the winter discharge period, and it is not until the following spring thaw that water can once again infiltrate the soil to recharge the groundwater and thus cause the water table to rise. By the way — that same 50° F groundwater base flow is the reason trout streams stay icy cold in summer.

Groundwater and Land Use in the Water Cycle



Wisconsin's aquifers

A rock or soil formation that can store or transmit water efficiently is called an aquifer. The state's groundwater reserves are held in thick, permeable layers of soil and rock. These layers are our four principal aquifers: the sand and gravel aquifer, the eastern dolomite aquifer, the sandstone and dolomite aquifer, and the crystalline bedrock aquifer.

Sand and gravel aquifer

The sand and gravel aquifer is the surface material covering most of the state except for parts of southwest Wisconsin. It is made up mostly of sand and gravel deposited from glacial ice or in river floodplains. The glacial deposits are loose, so they're often referred to as soil — but they include much more than just a few feet of agricultural loam. These deposits are more than 300 feet thick in some places in Wisconsin. Groundwater collects and moves in the pores and open spaces in between the grains of sand and gravel.

The glaciers, formed by the continuous accumulation of snow, played an interesting role in Wisconsin's geology. The snow turned into ice, which reached a maximum thickness of almost two miles. The ice sheet spread over Canada, and part of it flowed in a general southerly direction toward Wisconsin and neighboring states. This ice sheet transported a great amount of rock debris called "drift."

As the ice melted, large amounts of sand and gravel were deposited, forming "outwash plains." Pits were formed in the outwash where buried blocks of ice melted; many of these pits are now lakes. The sand and gravel aquifer was deposited within the past million years.

The sand and gravel outwash plains now form some of the best aquifers in Wisconsin. Many of the irrigated agricultural lands in central, southern and northwestern Wisconsin use the glacial outwash aquifer. Other glacial deposits are also useful aquifers, but in some places, large glacial lakes were formed and over time, accumulated thick deposits of clay. These old lake beds of clay do not yield or transmit much water.

Because the top of the sand and gravel aquifer is also the land surface for most of Wisconsin, it is highly susceptible to human-induced and naturally-occurring pollutants.

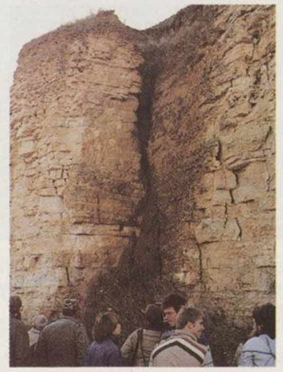
Eastern dolomite aquifer

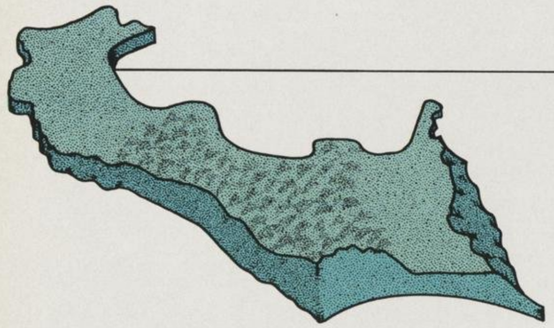
The eastern dolomite aquifer occurs in eastern Wisconsin from Door County to the Wisconsin-Illinois border. It consists of Niagara dolomite underlain by Maquoketa shale.

These rock formations were deposited 400 to 425 million years ago. Dolomite is a rock similar to limestone; it holds groundwater in interconnected cracks and pores. As a result, the water yield from a well mostly depends on the number of fractures the well intercepts. Closely spaced wells, therefore, can vary greatly in the amount of water that can be pumped.

Where the fractured dolomite bedrock occurs at or near the land surface, the groundwater in shallow portions of the eastern dolomite aquifer can easily become contaminated. In those areas (such as parts of Door, Dodge and Waukesha counties), there is little soil to filter pollutants carried or leached by precipitation. Little or no filtration takes place once the water reaches large fractures in the dolomite. This has resulted in some groundwater quality problems, such as bacterial contamination from human and animal wastes. Special care is necessary to prevent pollution.

The Maquoketa shale layer beneath the dolomite is a rock layer formed from clay that doesn't transmit water easily. Therefore, it is important not as a major water source, but as a barrier or shield between the eastern dolomite aquifer and the sandstone and dolomite aquifer.



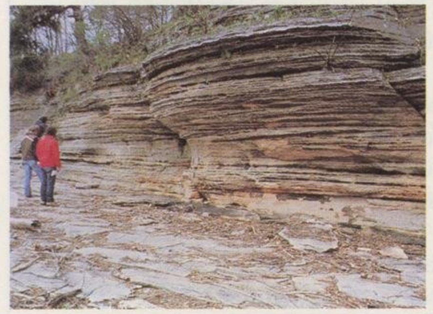


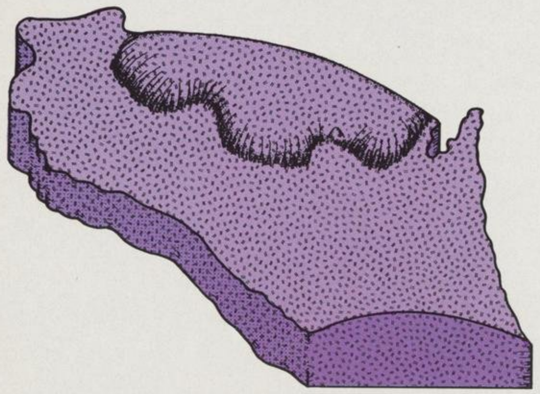
Sandstone and dolomite aquifer

The sandstone and dolomite aquifer consists of layers of sandstone and dolomite bedrock that vary greatly in their water-yielding properties. In dolomite, groundwater mainly occurs in fractures. In sandstone, water occurs in pore spaces between loosely cemented sand grains. These formations can be found over the entire state, except in the north central portion.

In eastern Wisconsin, this aquifer lies below the eastern dolomite aquifer and the Maquoketa shale layer. In other areas, it lies beneath the sand and gravel aquifer. These rock types gently dip to the east, south and west, away from north central Wisconsin, becoming much thicker and extending to greater depths below the land surface.

The rock formations that make up the sandstone and dolomite aquifer were deposited between 425 and 600 million years ago. The sandstone and dolomite aquifer is the principal bedrock aquifer for the southern and western portions of the state. In eastern Wisconsin, most users of substantial quantities of groundwater, such as cities and industries, tap this deep aquifer to obtain a sufficient amount of water.





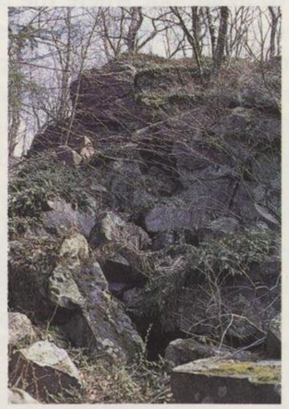
Crystalline bedrock aquifer

The crystalline bedrock aquifer is composed of a variety of rock types formed during a geologic time called the Precambrian Era, which lasted from the time the earth cooled more than 4,000 million years ago, until about 600 million years ago, when the rocks in the sandstone and dolomite aquifer began to be formed. During this lengthy period of 3,400 million years, sediments, some of which were rich in iron and now form iron ores, were deposited in ancient oceans; volcanoes spewed forth ash and lava; mountains were built and destroyed, and molten rocks from the earth's core flowed up through cracks in the upper crust.

The rocks that remain today have a granite-type crystalline structure. These are the "basement" rocks that underlie the entire state. In the north central region, they are the only rocks occurring beneath the sand and gravel aquifer.

The cracks and fractures storing and transmitting water in these dense rocks are not spaced uniformly; some areas contain numerous fractures while others contain very few. To obtain water, a well must intersect some of these cracks; the amount of water available to a well can vary within a single homesite. The crystalline bedrock aquifer often cannot provide adequate quantities of water for larger municipalities or industries.

Many wells in the crystalline bedrock aquifer have provided good quality water. However, most of these wells do not penetrate deeply into the rock. Water samples from deep mineral exploration holes near Crandon and deep iron mines near Hurley have yielded brackish water exceeding mineral concentrations in sea water. ■



GROUNDWATER Wisconsin's buried treasure

Threats to groundwater

ROBERT QUEEN

When spilled, even small quantities of liquids like gasoline can contaminate groundwater in neighboring wells.

You name it — gasoline, fertilizer, paint thinner, bug spray — if it's used or abused by humans in large enough quantities and dissolves in water or soaks through soil, it's capable of showing up in Wisconsin groundwater at some place or time.

Dealing with contaminants once they get into the groundwater is no small feat. Sometimes it's nearly impossible to figure out where the pollution is coming from; in some cases, the source of the contaminants may never be found. Isolating the source of a groundwater contaminant is a complicated puzzle involving a combination of chemistry, hydrogeology and old-fashioned trial-and-error, process-of-elimination sleuthing.

If a specific source is found, there's no guarantee that the person or company responsible for the pollution will be willing or able to clean it up, nor that the contaminants can be removed economically. And, as you'll discover in this section, groundwater contamination can often be the end result of the normal, day-to-day activities of you, your family and your neighbors. Remember: What we do on top of the ground affects the water lying beneath it.

The use and misuse of pesticides

Insecticides, herbicides and fungicides have been a mainstay of Wisconsin agriculture for years; they've been perennial topics in the news as well. Aldicarb, atrazine, alachlor — it doesn't take long for agricultural chemicals to become household words once the problem of drinking water contamination hits home.

These aids to modern farming trickle into the groundwater in a number of ways. Use Farmer Brown as an example. He purchases his agrichemicals from a pesticide dealer. At the dealership, the chemicals have been stored in an outdoor shed, where undiluted product may leak from a few damaged or corroded containers and seep into the ground. That's one route of contamination.

Back at the farm, Farmer Brown mixes a batch of pesticide in a spray

Department of Agriculture, Trade and Consumer Protection specialists are investigating the impact of pesticide use on groundwater in vulnerable areas of the state.


DEAN TVEDT

tank. By accident, he sloshes some down the side of the tank; it runs into the soil. Route two.

To get an extra measure of protection for his crops, Farmer Brown adds a couple more ounces of pesticide concentrate to his spray tank, exceeding the recommended proportions. When he applies the mixture, he doesn't realize that the worn nozzles on his sprayer are releasing too much pesticide on the fields. That afternoon, there's a heavy rainstorm; the excess chemical soaks into the ground and works into the groundwater. Route three.

Route four: When he's done spraying, Farmer Brown rinses his tanks and hoses, letting the liquid soak into his fields without knowing how much chemical residue is filtering into his soil. Then, he takes the empty containers and tosses them into the town dump. But they're not totally empty. Since he neglected to triple-rinse the bottles or cans before disposal, they still contain concentrated pesticide, which eventually leaches into the water table. Route five.

Once they hit the ground, some ag chemicals are absorbed by plants; others are consumed by bacteria and rendered harmless. However, it's possible for others to slip past the bacteria and plants and enter the groundwater, where they may stay unchanged for an indefinite period of time, or break down into different, perhaps more toxic, compounds.

In the early '80s, researchers discovered traces of aldicarb, the preferred chemical for controlling potato pests, in Central Wisconsin wells. Aldicarb was the first pesticide found leaching into Wisconsin groundwater, from normal, routine application rather than accidental spills. While aldicarb use has been curtailed, the issue of its effect on human health is controversial and continues to be debated.

Farmers in the sandy heart of the state aren't alone in knowing groundwater contamination first-hand. A 1989 study of 534 wells on Grade A dairy farms around Wisconsin found levels of atrazine, a widely-used corn herbicide, in 66 wells. Although most of the levels were below the state's groundwater enforcement standard, there's still cause for concern: Atrazine has been classed by the U.S. Environmental Protection Agency as a possible carcinogen. Pesticide contamination isn't exclusively a rural problem: The lawn and garden pesticides used in urban areas can leach into municipal water supplies.

There's a lot we don't know about the physiological effects of drinking water from wells contaminated with agricultural chemicals: How much contamination causes harm? Are the health problems immediate or long term? Are children affected more than adults? Consequently, when contamination is found that exceeds groundwater standards, well owners may be advised to drink bottled water.

Landfills

As a society, we've just begun to appreciate the benefits of recycling, of viewing wastes as resources to be used and reused. But we'll always produce some waste. By storing all the wastes we can't recycle in properly sited, designed, constructed and maintained landfills, we can minimize the possibility that leachate (the foul, sewage-like substance that forms when water percolates through solid waste) will contaminate groundwater near homes and wells.

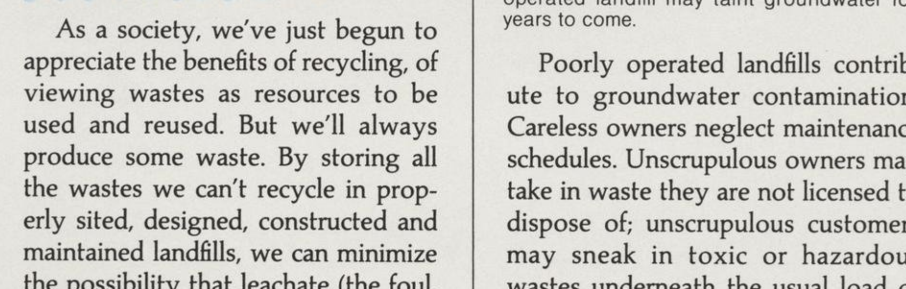
That's the ideal. There are about 150 such "engineered," licensed landfills operating in Wisconsin; most do a good job of protecting groundwater. Another 200 licensed landfills are required to monitor groundwater. But over 700 unengineered dumps "grandfathered" when landfill regulations were developed can't meet strict leachate collection standards. Many are slated to close within the next decade; until then, and for decades to come, unengineered landfills will allow toxic fluids to seep into groundwater.

DNR PHOTO

Closed after numerous violations, this poorly operated landfill may taint groundwater for years to come.

Poorly operated landfills contribute to groundwater contamination. Careless owners neglect maintenance schedules. Unscrupulous owners may take in waste they are not licensed to dispose of; unscrupulous customers may sneak in toxic or hazardous wastes underneath the usual load of trash. The result: Groundwater is sullied and rendered useless.

In addition, there are 2,700 known abandoned dumps in the state. Deserted before stiff regulations went into effect in the 1970s, these sites continue to leach contaminants into the groundwater. There are countless other hidden dumps in Wisconsin,



which often are discovered only after nearby wells are found to be polluted.

Ponds, lagoons and land disposal of wastewater

Municipal, industrial and private businesses use ponds, lagoons and other methods to store, treat and dispose of wastewater on their property. A familiar example is the common small community sewage plant, where a lagoon may be used as the final step in treatment before purified wastes are released into rivers or streams.

Sewage treatment lagoons like this one near Barneveld in Iowa County need to be sealed to protect the underlying groundwater.

Lagoons are sealed with compacted clay soils or plastic liners. Nevertheless, old or malfunctioning lagoons can leak anyway. As inspections turn up these imperfect systems, they are repaired or replaced. Open-air lagoons also are subject to wet and cold weather, which can interfere with the treatment process.

Even if there's nothing wrong with the lagoon, the people who oversee lagoon sewage systems can make mistakes and inadvertently pollute the groundwater. Some sewage systems use treatment lagoons to oxidize and settle solids, followed by seepage cells for filtering away treated wastewater through the soil. If the lagoons are improperly maintained or treatment is not complete, poorly treated wastewater can wind up in groundwater.

Some industries dispose of their wastewater in lagoons, by using it on irrigated farm fields near the plant, or by constructing a "ridge and furrow" system. This method directs wastewater down a one-foot wide, one-foot deep trench that looks like a long, ruffled potato chip. Some water is taken up by plants on ridges between the furrows and some evaporates, but most is filtered through the soil. No matter what the method, if the system is poorly managed, the operator fails to compensate for weather, or if more water is applied than the land can filter, the groundwater can be harmed.

Fertilizer and manure storage and application

A statewide cow-chip toss might be one way to handle the 80 pounds of waste produced by each adult milk cow every day in Wisconsin. Modern farmers prefer manure storage pits. But pits can be "the pits" if they are unlined or if the lining cracks and the waste leaks directly into the ground. Bacterial contamination and increased nitrate levels in the water may result, perhaps with the farmstead well as the first casualty. Neighboring farm water supplies could be harmed as well.

Excessive or improper application of manure and fertilizer to farm fields is Wisconsin's leading source of nitrate contamination in groundwater. Fertilizers used on urban lawns, gardens, parks and golf courses contribute to the problem, too.

Applying too much nitrogen fertilizer to crops can reduce farm profits and cause nitrate contamination in groundwater.

Nitrates — compounds of nitrogen and oxygen — get into groundwater with a little help from nature and a lot of help from people.

Plants completing their life cycle by rotting in soil add nitrates to groundwater. But so do failing septic tanks, wastewater from cities and industries, leaky landfills and manure storage pits, and heavy applications of manure or nitrogen fertilizers to fields and lawns. Overall, about 10 percent of Wisconsin drinking water wells exceed the state groundwater nitrate standard.

The good news is that nitrates are not usually harmful to adults or older children. In fact, we consume a great deal every day in our food. The bad news is that drinking water high in nitrates does threaten infants under the age of six months. Their stomach acid isn't strong enough to kill certain types of bacteria capable of converting nitrates to harmful nitrites. Nitrites bind hemoglobin in the blood, preventing oxygen from getting to the rest of the body; the baby may lose its natural color and turn blue. The result is methemoglobinemia, or "blue baby syndrome," which can cause suffocation.

The condition can be prevented by using bottled water during the child's first six months.

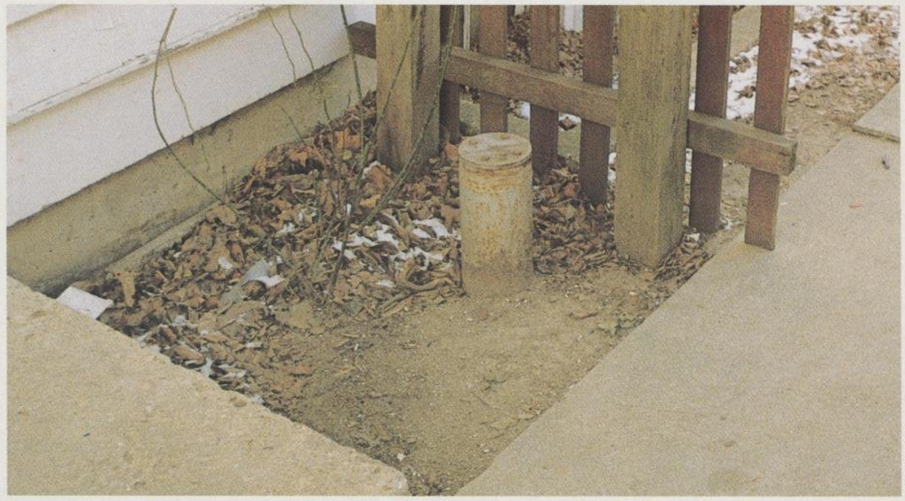
Septic systems

Private septic systems are used to treat human waste in areas not served by community sewage treatment facilities; nearly a half million septic systems are in use in Wisconsin. Here's how they work: Wastewater and solids flow from the house to a settling tank, then liquids continue out to an absorption field. Bacteria decompose solid waste in the tank, and as the wastewater passes into the absorption field, any suspended solids cling to soil particles and dissolved nutrients become available to plants.

Malfunctioning systems can cause wastewater to back up into the home, "pond" on the soil surface, or move directly into the water table without adequate purification. When a system fails, bacteria, nitrates, viruses, synthetic detergents, household chemicals, and chlorides may contaminate groundwater.

Hoisting the lid of a septic tank to see if it's time to pump out the sludge. Even properly maintained systems may pollute groundwater if they're built too close together or in areas where the water table is near the surface.

LISBETH QUADE



DNR PHOTO

An abandoned well is a direct line to groundwater. Old, unused wells should be filled in and sealed before bacteria or other contaminants get in.

Septic systems may fail due to poor siting, design, or construction; sometimes, it's the owner who's at fault for neglecting important operating and maintenance guidelines. (Check page 26 for tips on operating a safe septic system.)

Abandoned and drainage wells

Years ago, wells were dug by hand with picks and shovels, then lined with bricks, boards or stones. Dug wells were gradually replaced by "well pits" — a six- to 10-foot-deep hole through which a point was driven or a well drilled. The temperature in the underground pit remained relatively constant and kept the pump and pipes from freezing in the winter.

Although thousands of dug wells and well pits are still in use, many have been abandoned. If not properly filled, these forgotten wells give surface water a direct channel to groundwater; should the well seal leak, bacteria and other contaminants can get into nearby water supplies. Well pits — used or unused — tend to fill with surface water in the spring. And old dug wells offer a tempting place to throw refuse that can cause pollution.

Drainage wells are used to draw water off sections of wet ground by piercing a clay layer, allowing surface water to run directly into the groundwater. These wells have been prohibited in Wisconsin since 1936, but they do turn up occasionally, often when a nearby well owner discovers a problem with his or her water supply.

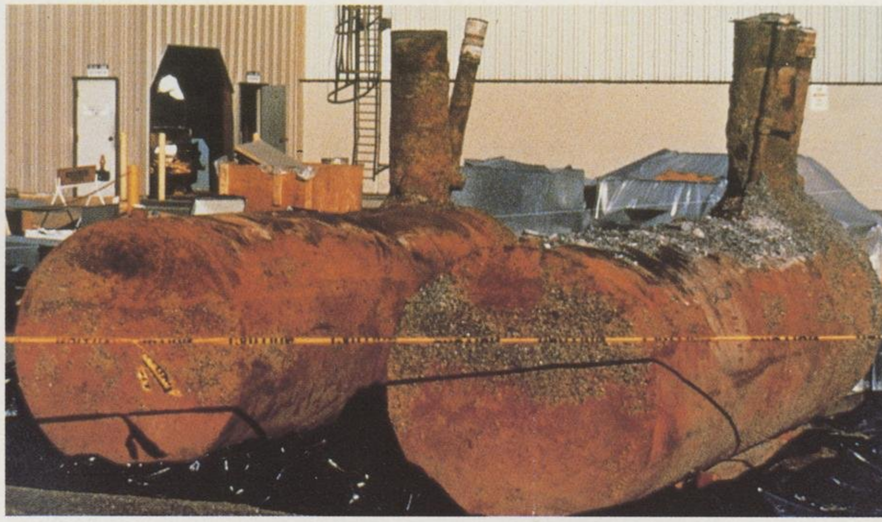
Spills and illegal dumping of industrial and commerical chemicals

Paint thinners, degreasers, electroplating solutions, dry cleaning fluids — they're the blood of industry and commerce. But when these solvents and fluids trickle into groundwater, they can contaminate the precious liquid that keeps us all alive.

Accidents happen — over 1,000 spills of toxic or hazardous materials are reported each year in Wisconsin. Luckily, many of those spills are small and can be cleaned up quickly, before an unwanted substance penetrates groundwater.

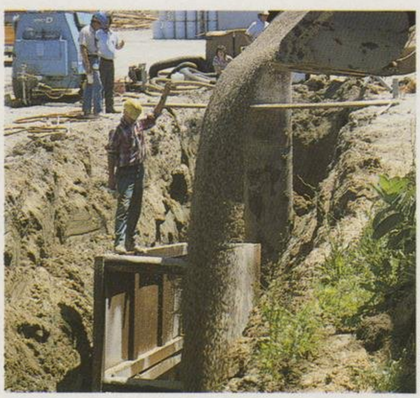
Oftentimes, the first people on the scene of a spill don't know how to deal with the problem. Their first reaction is to flush the area with water and dilute the offending chemical, washing it into the ground and perhaps into the groundwater.

An undetermined number of additional spills go unreported, their presence a secret until area wells become polluted. Although there are strict regulations governing the transport and storage of toxic and hazardous wastes, illegal dumping of dangerous compounds continues.



EPA PHOTO

Rust and LUST: Corroding underground storage tanks leak gas, fuel oil and chemicals into the soil and eventually, groundwater.



DNR PHOTO

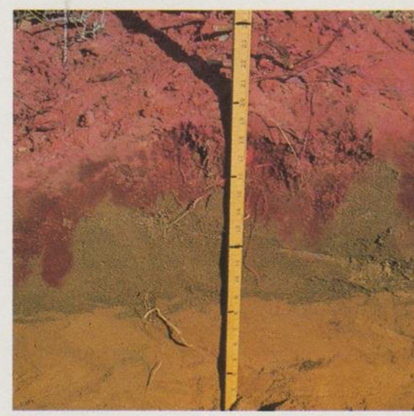
Cleaning up groundwater is a big, expensive job. At this site, contaminated groundwater will run through gravel-filled trenches, then be pumped out and treated.

The threat to groundwater from these toxic products is so grave that cleaning up spills, abandoned chemical dumps and sites where industrial chemicals have been improperly stored or disposed of has become a national priority. In Wisconsin, 32 sites have qualified for Superfund, a federal source of cleanup funds established in the 1970s. We rank 8th in the nation in Superfund sites; another 300 sites in the state are up for Superfund consideration.

Leaking underground storage tanks

People in the hazardous waste business call it LUST; for all of us, it spells trouble. Leaking underground storage tanks, most used to hold gasoline, diesel and fuel oil, are slowly corroding, releasing their contents into the soil and contaminating groundwater.

Thousands of Wisconsin's 140,000 underground tanks are leaking or have leaked in the past. More are found every year. Why? Many have exceeded their 20 to 30 year lifespan and have begun to rust as time and the elements take their toll. Even if a tank is carefully monitored, small leaks can go undetected for weeks, months or years, releasing thousands of gallons of liquid. It only takes a little gasoline in water to make it undrinkable; larger quantities seeping into wells or basements can cause explosions.



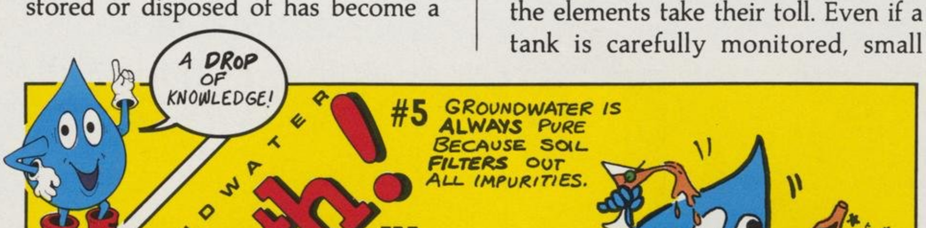
DNR PHOTO

Dye poured on the surface demonstrates how contaminants can move through soil to groundwater.

Sources of natural contamination

Minerals existing naturally in soils and rocks dissolve in groundwater, giving it a particular taste, odor, or color. Radium, radon gas, uranium, barium, fluoride, lead, zinc, iron, manganese and sulfur can be found at varying levels in Wisconsin wells.

The problem posed by most natural contaminants typically isn't one of safety, but aesthetics. High levels of iron in drinking water are found in



hundreds of places statewide. The iron stains plumbing fixtures and laundry, and gives drinking water an unpleasant taste and odor. Excess levels of fluorides, manganese, sulfur and lead are less common and more localized.

Natural contaminants lending a foul taste to drinking water may be confused with human-produced pollutants. Bacteria that digest iron, for instance, give off as a waste product a harmless slime that looks and smells like gasoline spilled on water.

Radium is present in some deep municipal wells in eastern Wisconsin; it's radioactive, and thus poses a risk for cancer. When levels exceed the drinking water standards set by the federal Safe Drinking Water Act, consumers are notified and advised to take precautions. Water softeners remove radium from water, but will increase sodium levels and the potential for leaching lead from solder into the water supply.

Radon, a naturally occuring radioactive gas, has been found in wells around Wisconsin. In many cases, the concentration of radon has been high enough to cause concern; the Environmental Protection Agency plans to set a standard for radon levels in water in 1990. Radon can easily be dispersed through aeration of water.

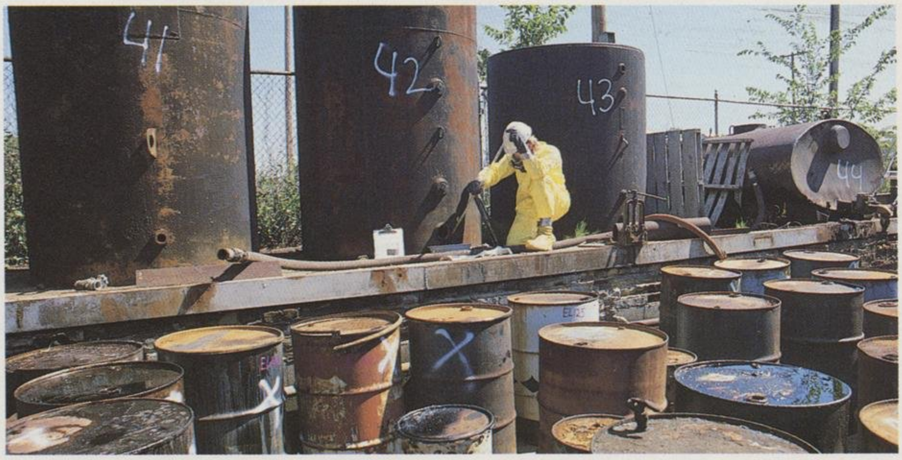
Groundwater cleanup

As you've read, groundwater contamination is often detected by a foul odor or taste in somebody's drinking water. An attempt is made to track down and stop the source of contamination and establish a new supply of drinking water if necessary.

It's usually impossible, however, to completely remove all traces of a groundwater contaminant and clean up the aquifer to a usable condition. The cost of even a partial groundwater cleanup can be enough to empty even the deepest of pockets.

One cleanup technique is to drill a recovery or extraction well. The contaminant seeps in with the groundwater, which is pumped out and treated. One well can cost thousands of dollars to drill; it may be necessary to drill scores of wells to handle a single site.

Another approach is to restrict use of the aquifer until natural dilution and organic processes purify the water — a slow method that may take years and prove unsuccessful if the site's hydrogeologic makeup is not thoroughly understood.



AL BROWN

Taking inventory of abandoned chemicals stored in leaky barrels at a bankrupt lubricant company in West Allis. Millions of dollars have been spent in Wisconsin in an attempt to clean up similar problems.

Who pays the bills for cleaning up groundwater? Who pays for repairing the facilities, drilling and casing deeper wells, extending municipal water lines and pumping out recovery wells? Who picks up the tab for bottled water and decreased property values resulting from contaminated groundwater? And who can put a price on the stress and worry engulfing families and communities whose once-reliable source of drinking water has been polluted?

Logically, the owner or operator of the contaminant source is the person who should pay for the cleanup. When a gasoline tank truck overturns, spill cleanup costs are paid by the owner. But in the case of abandoned dump sites, the original owners may be bankrupt, out of business, or dead. Pinpointing individual sources of sewage, pesticides, fertilizers and other widely-used or produced groundwater contaminants is a difficult, nearly impossible task. Who pays then?

You do — as a taxpayer and a consumer. Companies may charge higher prices for goods to cover pollution cleanup costs. Serious cases of groundwater pollution may be eligible for federal Superfund or LUST Fund money, which is supported mainly by taxes collected from producers of petroleum and chemicals. A portion of the taxes you pay also are earmarked for those funds.

Federal funds are used as enforcement funds, meaning that the owners, generators, transporters and operators involved with a contaminated site are subject to lawsuits to recover the cost of cleanup if they won't do it themselves. Funds from the federal programs enable the Department of Natural Resources to start site cleanups more quickly, before more damage is done; if the person or group responsible can pay, the money that's recouped can be used on other contaminated areas.

Not all Wisconsin sites are eligible for federal funds. That's why the Wisconsin Legislature created the Environmental Repair Fund (ERF), funded by your taxes and fees paid by industrial chemical users, producers and others. DNR staff use ERF to handle hazardous substance spills, pick up abandoned containers holding toxic products, investigate sites and undertake whatever monitoring and repairs are necessary. As of 1989, ERF has enabled the Department of Natural Resources to begin the cleanup process at 40 sites. ■

GROUNDWATER
Wisconsin's buried treasure

Protecting the resource

No doubt about it — it's easier and cheaper to prevent groundwater contamination than to clean up a polluted aquifer. Just as the threats to groundwater are many and varied, so are the methods used to protect groundwater. They range from tough laws to techniques you can use in your own home.

The GCC

When you think about all the diverse activities and events that can affect groundwater, it should come as no surprise that the responsibility for managing this buried treasure is delegated to many different government agencies. Cooperation is the key — and the Groundwater Coordinating Council (GCC) is the group turning that key.

Representatives from the departments of Natural Resources; Industry, Labor and Human Relations; Agriculture, Trade and Consumer Protection; Health and Social Services; Transportation; the University of Wisconsin; the Wisconsin Geological and Natural History Survey and the Governor's office serve on the council. Together, they've established a statewide management program to guide their groundwater protection efforts. The agencies distribute funds for groundwater research; set up groundwater monitoring programs; evaluate existing groundwater policies and

ROBERT QUEEN

programs and establish groundwater standards; exchange and catalog information related to groundwater; and seek to increase knowledge of the groundwater resource through public conferences, classes and educational materials.

Protecting groundwater is easy when you've got a PAL

In Wisconsin, you can't dispose of wastes by injecting them down a well. Septic systems may only be put in by licensed installers; the soil must be tested first to make sure the system will work and a county inspector must approve and permit the project. Rules like these protect the health of water users and the water itself; they are continually reviewed, expanded and strengthened.

To extend the scope of rules governing groundwater protection, Wisconsin's comprehensive Groundwater Standards Law was enacted in May, 1984. It applies to all groundwater in the state and must be used by all state agencies involved with the resource. State programs for landfills, hazardous wastes, spills, wastewater sludge, septic tanks, salt storage, fertilizer storage, pesticides and underground storage tanks must comply with the standards.

Under the law, two standards — an "enforcement standard" (ES) and a "preventive action limit" (PAL) — are established for every substance already detected in groundwater or with the potential to reach groundwater. The substances may have an effect on health, or may simply cause taste, odor, color or other "public welfare" problems. As of 1989, standards for 50 substances of health concern and 10 of welfare concern have been established. The Department of Health and Social Services recommends ESs and PALs for substances related to health concerns; the Department of Natural Resources develops standards for substances affecting public welfare.

ESs and PALs represent the concentration of a substance in groundwater. The PAL is either 10 percent, 20 percent or 50 percent of the ES, based on the effect the substance may have on health. Ten percent is used for cancer-causing substances, 20 percent for substances with other health effects and 50 percent for substances causing aesthetic or public welfare concerns.

For instance, the enforcement standard for perchloroethylene is 1.8 parts per billion (ppb); the preventive action limit is 0.18 ppb, or 10 percent of the ES. For nitrates the ES is 10 parts per million; the PAL is 2 ppm, or 20 percent of the ES. For iron, the ES is .3 ppm; the PAL is .15 ppm, or 50 percent of the ES.

The PAL serves two purposes. It's used to establish the codes for facility design (a landfill, for example) and set up rules for using certain products (such as pesticides) to prevent contamination right from the start.

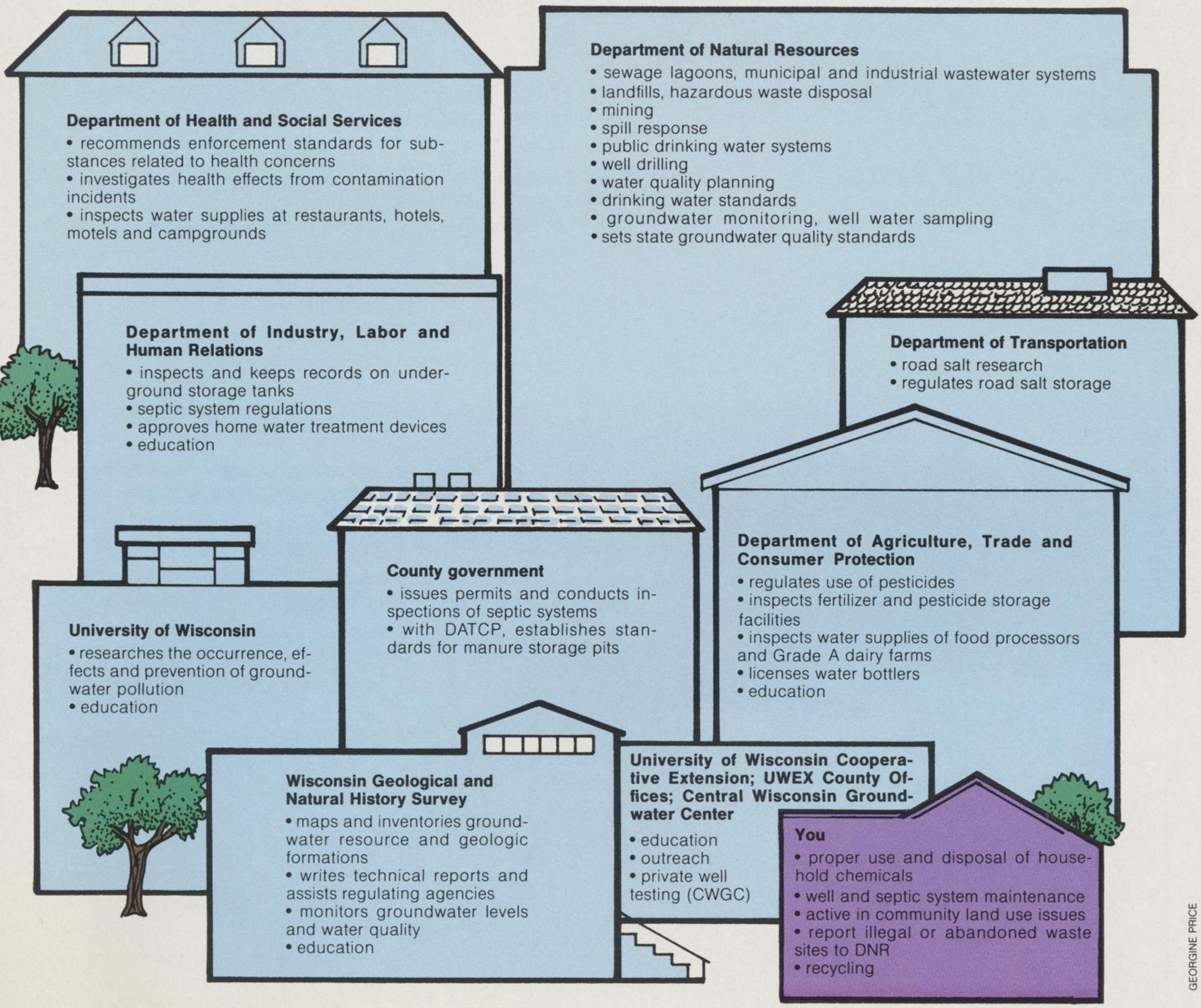
The second purpose of the PAL is to serve as an early-warning system. The red lights and buzzers go off to let state agencies know low levels of pollution are developing and that some action may be necessary to prevent those levels from increasing. PALs provide regulatory agencies with time to take preventive measures to ensure that the offending substance does not reach or exceed the enforcement standard.

If a substance has attained or exceeded its ES, the regulatory agency must stop the activity that's releasing the substance into the groundwater unless a way can be found to quickly bring the pollution level below the ES.

Committed to the resource

There's plenty of activity going on under the umbrella of the state

Who's in charge of groundwater protection?



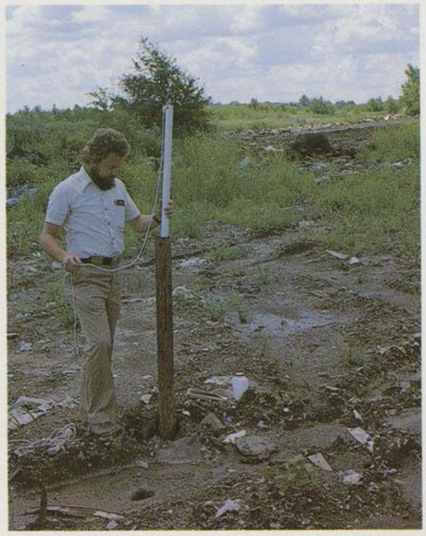
GEORGINE PRICE

groundwater program, as you'll discover in this section: The regulatory agencies involved are committed to protecting Wisconsin's buried treasure now and for the future.

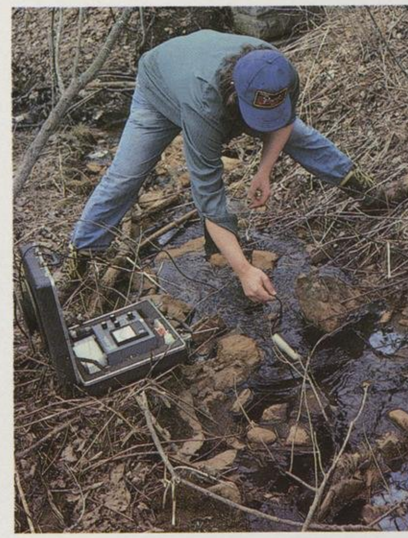
Department of Natural Resources

It's only natural that a resource like groundwater receives a lot of attention from the Department of Natural Resources. Everyday activities like solid waste specialists reviewing a site plan for a new landfill, wastewater technicians discussing water treatment options with a paper mill owner, foresters planting pine seedlings to rejuvenate an eroded slope, have an effect on the quality of Wisconsin's groundwater.

DNR people working in water resource management, wastewater, solid and hazardous waste, water supply and environmental repair take a special interest in groundwater protection. A large part of the work they do involves spying on groundwater from up above with the help of wells.



JIM ESCALANTE

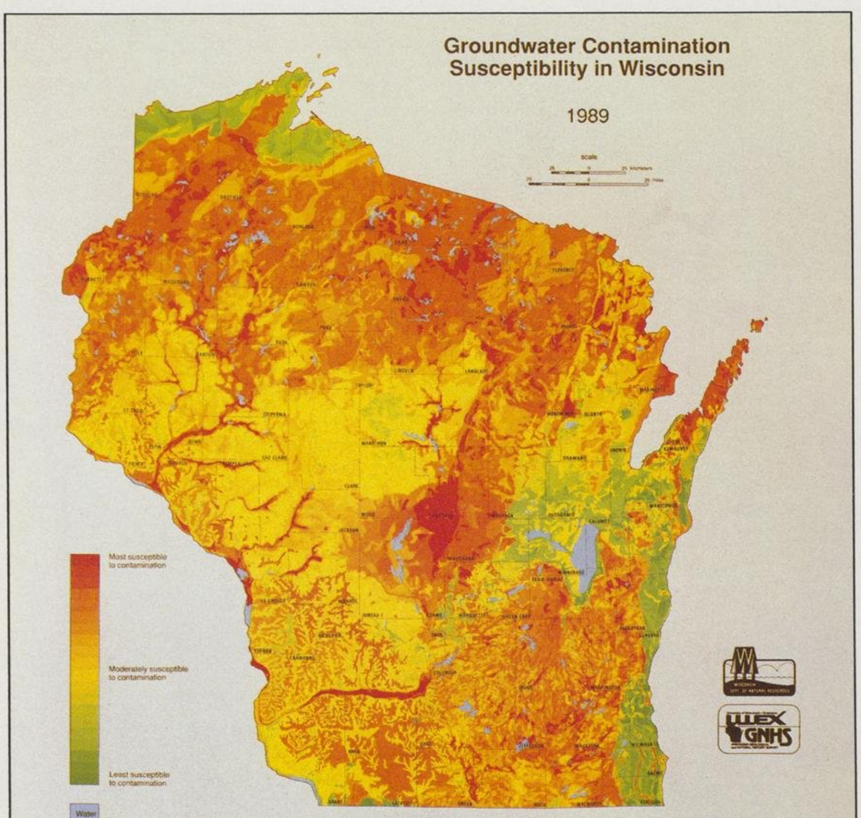


DNR PHOTO

DNR employees on groundwater duty: Collecting water samples from a monitoring well in a landfill (left); testing leachate for conductivity to determine the amount of dissolved solids (right).

Specially drilled monitoring wells are used to check on a particular problem; existing private or public wells are sampled regularly to gather information on the groundwater resource.

By periodically sampling wells scattered around the state, DNR staff collect valuable data on groundwater contamination used to establish or adjust PALs and ESs. Wells reveal what contaminants are in the groundwater and at what levels — important information that dictates what kind of action will be necessary to alleviate a contamination problem. Data from monitoring wells also can show if current groundwater protection practices are working or need to be changed. Plus, water levels in wells yield information on the movement of groundwater.



To relax after collecting gallons of groundwater data, DNR staff like to indulge in a nip of GIN: the Groundwater Information Network. GIN is a computerized system providing a standardized format for groundwater data, allowing DNR employees in wastewater, solid and hazardous waste, environmental repair, water supply and water resource programs to contribute groundwater monitoring and sampling information. With each new piece of knowledge, the hidden groundwater resource becomes a little more visible.

In conjunction with the Wisconsin Geological and Natural History Survey, the Department of Natural Resources published the Groundwater Susceptibility Map, a useful tool designed to prevent groundwater contamination from occurring or worsening. The map shows areas of the state that are more (and less) sensitive to contamination because of the materials overlying the groundwater. Soil characteristics, type of bedrock, depth to bedrock, depth to the water table and other data are incorporated into the map. By knowing the areas where groundwater is vulnerable, the state regulatory agencies can better plan groundwater protection activities and set priorities for action.

Wisconsin Geological and Natural History Survey

The Survey, the principal source for maps and records about Wisconsin's groundwater resources and related geology, supplies the state regulatory agencies with technical assistance and a wealth of information.

CENTRAL WISCONSIN GROUNDWATER CENTER

A technician decontaminates and rinses the bailer that will be inserted into a monitoring well to sample water for volatile organic chemicals in Wausau.

In addition to publishing the susceptibility map, the Wisconsin Geological and Natural History Survey has worked with the Department of Natural Resources to: locate the water table and map shallow aquifers using ground-penetrating radar, study the effects of drainage ditches on groundwater flow in central Wisconsin, and examine the movement of groundwater in fractured rock in Door County. WGNHS helped the Department of Agriculture, Trade and Consumer Protection by installing 45 monitoring wells for a recent pesticide study and assisted the Department of Industry, Labor and Human Relations in evaluating permit requirements for private sewage systems.

The Survey houses a collection of well cuttings and rock samples from around the state — "hard" evidence of what's hidden below the ground you walk on. County studies of geology and groundwater are produced by the survey for use by anyone interested in the hydrology of a specific area. Survey geologists and cartographers are mapping Wisconsin's bedrock and collecting data to present a clearer picture of the glacial geology of the state.

Department of Transportation

To keep Wisconsin from slipping on a wintertime source of groundwater pollution, the Department of Transportation has set standards for the storage of road salt. Storage sites must have an impermeable base with adequate drainage as well as an impermeable cover; a holding basin must be nearby to contain any runoff. All salt storage facilities are owned by county government; the DOT works side-by-side with county road crews to prevent stockpiled road salt from leaching in concentrated amounts into the groundwater.

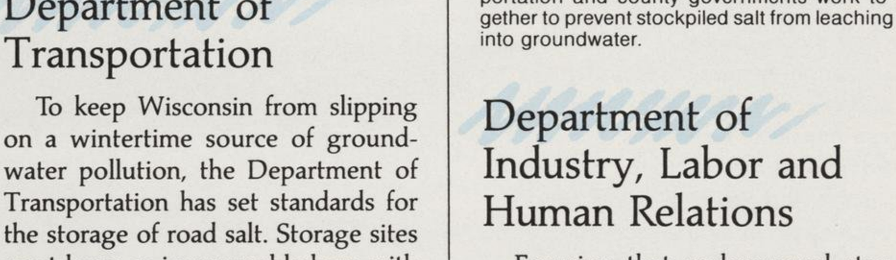
DEAN TVEDT

Uncovered mountains of salt are a thing of the past in Wisconsin. The Department of Transportation and county governments work together to prevent stockpiled salt from leaching into groundwater.

Department of Industry, Labor and Human Relations

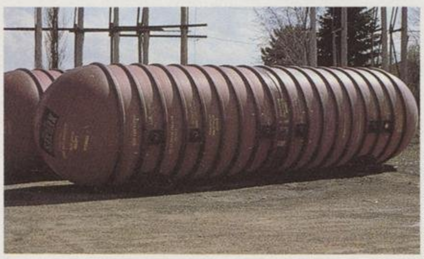
Ensuring that underground storage tanks of all kinds don't leak keeps staff at the Department of Industry, Labor and Human Relations busy. The agency keeps records on over 130,000 tanks used to store gasoline, fuel oil, pesticides and other products; some tanks are inspected regularly. More tanks are added to the inventory every week.

DILHR has an interest in another kind of tank — septic tanks. The



Jeanne Gomoll 89

agency writes and revises Wisconsin's plumbing code, an important part of which deals with private septic systems. With the help of county government officials, who are responsible for issuing septic tank permits and conducting regular inspections, DILHR keeps Wisconsin citizens healthy and Wisconsin's groundwater safe.



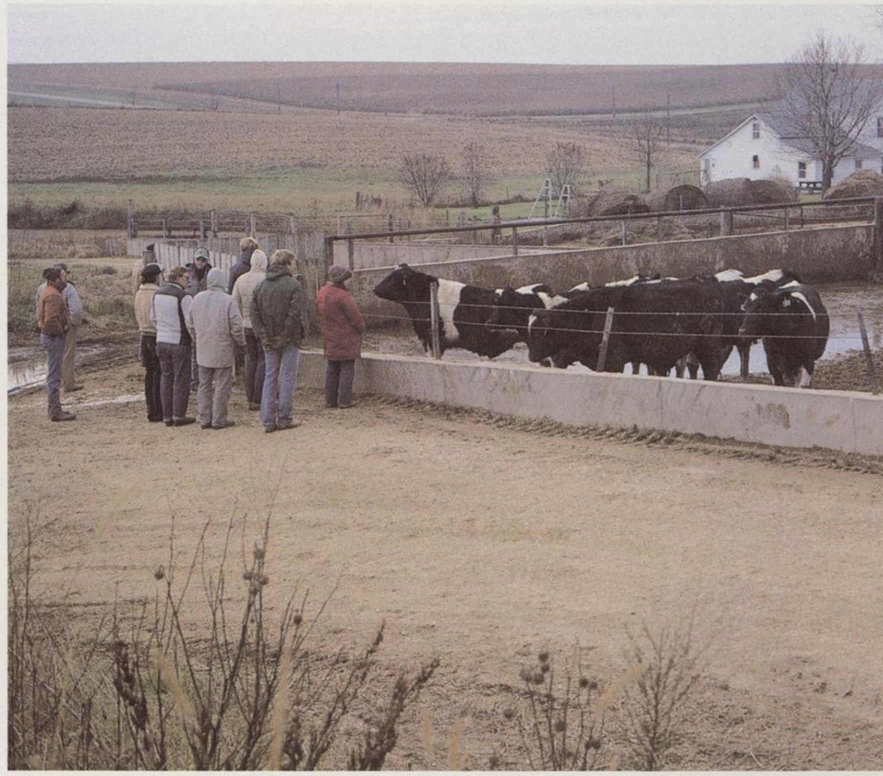
WENDY WOJNER

These spanking-new fiber glass underground fuel tanks were installed at the Janesville Oasis in 1988. The tanks will not rust and are less likely to leak than their old metal counterparts.

Department of Health and Social Services

Recommending ESs and PALs for substances in groundwater that can cause health problems is one way the Division of Health, Department of Health and Social Services works to protect groundwater and the people who drink it. Division of Health staff analyze data from toxicological (the harmful actions of substances on biological tissue) and epidemiological (the incidence and distribution of a disease within a given population) research to determine "how much is too much."

DHSS also inspects water supplies at restaurants, hotels, motels and campgrounds once every 12 to 18 months to ensure that they comply with safe drinking water standards.



SUSAN BERGQUIST

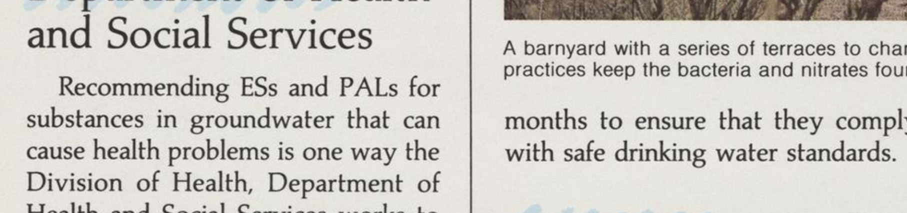
A barnyard with a series of terraces to channel animal wastes for proper storage. Sensible farm practices keep the bacteria and nitrates found in manure out of groundwater.

Department of Agriculture, Trade and Consumer Protection; University of Wisconsin-Extension

Agriculture depends on clean groundwater. To guard Wisconsin's buried treasure, the Department of Agriculture, Trade and Consumer Protection regulates the bulk storage of fertilizer and pesticides and conducts frequent inspections of storage facilities. DATCP works with county governments to establish standards for manure storage pits. Food processors and dairies come under close scrutiny from this department; they are inspected regularly for water purity and proper waste disposal methods.

Groundwater monitoring is a continuing process at DATCP; identifying the effects on groundwater from normal field application of fertilizers and pesticides is of particular interest.

To keep nutrients and pesticides out of groundwater, DATCP developed a technical bulletin entitled "Best Management Practices for Wisconsin Farms" with the help of the University of Wisconsin-Extension. This important bulletin offers recommendations to farmers on how and when to apply pesticides, nitrogen fertilizers and manure for maximum results with a minimum of groundwater contamination. Crop rotation, crop selection, scouting for weeds and pests and other non-polluting



DNR PHOTO

Students get a tour of a state-of-the-art landfill that is sealed and has a leachate collection system to keep contaminants out of groundwater.

farm management techniques are included in the text.

The UW-Extension works at the county and state level, offering lectures, demonstrations and seminars on groundwater protection to the people of Wisconsin.

Wisconsin's institutions of education

In the long run, education is the most important tool we can use to safeguard groundwater, a fact recognized by the University of Wisconsin and other schools and colleges. Through traditional and interdisciplinary coursework, students absorb the background necessary to pursue careers in research, hydrogeology, wastewater management, soil science and other disciplines vital to groundwater protection. Environmentally safe methods of farming can be explored in UW agricultural "short courses" and classes on sustainable agriculture.

Groundwater education doesn't stop at Wisconsin's schools. People from all the agencies participating in the groundwater management plan know their jobs are only half done if you don't know what they've been doing. They also know that groundwater is too big and too important a resource to be handled alone. They need your help.

That's why they attend town meetings to talk about local groundwater issues. That's why you'll find groundwater exhibits at fairs and farm progress days. That's why there are "Clean Sweep" toxic waste collection days, and brush-up classes for county soil inspectors, and booklets on how to take care of private septic systems and wells.

If you've got any questions, just ask!

Research: A closer look at groundwater

Getting a good idea of what's going on underground isn't easy when you're stuck up above — that's why research is crucial to groundwater protection. The collected facts and figures now available paint only a partial portrait of the groundwater resource; it's difficult to make important decisions about groundwater use with limited knowledge. As new information from surveys, tests and experiments filters in, the picture becomes more complete.

State agencies involved with groundwater protection are conducting two kinds of research. *Basic research* seeks to define the distribu-

KEN BRADBURY

Wells are the "eyes" of groundwater researchers. Mike Lembcke of the Wisconsin Geological and Natural History Survey pierces the soil with a drilling rig; the new well will reveal another drop of knowledge about groundwater.

tion, movement and chemistry of Wisconsin's groundwater. *Applied research,* which relies on a strong foundation of basic groundwater knowledge, is directed toward solving specific problems and developing or improving methods, products and materials used in groundwater management.

The broad category of "contaminant transport" — how pollutants move and change in groundwater — has been the agencies' top priority for basic research in recent years. Understanding how contaminants move around underground and how they may be altered by minerals and organisms in the soil and groundwater will aid future cleanup efforts.

Researchers are especially curious about the vadose zone, the area of soil and rock just above the water table. Most all contaminants must move through the soil to reach groundwater; the chemical and physical processes occurring in the vadose zone determine which pollutants will leach through. As our knowledge of the vadose zone increases, we'll be able to improve groundwater protection techniques.

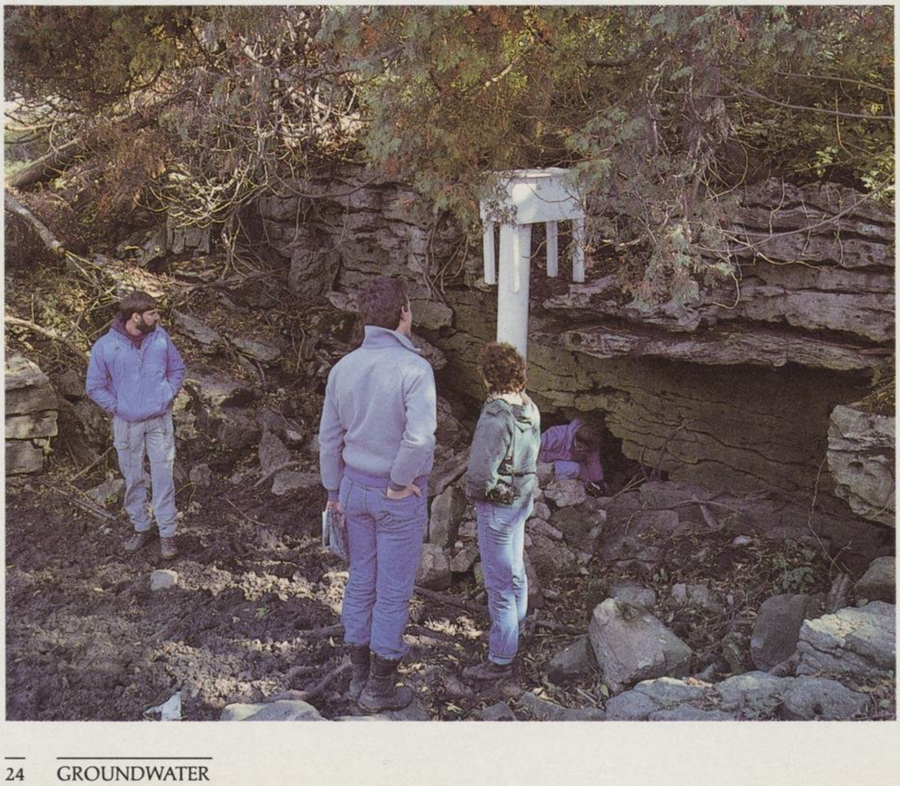
The University of Wisconsin plays a lead role in organizing and conducting groundwater research. UW soil scientists are studying the movement of nitrates, Wisconsin's most common groundwater pollutant, in the vadose and saturated zones. The transport of volatile organic chemicals (VOCs), which can have both short- and long-term health effects, is challenging staff at the UW and the departments of Natural Resources and Health and Social Services. Researchers at the Department of Agriculture, Trade and Consumer Protection and the UW are tracking the paths of aldicarb and other pesticides found in Wisconsin groundwater.

The information gleaned from basic research will help the Department of Natural Resources design better techniques for treating contaminated groundwater. The research also can be applied to the design, construction and operation of safer landfills; the development of regulations to govern the proper use and storage of pesticides; better measures to handle hazardous waste spills; and other methods to reduce or stop pollution at the source.

The Department of Agriculture, Trade and Consumer Protection wants to know if chemical residues are leaching into groundwater in nonirrigated areas at rates similar to irrigated areas. DATCP is investigating high-capacity irrigation wells to see if the wells are capable of changing groundwater flow and drawing contaminants down into lower zones of the aquifer.

Department of Industry, Labor and Human Relations researchers are examining the changes in groundwater quality and quantity under seepage beds of large wastewater disposal systems; the effects on groundwater from the use of perforated pipe for storm sewer drainage; and better methods of purifying home drinking water.

A barnyard drains into this crevice in Door County's limestone bedrock. Monitoring wells have been installed to document changes in water quality from improvements in animal waste management practices on the farm.



AL LULLOFF

The biggest challenge facing the Department of Health and Social Services is determining the health effects of single and multiple contaminants in drinking water. Studies at DHSS focus on how atrazine and alachlor, two common pesticides, change or break down in groundwater and the effects the pesticides and their breakdown products have on human health.

The Wisconsin Geological and Natural History Survey conducts research on groundwater recharge processes in Wisconsin, soil characteristics that govern infiltration and recharge, the hydrogeology of glacial materials, and the flow of water in fractured crystalline rock aquifers and other geologic formations.

The Survey also is investigating the value of wellhead protection, a groundwater protection method that has been used successfully in Europe for years and is gaining popularity in the U.S. The method consists of restricting activities that have the potential to contaminate groundwater from areas near wells, well fields, and the recharge areas of the aquifers supplying water to the wells. The wellhead protection study will be conducted in two areas: over a fractured dolomite aquifer in Door County, where the focus will be on wellhead protection for farmers and rural homeowners, and over a fractured crystalline rock aquifer in Portage County, for a small community receiving groundwater from a single municipal well.

If you care about groundwater, but also like highways that are in "good winter driving condition" you'll be glad to know that the Department of Transporation is conducting research on de-icers to replace the sodium and calcium chlorides usually used on Wisconsin roads. Calcium magnesium acetate, a noncorrosive chemical manufactured from limestone and a mild acid, is one candidate that's been tested with good results.

How to protect the groundwater you drink and use

You've read about what government and industry are doing to guard groundwater. Now, it's your turn.

Examine your own habits. Everyday activities can affect groundwater quality. Think about the ways you use water at home. If you've always considered pure, clean water to be a cheap, unlimited resource, chances are you're accustomed to wasting water and haven't been concerned about what you pour down the drain.

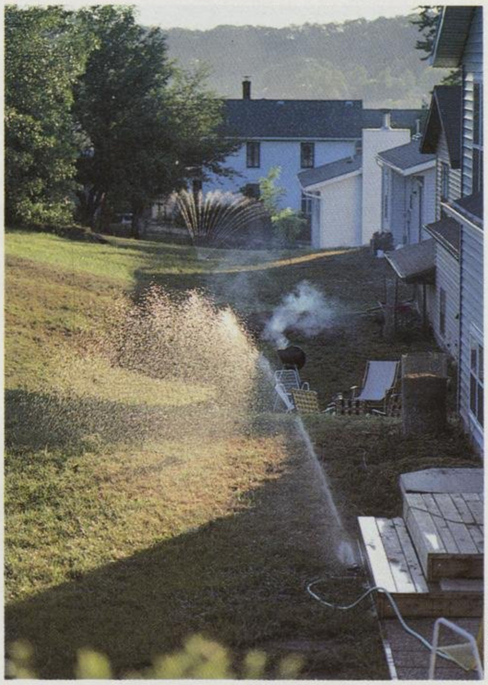
A little common sense will go a long way toward keeping Wisconsin's groundwater clean. Here are some ways to cut back on water use and protect groundwater:

1. *Household toxic wastes.* Don't use household drains as ashtrays, wastebaskets or garbage disposals! Toilets (and kitchen sinks, garage drains and basement washtubs) are not the places to discard old varnish, paint stripper, fats, oil, antifreeze, leftover crabgrass killer or any other household chemicals. Just because it's down the drain doesn't mean it's gone! These products may end up in your water supply, especially if you have a private septic system. Store your toxic products in tightly sealed containers in a safe, dry spot, share them with others who can use them, or bring them to the annual Clean Sweep event in your community (call your DNR district office for details.)

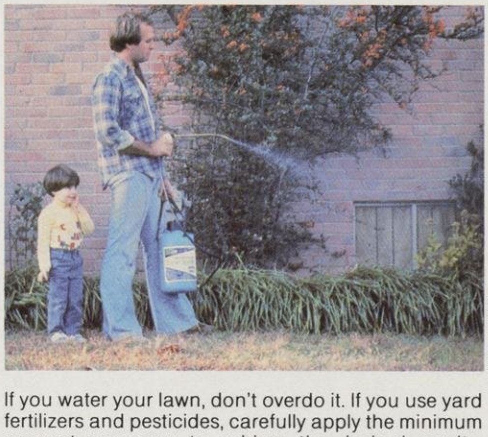
2. *Lawns.* Reduce or eliminate the use of lawn pesticides and fertilizers. Depending on your soil type, a significant amount of these chemicals can reach groundwater.

Water your lawn slowly, thoroughly and as infrequently as possible. Excess water can leach lawn chemicals into the groundwater. Water at night to minimize evaporation and help reduce high demands on water supplies during the day. Consider reducing the size of your lawn by adding trees, shrubs and ground covers.

3. *Recycle!* Reuse or recycle plastic bags and containers, aluminum cans, tin cans, glass, cardboard, newspaper, paper bags and other paper products. Don't dump waste oil down the drain or on the ground — bring it to community collection tanks where it will be picked up and reprocessed. Recycling conserves landfill space. Less garbage in the landfill means less harmful leachate that could contaminate groundwater.



ROBERT QUEEN

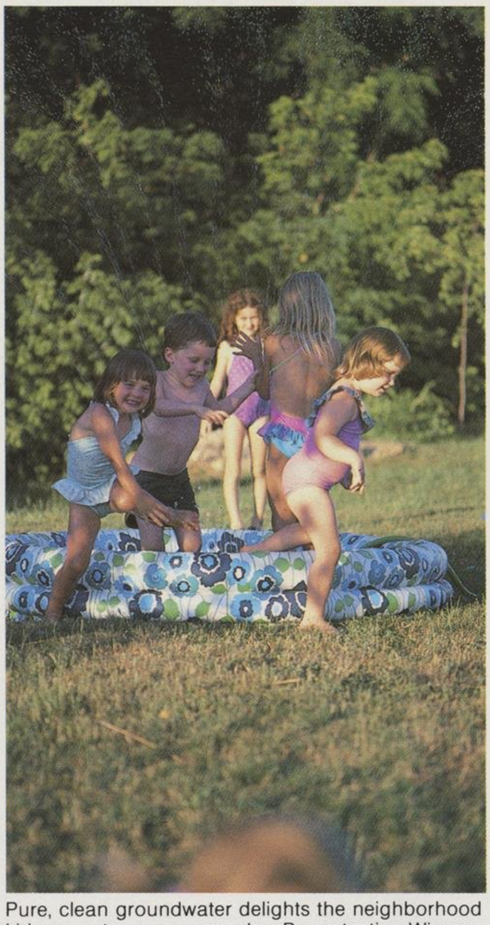


DNR PHOTO

If you water your lawn, don't overdo it. If you use yard fertilizers and pesticides, carefully apply the minimum amount necessary to achieve the desired results. Overwatering or heavy rains can leach lawn chemicals into groundwater.

DAN WILSON

These household products contain volatile organic chemicals. Follow label directions for use and if there are leftovers, dispose of them properly -- not down the drain or with the garbage, but at a Clean Sweep collection day.



ROBERT QUEEN

Pure, clean groundwater delights the neighborhood kids on a steamy summer day. By protecting Wisconsin's buried treasure today we can ensure its quality for future generations.

4. *Biodegradable soaps and cleansers.* Go easy on groundwater! Use soaps and household cleansers that are nontoxic and biodegradable. Or try these environmentally friendly alternatives: Baking soda on a damp cloth to scrub sinks, appliances and toilet bowls; a mixture of white vinegar and water for cleaning ceramic tile floors, windows and other glass surfaces; pure soap flakes and borax for washing clothes.

5. *Look for and fix leaks.* A dripping faucet can waste 20 or more gallons of water a day; a leaking toilet, several thousand gallons a year. An inexpensive washer is usually all you need to fix a leaky faucet. Toilet leaks can often be stopped by adjusting or replacing the inexpensive float arm or plungerball.

6. *Bathing and showering.* Turn off the water while soaping up during a shower to save extra gallons. Bathers should put the stopper in the drain before running the water, then mix cold and hot for the right temperature.

7. *Dishwashing.* Use the minimum amount of detergent needed to clean plates, glasses and silverware satisfactorily. If you wash dishes by hand, don't leave the water running while rinsing them.

Rinse dishes before stacking them in an automatic dishwasher. Make sure the dishwasher is full before you turn it on; it takes as much water and energy to wash a half-load as it does to wash a full load.

8. *Automatic washing machine.* Always set the fill level to match the size load you are washing. Remember: Full loads save water because fewer loads are necessary.

9. *Garbage disposals.* They're noisy, use a lot of water and electricity, and increase the amount of waste in the water going to the wastewater plant or septic system. Dispose of scraps in garbage cans. Better yet, compost your kitchen waste and use it as a mulch around yard plants to keep moisture in the soil.

10. *Use water-saving devices and appliances.* Toilet dams or inserts placed in the toilet tank retain water during flushing and can save up to three gallons per flush. A plastic bottle weighted with washed pebbles makes a good insert.

— a water-saving shower head can cut the amount of water used to about three gallons per minute without sacrificing the feeling of a good drenching.

— low-flow faucet aerators mix water with air and reduce the amount of water flowing from your sinks. Aerators are designed for either inside or outside threaded faucets, and use about 40% less water than a standard aerator.

Take care of your septic system. Even permitted and properly constructed septic systems can fail if the soil is highly permeable or the water table is close to the surface. Nature notwithstanding, you can keep a septic system in good working order by following these tips:

1. *Have your septic tank inspected once a year* to find out the level of scum and sludge that has built up; the tank should be pumped when the sludge and scum occupy one-third of the tank's liquid capacity. NEVER go into a septic tank — it may be full of toxic gases.

2. *Hire only licensed septic tank pumpers to clean out your tank.* They should pump through the manhole and inspect inlet and outlet baffles for any damage. County sanitarians will have the names of reliable septage haulers in your area.

3. *There are no known chemicals, yeasts, bacterial preparations, enzymes or other additives for septic tanks that will eliminate the need for periodic cleaning.*

4. *Be cautious about what you put in your septic system.* Ordinary amounts of bleaches, lyes, soaps, detergents and drain cleaners will not harm the system, but household chemicals like paint thinner, solvents, gasoline, oil and pesticides should NEVER be drained into a septic system. Once released in the absorption field, these toxic products can leach into groundwater and into your water supply.

5. *Never flush bones, coffee grounds, disposable diapers, sanitary napkins, cigarette butts or other materials that do not break down easily into a septic tank.*

6. *Avoid dumping grease down the drain.* It can build up in the tank and clog the inlet or the soil absorption field.

Properly locate and construct wells. Wells can be a safe, dependable source of water if sited wisely and built correctly.

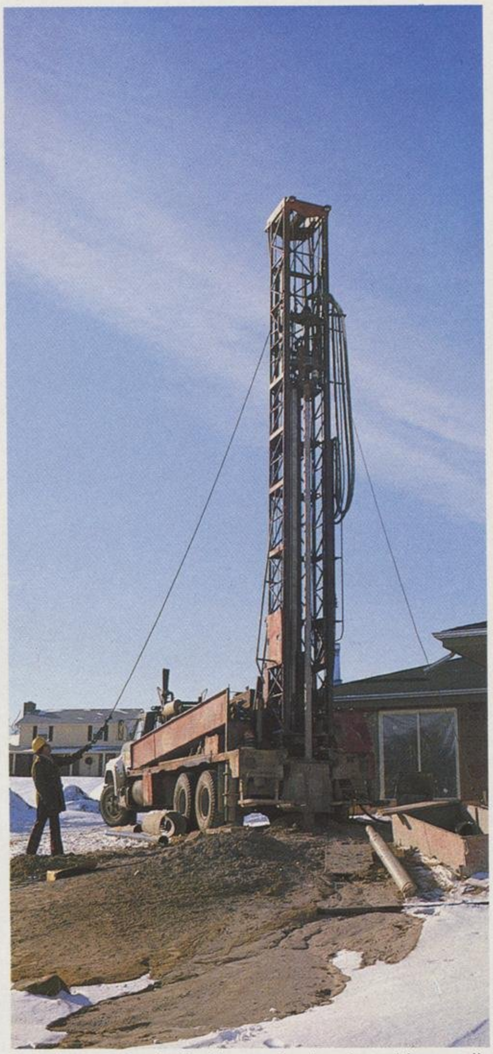
1. *Ask questions if you plan to drill a new well or intend to purchase property with an existing well.* Talk to your neighbors: Do they have any problems with their wells? How deep are wells in the area? Were there ever any contaminated wells in the area? How was the contamination taken care of? How was the land where you want to drill the well used in the past?

Talk to local government officials: What are the local laws governing private water supplies? Are housing densities low enough to ensure enough water for everyone's needs? Are there zoning restrictions limiting certain types of land use? What current land and water uses — irrigation, a quarry — in the area might affect your water quality or quantity?

2. *Consult the Wisconsin well code.* Established in 1936, the Wisconsin well code is administered by the Department of Natural Resources, which sets standards for well construction. The code lists the distances required between the well and septic tanks, sewage drainfields or dry wells, sewer lines, farm feedlots, animal yards, manure pits, buried fuel tanks, fertilizer and pesticide storage sites, lakes, streams, sludge disposal and other potential sources of contamination. Wells should always be located up the groundwater gradient and as far from these potential sources of contamination as possible.

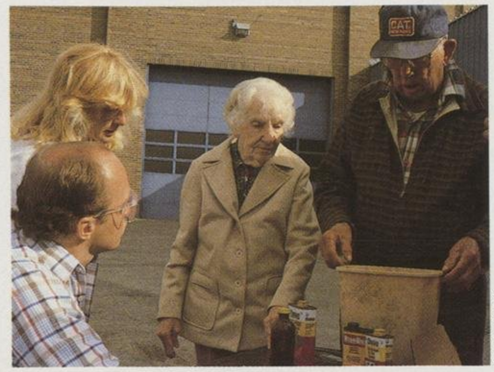
3. *Hire reputable, experienced, licensed installers.* Wells should be drilled only by people registered with the Department of Natural Resources and holding current well driller permits. Pumps may be installed only by people holding DNR pump installer permits. No license is required if you construct your own well or install your own pump. However, state law requires that the work be done according to the state well code.

The well driller is responsibile for flushing the well, test pumping it, disinfecting it, collecting a water sample for bacteriological tests, sending a well constructor's report to the Department of Natural Resources and



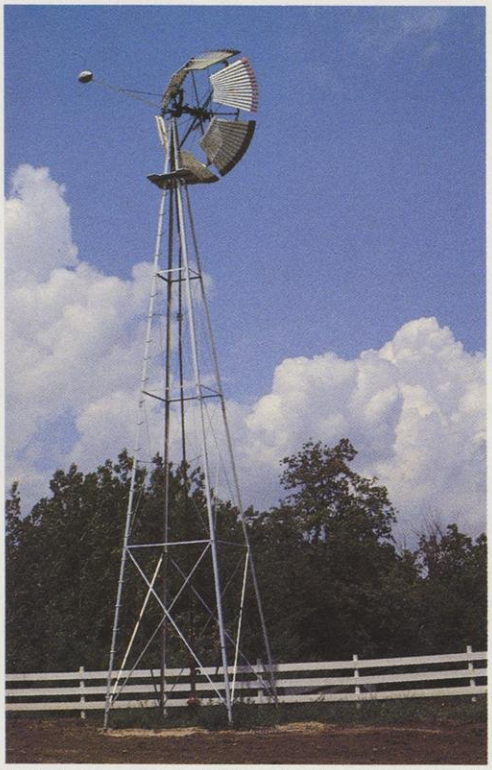
DEAN TVEDT

A safe supply of drinking water begins with a well-built well.



DNR PHOTO

Encourage your local officials to sponsor Clean Sweep programs to collect and dispose of household hazardous wastes in your community.



ANNE SHORT

A picturesque hazard. Old wells allow contaminants to seep into groundwater; fill them in before problems begin.

DNR PHOTO

Attend meetings and hearings on land use and waste disposal issues affecting groundwater where you live.

providing the owner with a copy. This document contains a record of the soil and rock layers penetrated by the well and lists the work performed and materials used — important information to have on hand if your well is ever found to be contaminated. Reports collected over a period of time in one area can give researchers an idea of what's going on underground in a particular place.

A pump installer, if different from the driller, must disinfect the well and collect a water sample to check for bacteria.

4. *How often should I have my well tested?* Have your well tested for bacteria and nitrates annually, and at any other time if a change in odor, taste, color or clarity causes you to suspect contamination. Check for nitrates when infants use the water. (See side story, "How safe is my drinking water?")

5. *How do I fill in an old, unused well?* Fill and seal unused wells with concrete or bentonite, a type of clay. Your DNR district water supply staff, county sanitarian or local well driller can show you how to close off the old well to prevent groundwater pollution.

For copies of "You and Your Well" and "Rural Property: Protecting Your Investment and Wisconsin's Environment," write DNR Bureau of Information and Education, Box 7921, Madison, WI 53707.

Report illegal or abandoned waste sites or incidents of improper waste disposal. Your DNR water supply specialist relies on you to be the lookout for potential groundwater pollution. Don't hesitate to call DNR environmental response and repair staff if you see someone dumping waste illegally or find an old dump site with rusting, leaky barrels.

Get involved in groundwater management. Wisconsin has a good system of public hearings and reviews where you can express your opinions and learn more about local and statewide groundwater issues. Call DNR Dialog at (608) 267-7787 for a taped schedule of hearings.

Keep up with local land use and waste disposal issues. Increased housing density, commercial development, highway construction, landfills and other signs of modern progress may have an adverse effect on groundwater quality if not carefully planned and constructed. City, town or county governments may need to institute zoning regulations or prohibit or restrict activities that could endanger groundwater. Find out what the land-use issues are in your community and stay informed; encourage your neighbors to do the same. Attend community meetings and let your elected officials and utility operators know that provisions to protect groundwater must be the first step in any local land use or waste disposal proposal.

Jeanne Gomoll '89

Who can answer my questions about groundwater?

There are people all over the state who want to help you understand Wisconsin's buried groundwater treasure.

DNR PHOTO

1. **DNR water supply specialists** at the six district offices can tell you more about the Wisconsin Well Code, show you how to disinfect your well, explain sources of contamination, sample wells, give advice on drinking water problems and the proper disposal of toxic household products.

Southern District
3911 Fish Hatchery Rd.
Fitchburg, WI 53711
(608) 275-3266

Southeast District
2300 N. Dr. Martin Luther King, Jr. Dr.
Milwaukee, WI 53212
(414) 562-9500

Lake Michigan District
1125 N. Military Ave.
Green Bay, WI 54307
(414) 497-4040

Western District
1300 Clairemont Ave.
Eau Claire, WI 54702
(715) 839-3700

North Central District
107 Sutliff Ave.
Rhinelander, WI 54501
(715) 362-7616

Northwest District
Highway 70 West, Box 309
Spooner, WI 54801
(715) 635-2101

2. **The Wisconsin Geological and Natural History Survey** has maps and other information on aquifers and rock strata. For a list of WGNHS publications, write: Wisconsin Geological and Natural History Survey, 3817 Mineral Point Road, Madison, WI 53705.

3. **Your county University of Wisconsin-Extension office** can help plan safe, functional farmyards and rural homesites. Call or write your extension office for booklets on safe drinking water, groundwater protection, best management practices for pesticide and fertilizer use and other topics. Look for the address and phone number under the county listing in the phone book white pages.

4. **The Department of Industry, Labor and Human Relations** has the details on proper septic system operation. Write DILHR, Office of Division Codes & Applications, P.O. Box 7969, Madison, WI 53707 and ask for publication SBD-7009, "Is the grass greener over your septic system?"

5. **The Department of Agriculture, Trade and Consumer Protection** offers information on best management practices for farms. Write DATCP, 801 W. Badger Rd., Madison, WI 53708.

6. **The Central Wisconsin Groundwater Center** is a clearinghouse for information on groundwater issues in Wisconsin's Central Sands area. The Center tests private wells, maintains a data base of private wells in the area and offers educational materials. Write CWGC, Room 010, Student Services Center, University of Wisconsin-Stevens Point, Stevens Point, WI 54481.

How safe is my drinking water?

ROBERT QUEEN

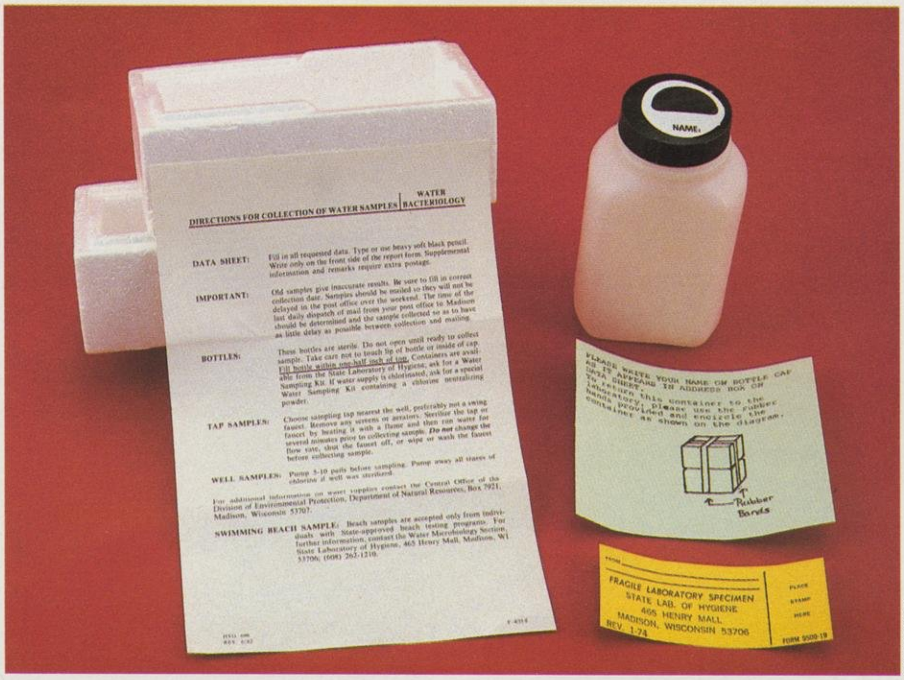
Nothing can quench our thirst for pure, safe drinking water.

Many Wisconsinites, urban and rural, are concerned about the quality of the water they drink, with good reason. As you've read in the preceding pages, threats to a pure water supply exist everywhere, the result of our daily activities. How do you know if your water is safe to drink?

If your water is supplied by a community water system, you can call your water system manager or DNR public water supply specialist and ask if the water quality meets state drinking water standards. Systems are required by law to keep data going back at least five years on bacterial counts, and 10 years for levels of organic and inorganic compounds and other water contaminants. System owners collect bacteria samples monthly and the Department of Natural Resources checks chemical and radiological quality every three to five years to ensure compliance with clean drinking water standards. When standards are exceeded, the system owner is required to give public notice to water consumers.

If you use a private well, the State Laboratory of Hygiene will test your drinking water for bacteria, nitrate or fluoride. The 1989 price is $7 for each test. The bacteria, nitrate and fluoride tests can be made from the same sample bottle of water. For a test kit, call the lab at (608) 262-1293 or write the State Laboratory of Hygiene, 456 Henry Mall, Madison, WI 53706. Private labs will also do these tests.

If you have reason to believe that your water has been contaminated by chemicals, contact your DNR private water supply specialist to investigate. Tests for chemical contaminants, such as volatile organic compounds or pesticides, must be done by private laboratories. Check the yellow pages under "laboratories" or "water analysis" or ask your DNR private water supply specialist for the phone number of a certified lab in your area.



DNR PHOTO

If you have a well, you should periodically collect a water sample and have it tested at a certified lab for bacteria and nitrates. Test kits with instructions are available for a small fee.

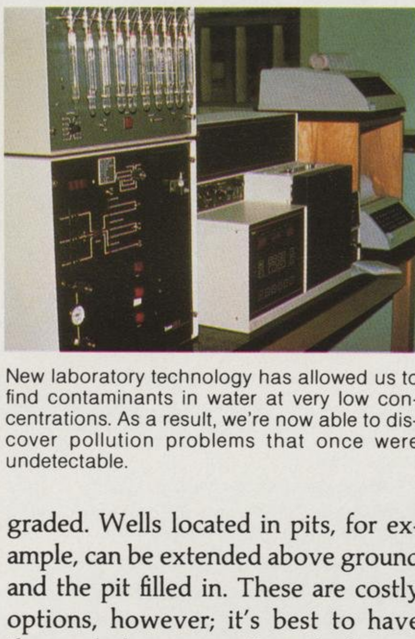
The cost will range from $30 to $1,000, depending on the number and type of chemicals analyzed and the lab's test methods.

If bacterial contamination has occurred, check for flooded well pits, broken seals, improperly abandoned wells in the area, especially old dug wells, quarries, any physical changes to the surrounding area, such as housing developments or landfills, or spills or dumping of wastes.

Wells can be disinfected by displacing all the water in the well with a mixture of bleach (containing at least 5 percent chlorine) and water or by dropping chlorine tablets or powder down the well. Constant chlorination is prohibited; the well must be replaced or reconstructed instead. (Write DNR Bureau of Water Supply, P.O. Box 7921, Madison, WI 53707 for literature on private well operation.)

If high nitrates are the problem, the well construction and location should be checked. Use bottled water or water low in nitrates for infants under six months old.

Wells can sometimes be deepened to get past the contamination. Inadequate well installations may be upgraded. Wells located in pits, for example, can be extended above ground and the pit filled in. These are costly options, however; it's best to have the work done properly in the beginning to avoid problems later. Your DNR private water supply specialist can give you advice on obtaining a safe drinking water supply.



DNR PHOTO

New laboratory technology has allowed us to find contaminants in water at very low concentrations. As a result, we're now able to discover pollution problems that once were undetectable.

If your water utility or a lab test alerts you to the presence of high levels of chemicals in your drinking water, you may be advised to drink bottled water or drill a new well. But what about low levels of contaminants? Will small quantities of benzene, a major component of gasoline, or perchloroethylene (PCE), a chemical used in dry-cleaning solvents, make your water undrinkable?

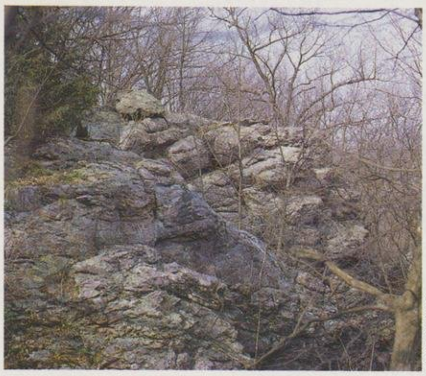
The answer is no. That's not to say, however, that the water is totally safe to drink. For instance, the Environmental Protection Agency estimates that one part per billion of PCE in drinking water could lead to one or two additional cases of cancer in a population of one million people who drink such water over a 70-year lifetime.

Contamination of drinking water, even at very low levels, should not be taken lightly, nor should the risks be exaggerated. To keep the risk of contamination as low as possible, public agencies and private citizens must continue to make tough decisions on what's worth the risk and what's not.

GROUNDWATER
Wisconsin's buried treasure

Groundwater glossary

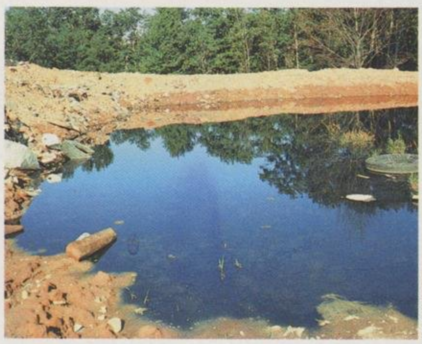
Aquifer: A rock or soil layer capable of storing, transmitting and yielding water to wells.
Artesian: A condition referring to groundwater under sufficient pressure to rise above the aquifer containing it. Sometimes it produces flow at the surface.
Coliform bacteria: A group of bacteria found in animal feces or sewage whose presence in well water may indicate contamination carried by surface water to groundwater. Water containing high levels of coliform bacteria should not be consumed.
Dolomite: Calcium magnesium carbonate, a common rock-forming mineral. Many rocks in Wisconsin generally referred to as limestone are actually dolomite.
Aesthetic contaminant: A substance that gives water an objectionable appearance, taste or odor, but which does not by itself present a threat to health.
Evaporation: The process by which water is changed from a liquid or solid into vapor.
Evapotranspiration: Water returned to the atmosphere by evaporation from water and land surfaces, and by the activity of living plants.


DNR PHOTO

Geology: The science dealing with the origin, history, materials and structure of the earth, together with the forces and processes operating to produce change within the earth and on its surface.
Glacial drift: Sediment transported or deposited by glaciers or the water melting from a glacier.
Groundwater: Water beneath the surface of the ground in a saturated zone.
Hardness: Dissolved calcium and magnesium salts in water. Compounds of these two elements are responsible for most scaling in pipes and water heaters. Hardness is usually reported in milligrams per liter (mg/l). Zero to 60 mg/l is soft, 61 to 120 mg/l is moderately hard, 121 to 180 mg/l is hard and more than 180 mg/l is very hard water. For household water softening, hardness is usually expressed as grains per gallon.
Hydrogeology: The study of groundwater and its relationship to the geologic environment.


ALLEN F. HILLERY

Hydrologic cycle: The complete cycle through which water passes from the atmosphere to the earth and back to the atmosphere.
Hydrology: The science encompassing the behavior of water as it occurs in the atmosphere, on the land surface and underground.
Impermeable: Having a texture that does not permit water to move through quickly.
Infiltration: The movement of water into and through a soil.

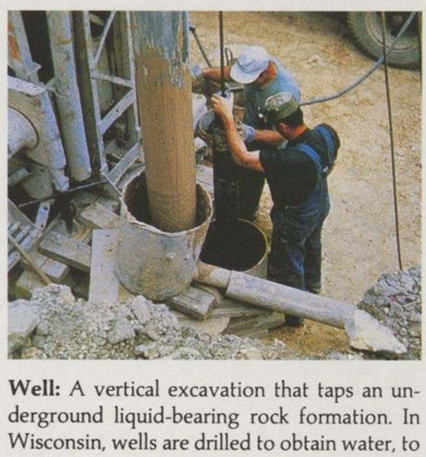

DNR PHOTO

Leachate: A liquid formed by water percolating through soluble waste material. Leachate from a landfill has a high content of organic substances and dissolved minerals.
Limestone: A sedimentary rock consisting chiefly of the mineral calcite (calcium carbonate).
Oxidize: To combine with oxygen.
Permeability: The capacity of rock or soil to transmit a fluid, usually water.
pH value: A measure of alkalinity or acidity. The pH scale runs from 0 to 14, 7.0 being the neutral point. Numbers below 7.0 indicate acidity; numbers above 7.0 indicate alkalinity.
Potable: Fit to drink.
Risk assessment: Estimating the degree of harm people will face if exposed to a particular level or quantity of a substance.
Risk management: Balancing the physical, economic, social and political costs of reducing or eliminating a hazard to human health and the environment.
Runoff: Precipitation not absorbed by the soil.
Saturated zone: That part of a water-bearing layer of rock or soil in which all spaces, large or small, are filled with water.

Septic tank: A sewage settling tank in which organic solids are separated from wastewater flowing through the tank. The solids in the settled sludge on the bottom of the tanks are decomposed by bacterial action and the overflowing wastewater is dispersed into the soil through a drainage field.
Sludge: Sediment remaining after wastewater has been treated.


ROBERT KELLER

Spring: Natural discharge of groundwater at the surface.
Vadose zone: The area of soil and rock just above the water table.
VOC: Volatile organic chemicals. Commonly-used chemicals that evaporate rapidly when exposed to air but remain suspended in water. VOCs are found in fuels, grease removers, solvents, polishes, dry cleaning solutions and other products.
Water table: The level below which the soil or rock is saturated with water, sometimes referred to as the upper surface of the saturated zone.


DNR PHOTO

Well: A vertical excavation that taps an underground liquid-bearing rock formation. In Wisconsin, wells are drilled to obtain water, to monitor the quality of groundwater or to determine the depth of the water table.