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WISCONSIN NATURAL RESOURCES

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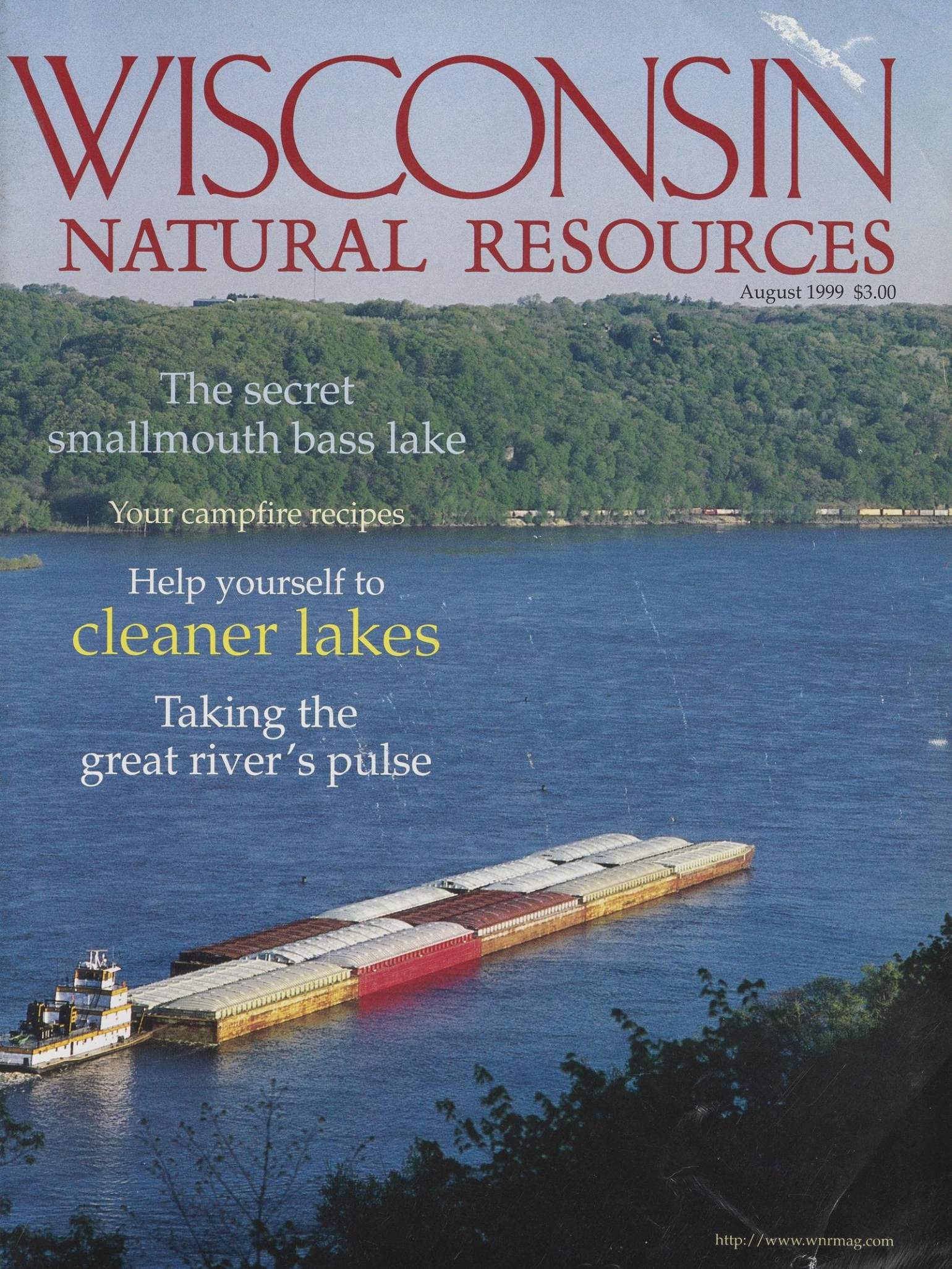

The secret smallmouth bass lake

Your campfire recipes

Help yourself to cleaner lakes

Taking the great river's pulse

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Lithe lumber

When twigs twitch, they may be walking sticks.

Look closely. Do you see both walking sticks? *(inset)* Walking sticks remain motionless for hours to fool would-be predators.

Anita Carpenter

Something gently touched my shoulder as I walked through the tangled underbrush of an oak woods on a warm, late-summer day. Rather than brush it off, I glanced, and sitting there, as proudly as an epaulet on an officer's dress uniform, was a three-inch walking stick. I raised my hand toward the unexpected visitor. On six long, spindly legs, the insect slowly walked onto my hand. Lowering its body close to my finger, it extended long, almost body-length, thread-like antennae straight ahead and froze. When I gently waved my hand, the walking stick swayed in the "gentle breeze," trying to keep its balance.

More than 2,500 species of walking sticks, collectively called stick insects, inhabit the earth; most are found in the tropics. The largest present-day insect, measuring 13 inches, is a walking stick found in Borneo. My friend, *Diapheromera femorata,* is the only walking stick species found in the northern United States. The males may reach three inches while females grow to 3¾ inches.

Northern walking sticks are wingless. A small head tops an almost cylindrical body. The elongated thorax measures about half the body length (note the thorax distance between the first and third leg pairs). The abdomen is tipped with two, small sickle-shaped cerci, which are used to sense the environment.

continued on page 29

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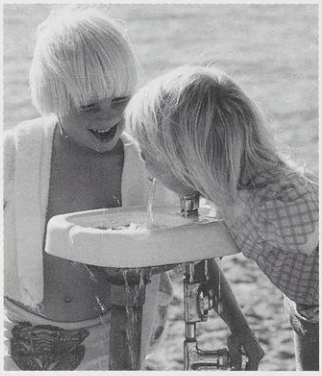
WISCONSIN NATURAL RESOURCES

August 1999 Volume 23, Number 4

ROBERT QUEEN

DONNA KRISCHAN



WIS. DEPT. OF TOURISM

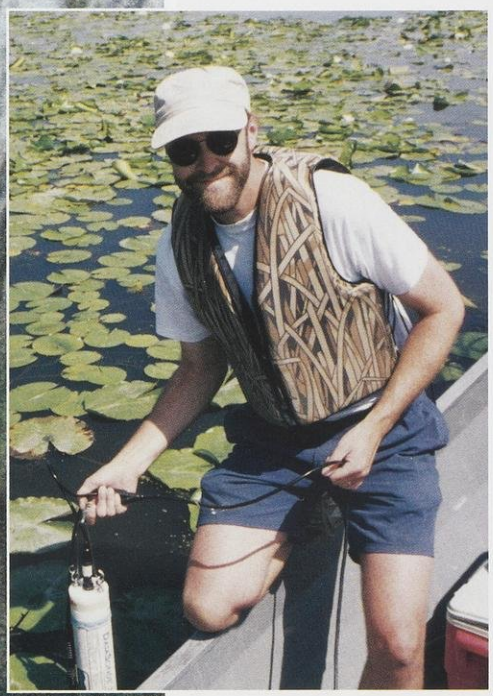
THOMAS A. MEYER

FRONT COVER: Locks and dams on the Mississippi allow barge traffic, but slow the river's ability to flush sediment, nutrients and chemicals. See page 4. ROBERT QUEEN, Madison, WI

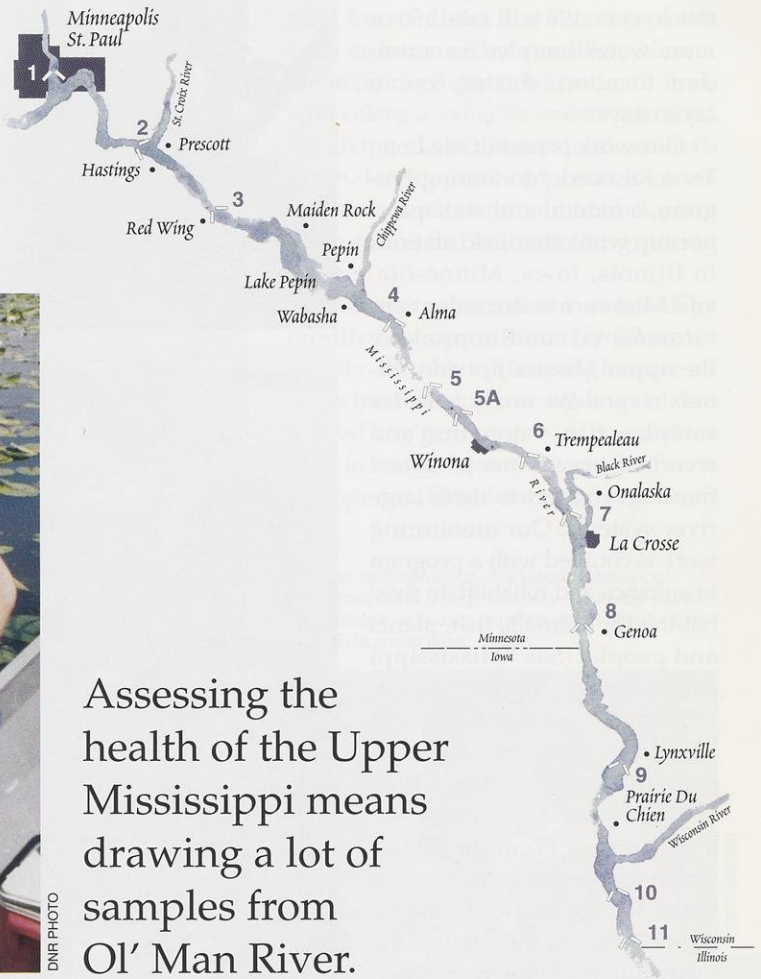
BACK COVER: Kohler Park Dunes SNA along Lake Michigan in Sheboygan County. For a map or more information, contact the State Natural Areas Program, DNR, Box 7921, Madison, WI 53707 (608)266-0394. THOMAS A. MEYER, Mount Horeb, WI

WALKING STICK PHOTOS BY DON BLEGEN

Taking the



DNR PHOTO



Assessing the health of the Upper Mississippi means drawing a lot of samples from Ol' Man River.

great river's pulse

Terry Dukerschein

On these hot mornings, the airboat fans us with sticky, humid air on the trip to the main channel of the Mississippi River. If it's foggy, we temper our speed to look out for obstructions until the morning haze lifts. Some days, the fog just hangs on between the river bluffs; we can barely see the channel markers. When we stop to collect a sample, the still air distorts sounds — splashing fish, a rumbling train and a droning boat may all be closer or further away than we think.

Tucked into a cooler are about a dozen large bottles we will use to sample the Mississippi at preset monitoring spots. Only the extremes — thunderstorms, hail, blizzards, high winds, and Coast Guard closings — keep us off the river.

By "us," I mean the biologists, fisheries managers and researchers at DNR's Onalaska Field Station who collect Mississippi River water samples every other week, all year. Today we are doing our quarterly sampling of Navigation Pool 8 (the river segment between Dam 7 at Dakota, Minn.

(left) **Wild rice grows in the shallow backwaters of Pool 8 on the Mississippi. Waters trapped behind the lock-and-dam system create shallow reservoirs that are filling-in with sediment.** ***(above)*** **Jim Fischer, DNR water quality specialist, samples water quality in Pool 8. More than 150 samples will be analyzed quarterly for aquatic health.** ***(map)*** **Wisconsin teams share responsibilities with Minnesota and Iowa teams to monitor the river from the St. Croix River down to the state line.**

TERRY DUKERSCHEIN

and Dam 8 at Genoa, Wis.). It's 23 miles long and up to five miles wide. We will take 150 or more water samples from random locations during five to seven days.

Our work is part of the Long Term Resource Monitoring Program, a federal and state partnership with other field stations in Illinois, Iowa, Minnesota, and Missouri to document environmental conditions along the upper Mississippi and Illinois rivers. We analyze water samples, fish, vegetation and riverbed organisms to detect trends or changes in these large river systems. Our monitoring work is coupled with a program to enhance and rehabilitate river habitat for animals, fish, plants and people. (See "Mississippi River rehab," in our August, 1998 issue.) Together, these habitat and monitoring programs comprise the U.S. Army Corps of Engineers' Environmental Management Program (EMP), which was authorized under the Water Resources Development Act of 1986. The information the team collects helps river managers and the public gauge when the rivers are being used wisely and when human activities harm natural river communities.

TERRY DUKERSCHEIN

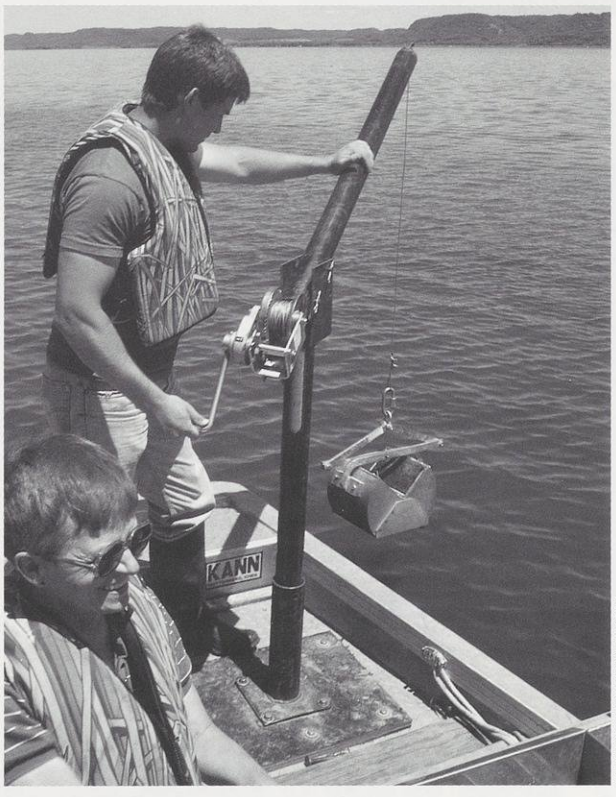


PHOTO COURTESY OF USGS

(top) When sediments make water too shallow, researchers get out and push their boat to the sampling site.
(above) Clam-like dredges sample the riverbed for aquatic foods and contaminants.

Interpreting the data we gather can be a challenge. For example, water clarity trends from upstream to downstream differ in different pools. In Pool 4 (between Red Wing, Minn. and Alma, Wis.) water clarity is not as good in the upper portion as it is downstream. In Pool 8, downstream from Pool 4, the water is clearer upstream and gets cloudier downstream.

Walt Popp, team leader for Minnesota's field station, speculates that suspended particles carried by the Minnesota River to Pool 4 settle out in deep Lake Pepin. Jim Fischer, Wisconsin field station water quality specialist, posits that because Pool 8 does not have deep, slack water like Lake Pepin, there's nowhere for the silt to settle on the journey downstream.

It's all part of tracking the life signs of the Big River.

Searching the shallows

Wide rivers like the Mississippi tend to fill-in backwater bays where turbid water slows down and soil particles settle out. Eric Kramer, DNR fisheries technician, takes samples each spring from 150 sites in the Mississippi backwaters looking for bottom-dwelling animals like young mayflies, midges and fingernail clams — important foods for fish and waterfowl. The bottom-dwellers also indicate if the environment has been disturbed and polluted. For instance, if mayflies are absent from an area that would otherwise be suitable for them, biologists suspect certain types of pollution and investigate further.

Changing water depths are also recorded. Riverbed sampling sites that consistently were in a couple feet of water in the mid-1970s now have just a few inches of water above the silted mud. "It's work to reach them," Kramer says. "If we don't have high water, we have to get out and push the boat to some of the monitoring sites."

Aerial photos taken by the U.S. Geological Survey and the U.S. Fish and Wildlife Service are used to identify and electronically map floating, emergent, and terrestrial vegetation. These observations have to be verified on the ground — up close and personal. Heidi Langrehr, our field station's vegetation specialist, and her assistant spend a good part of their day mucking about in the river shallows. They often return from a day of sampling spattered from head to foot with black mud. On the other hand, the job has its rewards — for instance, when the two slowly motor through a sea of pale yellow lotus blossoms fringed by tall, feathery wild rice. They follow narrow channels winding into the silty backwaters preferred by algae, aquatic insects, breeding and migrating waterbirds, and fish such as sunfish, bluegills, largemouth bass, black crappies and northern pike. As the backwaters continue to fill with sediment, they become too shallow for fish.

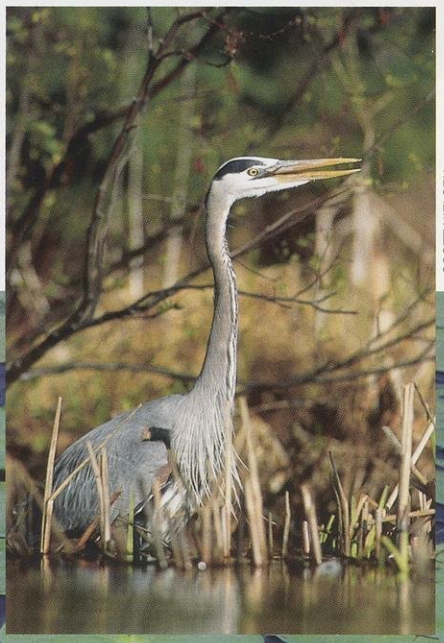
In late spring and mid-summer, Langrehr's crew collects plants from approximately 1,200 sites in eight different backwaters of Pool 8. They find common underwater vegetation such as coontail and waterweed, Eurasian

water milfoil (a non-native invader), various pondweeds (which are valuable food for wildlife), and floating plants such as lotus and water lilies. Nearer the main river channels, Langrehr finds wild celery, a valuable underwater food for diving ducks. Since aquatic animals ultimately depend on plants for food and shelter, it's important to track plant abundance throughout the growing season.

Our crews also assess river health by monitoring approximately 30 water quality variables. River anglers are always interested in our readings of dissolved oxygen content since waters high in oxygen generally support more fish species. Dissolved oxygen general-

DON BLEGEN

Despite sedimentation, the Upper Mississippi River maintains a huge diversity of healthy plants and animals including mayflies, great blue herons and white water lilies.



SCOTT NIELSEN

STEPHEN J. LANG

MiAe LIPE-BUTTERBRODT, USGS

MiAe LIPE-BUTTERBRODT, USGS

(top) The river portion between the Twin Cities and Rock Island, Ill. is considered "moderately impacted" due to changes in native fish, native vegetation, recovery from disturbance, land changes and size of the floodplain.
(above left) Carp are the most common non-native fish species in the Mississippi River.
(above) Fyke nets are used along shallow shorelines without currents to sample for panfish, game fish, turtles and other animals that cruise the riverbanks.

ly remains adequate in Pools 4 and 8 but occasionally dips lower in the backwaters. Because oxygen dissolves best in colder, moving water, the shallow, sluggish backwaters sometimes contain a different mix of fish and other aquatic life.

Fluctuating water level, the shape and size of a backwater and its connection to the main river channel, as well as the amount of ice and snow cover can also change dissolved oxygen and water temperature. Based on population data, river managers speculate that many young panfish never make it through their first winter because suitable overwintering areas in river backwaters are becoming scarce. Scientists hope to use computerized mapping and monitoring data to help managers improve winter habitat for fish.

Fish species that prefer more river-like conditions have other problems. When deeper water rises behind a dam, the water slows and some river-like areas disappear. Dams are also a barrier to migratory fish traveling to spawning or wintering areas. The monitoring crews seldom collect lake sturgeon, paddlefish, and blue suckers — commercially important migratory species that were once common throughout the Mississippi River. The scarce fish are difficult to collect in the deep, flowing waters they prefer.

That's not to say the Mississippi River fishery lacks variety. In our monitoring work in Pool 8, we capture 75–78 different fish species per year. Most Midwestern lakes contain fewer than 15 species of fish. Given the variety, researchers use a host of electroshocking and net-

LISA HODGE RICHARDSON

Floods in the summer of 1997 gave vegetation researchers an extra challenge to survey the forest floor for seedlings. Survivors tough out both high water and drought on the river.

Where research is headed

Partners in EMP have been designing and implementing studies and models to focus on particular river management issues that are raised by the monitoring results. Wisconsin's Long Term Resource Monitoring Program field station employees are collaborating with scientists from the U.S. Geological Survey, the University of Wisconsin-La Crosse and the University of Tennessee to address how floods, droughts, and normal water flows affect the growth of selected fish species; how accurately aerial photography detects underwater vegetation; how flooding affects what grows in floodplain forests; and how environmental factors affect winter habitat conditions in backwaters. Program field stations have also assisted the U.S. Army Corps of Engineers with water quality, fish, and vegetation monitoring to evaluate the effectiveness of EMP habitat restoration projects on the Mississippi River.

Monitoring data, maps, aerial photos, and report summaries from the Long Term Resource Monitoring Program can be found on the U.S. Geological Survey's website: http://www.umesc.er.usgs.gov/.

Also check the website for details about "Ecological Status and Trends of the Upper Mississippi River System," the survey's April 1999 report examining trends in fisheries, water quality, vegetation and other aquatic life on the Mississippi River.

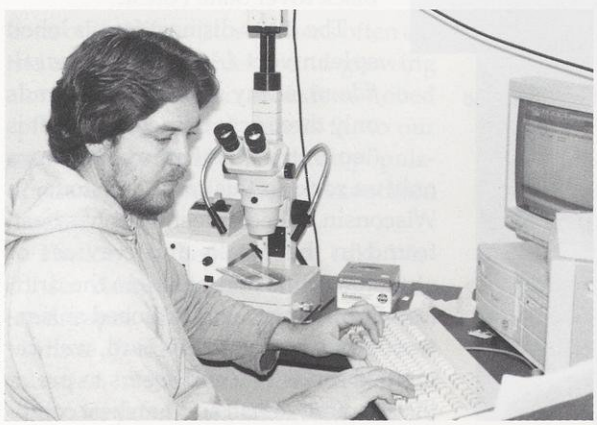
ting techniques in the 500 or so fish collection sites in Pool 8 each year.

The fisheries data, vegetation data, and other monitoring data can be mapped and combined to provide clues for managing the Mississippi's wild resources. We now know that catfish are more abundant in the southern reaches of the Upper Mississippi. And catch data shows that catfish near La Crosse reproduce abundantly, but only in certain years under certain conditions.

Compared to the world's other temperate rivers of similar size, the Mississippi supports remarkably large numbers of animal species and the river remains an exceptional biological resource. It deserves comprehensive monitoring and habitat preservation plans, and it deserves attention along its entire length. Like a coordinated team of medical personnel, the partners in the Environmental Management Program monitor the river's vital signs, ready to diagnose and treat this vast patient whose health determines the well-being of so many species, including our own. □

Terry Dukerschein leads DNR's long-term monitoring subteam on the Mississippi River in Onalaska.

(left) Andrew Bartels, DNR fisheries, uses a high-power microscope to see and measure growth rings on fish scales. He found that nearshore fish like bluegills grew more quickly during flood times than fish that feed in the open water, like black crappies.
(right) Sampling river health continues year-round, and around the clock. This measures dissolved oxygen and other conditions every half-hour.



TERRY DUKERSCHEIN

SHANNON GIVEN

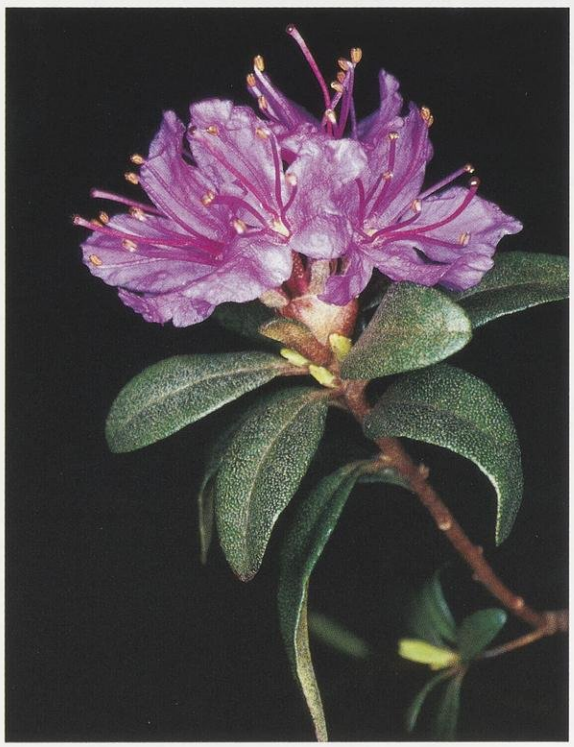
Meet the disjuncts

Plants from far-away places find congenial corners of habitat in Wisconsin.

Story and photographs by Thomas A. Meyer

On a weathered sandstone cliff sculpted by wind and water of the Kickapoo River, a half-dozen tenacious plants cling to a damp, narrow cleft in the sheer rock face. Their tough, woody stems bear waxy, evergreen leaves and, in May, sprays of vibrant magenta flowers. The plant's scientific name is *Rhododendron lapponicum,* but it goes by the more common title Lapland azalea. It's Wisconsin's only native member of the plant group containing the rosebays, azaleas and rhododendrons.

What's remarkable about these small, scraggly shrubs is not their beautiful flowers or their ability to grow in such a precarious place, but that they're found in Wisconsin at all. The Kickapoo's Lapland azaleas are far from home — nearly 900 miles away, in fact! They're what plant geographers call a "disjunct" species — a plant growing in a natural setting far distant from its home range. The Lapland azalea's primary range circles the globe in arctic and alpine regions of the northern hemisphere (including Lapland) and in the higher elevations of the Adirondack Mountains. Only two other small populations of this plant are known to exist in North America outside of its main range — one in the Dells of the Wisconsin River (where it is protected in a DNR-owned State Natural Area) and the other in a northern Minnesota cedar swamp.



Lapland azalea *(Rhododendron lapponicum)* grows in cool Kickapoo valley crevices far from its main range in arctic and alpine regions like Lapland and the Adirondack Mountains.

Other long-distance travelers

Wisconsin is home to a number of other interesting disjunct species, two of them ferns. Growing under a canopy of red maples and towering white pines in the moist, peaty soil of Jackson and Monroe counties is the Massachusetts fern, *Thelypteris simulata.* As its common name suggests, it is a plant of the northeastern U.S., ranging from Nova Scotia south to Virginia. The nearest population is in central Pennsylvania. In our state, it typically grows with a variety of other ferns, clubmosses, sphagnum and sedges. Look for Massachusetts fern in the Jay Creek Pine Forest State Natural Area and in the Black River State Forest.

The other disjunct fern is lobed spleenwort *(Asplenium pinnatifidum),* a tiny species with fronds only three or four inches long. It is "epipetric," meaning it grows only on rock, in this case sandstone. In Wisconsin, lobed spleenwort has been found in the cracks and crevices of sandstone cliffs and pillars in the driftless area of Iowa County. Lobed spleenwort grows only on very hard, well-cemented sandstone and seems to prefer the sunniest, driest, and harshest condi-

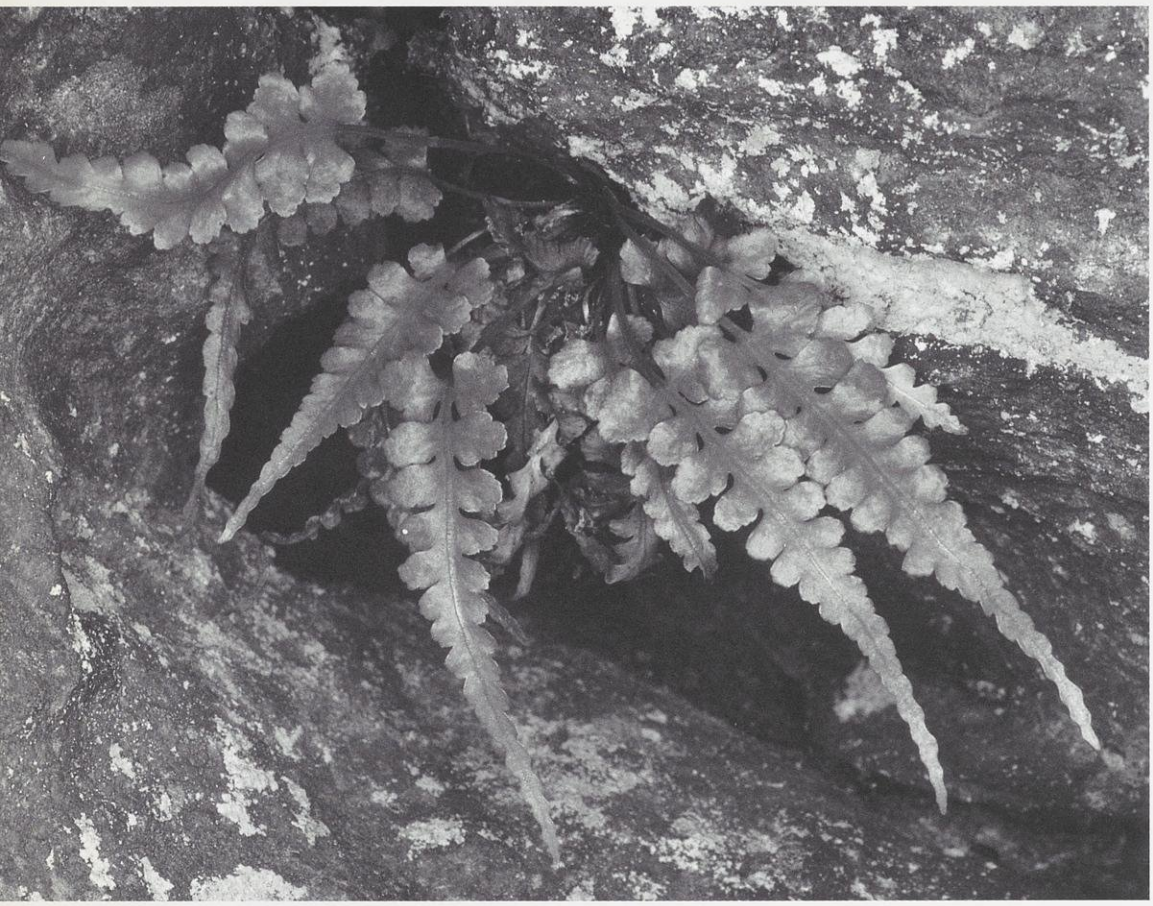
(above) The Massachusetts fern *(Thelypteris simulata)* grows in moist, peaty soils of western Wisconsin. It's an East Coast native ranging from Nova Scotia south to Virginia.

(left) Meadow beauty *(Rhexia virginica)* is an Atlantic Coast native that has taken root in Wisconsin at the Sohlberg Silver Lake State Natural Area in Adams County.

tions on a cliff; crustose lichens often are the only other species found growing alongside this hardscrabble fern. Lobed spleenwort's home range is far to our south and east, with the nearest population nearly 400 miles away in southern Illinois.

The low, flat bed of glacial Lake Wisconsin dominates the central sands landscapes of Adams, Juneau, Sauk, Monroe, Jackson, Portage and Wood counties. In this region, small shallow softwater ponds and lakes with widely fluctuating water levels mimic the conditions of the marshes and bogs along the Atlantic coastal plain, the area of the eastern U.S. between the coast and the piedmont.

Growing among the sedges, rushes and other common wetland species is an intriguing array of disjunct plants commonly found on the coastal plain, but rarely inland. They're adapted to damp, sandy shorelines that are exposed during low water levels and then periodically flooded. These species sur-



The lobed spleenwort *(Asplenium pinnatifidum)* only grows three to four inches tall in rocky cracks and crevices.

vive by reestablishing themselves from seeds buried in the soil when it is exposed during dry periods.

Among Wisconsin's Atlantic coastal plain disjuncts are the bald rush *(Psilocarya scirpoides)*, netted net-rush *(Scleria reticularis)*, cross milkwort *(Polygala cruciata)*, and meadow beauty *(Rhexia virginica)*. Meadow beauty is perhaps the showiest of these, sporting bright rose-pink flowers with large yellow anthers. An excellent place to see these denizens of the East Coast is Sohlberg Silver Lake State Natural Area in Adams County (see our August 1998 issue). Look for these plants from late July through August.

How did they make the trip?

Although botanists are still somewhat puzzled to explain precisely how the disjuncts found their way to Wisconsin, they have proposed several hypotheses to explain the plants' presence here.

Some think species such as Lapland azalea normally found in, and adapted to, frigid areas to our north may have migrated south in front of advancing glaciers. It's possible they were more widespread here in the past, especially in the unglaciated Driftless Area of southwest Wisconsin. As the post-glacial climate warmed, these species shifted back north, but hung on in a few places that retained cool micro-environments, like the gorge of the Kickapoo River. Both of Wisconsin's azalea cliffs have cool water seeping from crevices and cracks in the sandstone. The water maintains a consistently chilly, damp substrate for the plant's roots — similar to that in its arctic homeland.

The presence of Massachusetts fern and lobed spleenwort is believed to be a result of the long-distance dispersal of spores — exceptionally tiny, dust-like "seeds" borne by the wind. The spores could have been swept into Wisconsin on strong breezes, eventually landing in hospitable habitat. How the spores moved from east to west, given the prevailing westerly winds, and why Massachusetts fern and lobed spleenwort aren't found in intervening areas with suitable habitat, remains a mystery.

Long-distance seed dispersal probably played a role in the occurrence of Atlantic coastal plain disjuncts in central Wisconsin. Instead of being blown by the wind, the heavy seeds may have hitched a ride on birds, primarily waterfowl and shorebirds migrating from eastern wetlands through Wisconsin. A second theory involves the westward migration of coastal plain plants along the extensive shoreline habitat of connected lakes and drainages that were present immediately following the retreat of the glaciers. Some botanists think a combination of these two schemes is the most likely explanation.

Not surprisingly, most disjunct species are considered rare in Wisconsin. Lapland azalea, of which there are only two populations here, and lobed spleenwort, of which there are only five populations, are listed as state-endangered species. Most of the others are listed as species of special concern —plants believed to be rare. Not enough information is available to rank them as endangered or threatened.

The DNR's Bureau of Endangered Resources tracks the status and location of these far-flung plants. If you happen upon a new population, bureau staff would appreciate knowing more about it. Please call (608)266-7012 to share your discovery. □

Thomas A. Meyer is a natural areas specialist in the State Natural Areas Program of DNR's Bureau of Endangered Resources in Madison.

The secret smallmouth lake in the U.P.

The lure of a secret fishing hole was a sure thing.

Dave Crehore
Story illustrations by Tom Lowes

The story began in the White House Lunch on a June noon in the mid-1950s.

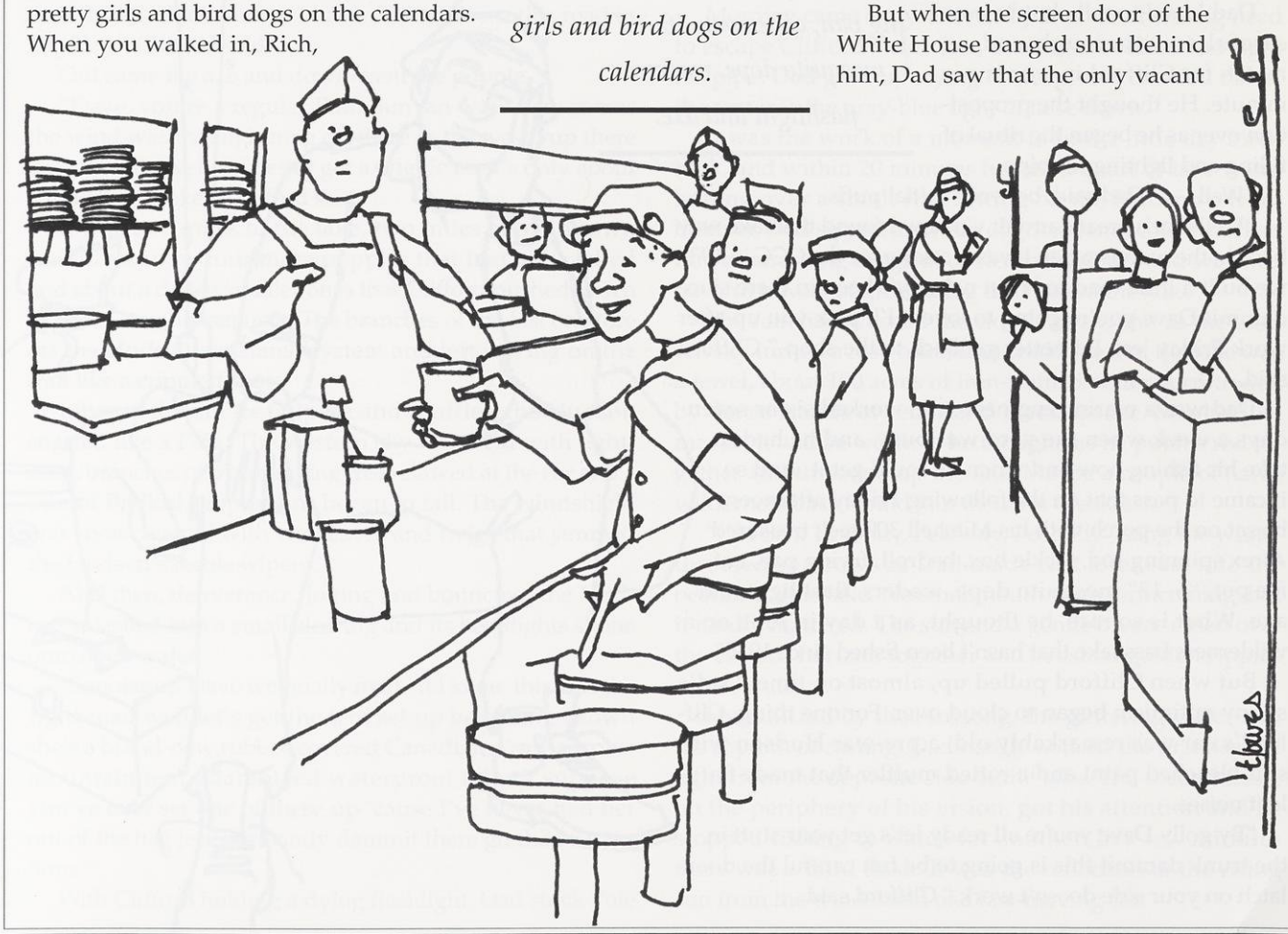
The White House Lunch was on the north bank of the Manitowoc River, surrounded by the Manitowoc Shipbuilding Co., Burger Boat and the White House milk condensery. It was small, noisy, hot in all seasons and incredibly busy when the shipyard was working three shifts.

The White House smelled wonderfully of fried onions and cigarette smoke, which darkened the walls and even the pictures of pretty girls and bird dogs on the calendars. When you walked in, Rich, who owned the place, would point to an empty stool at the counter, yell "hamburgeronion" to the kitchen, and slap down a ruby-red plastic glass of ice water. You didn't want a hamburgeronion? Tough. Hamburgeronions were du jour and du always at the White House.

The White House smelled wonderfully of fried onions and cigarette smoke, which darkened the walls and even the pictures of pretty girls and bird dogs on the calendars.

Trouble was coming, but Dad didn't sense it as he left his sweltering office at the shipyard and headed for lunch at the White House that day. Even the hellish spit, pop and flash of welding in the yard's fabrication shop didn't seem like a warning.

But when the screen door of the White House banged shut behind him, Dad saw that the only vacant



spot at the counter was next to Clifford. That was an omen.

Clifford was a thin, red-headed welder and a lonely nonstop talker. He lived to fish, but not at local places like Pigeon Lake or the Carptown pier. For Clifford, real fishing didn't start until you were north of Highway 64, as far back in the woods as possible, and in the company of a good listener.

Clifford saw Dad, smiled and patted the empty stool beside him. Knowing that Dad was a bass fisherman, he shifted smoothly from perch, which he had been discussing with a grizzled pipefitter, to smallmouth bass in the Northwoods.

"Dammit Dave you know that little smallmouth lake up in Michigan I'm always talking about well I was thinking the other day I said to myself dammit I've got to get Dave Crehore up there because he's the only other guy I know who likes smallmouth and why should I keep it to myself I just got a new tent so why don't we drive up there Friday night and camp out right on the lake we won't need a boat and we can take my car so what do you say?" Clifford said.

Dad loved to talk, but he was careful and thorough and no match for Clifford in words per minute. He thought the proposition over as he began the ritual of filling and lighting his pipe.

"Well —," Dad said, between initial puffs.

"Well that's great dammit y' know I found that lake way back in the woods when I was working for the CCC in 1935 we built a little road to it but nobody's been in there since dammit Dave you're going to love it I'll pick you up after work Friday jeez I'd better get back to the shop," Clifford said.

Dad was a marine engineer who worked six or seven days a week when the yard was busy, and he had to take his fishing how and when he could get it. And so it came to pass that on the following Friday afternoon, he sat on the porch with his Mitchell 300 reel, treasured Airex spinning rod, tackle box, bedroll, frying pan, coffee pot, "6–12" mosquito dope, waders, flashlight and axe. What is so rare, he thought, as a day in June on a wilderness bass lake that hasn't been fished since 1935?

But when Clifford pulled up, almost on time, Dad's sunny optimism began to cloud over. For one thing, Clifford's car was remarkably old, a pre-war Hudson with sun-bleached paint and a rotted muffler that made flatulent noises.

"By golly Dave you're all ready let's get your stuff in the trunk dammit this is going to be fun careful the door latch on your side doesn't work," Clifford said.

"OK," Dad said.

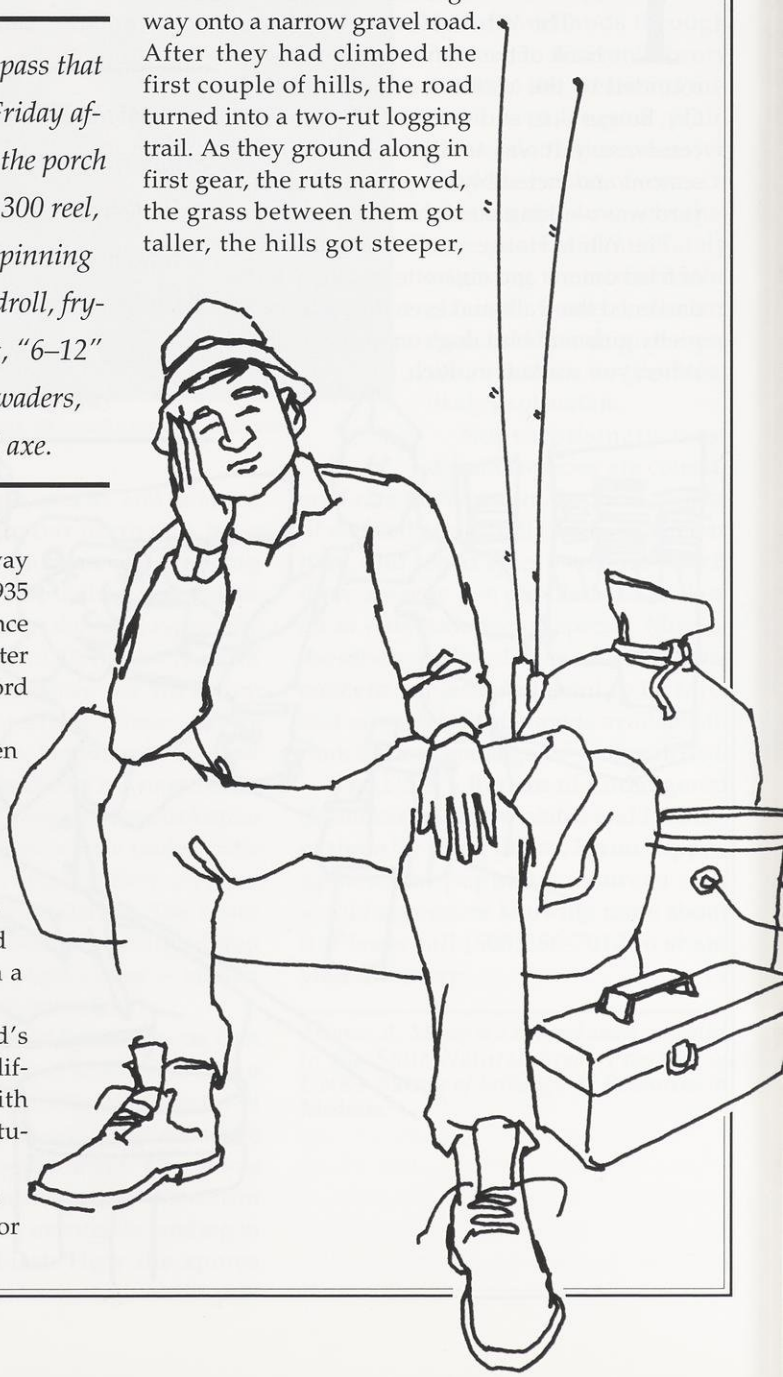
And off they went, west on Highway 10 to Appleton and New London, north on 45 to Antigo, where they bought Michigan licenses at a bait shop, and on to Land O' Lakes.

It was midnight when they crossed the Michigan line and entered the Upper Peninsula. Bats and bugs fluttered in the headlight beams as they drove through young plantations of red pine. Then Clifford slowed down.

"Dammit Dave I'm pretty sure we take the next right and go east about five miles or so whoops I think that's the road but I'd better drive on and make sure it isn't the next one no that doesn't look like it I think it really was the first one so I'll turn around and go back," Clifford said.

Clifford turned off the highway onto a narrow gravel road. After they had climbed the first couple of hills, the road turned into a two-rut logging trail. As they ground along in first gear, the ruts narrowed, the grass between them got taller, the hills got steeper,

And so it came to pass that on the following Friday afternoon, he sat on the porch with his Mitchell 300 reel, treasured Airex spinning rod, tackle box, bedroll, frying pan, coffee pot, "6–12" mosquito dope, waders, flashlight and axe.



and the Hudson began to slow down. Finally it stopped altogether halfway up a hill.

"Jeez Dave I wonder what's wrong sure am glad you brought a flashlight my God the mosquitoes are thick you'll have to hold up the hood for me dammit the accelerator cable is busted no wonder it won't run how are we going to fix it?" Clifford said.

Dad dug his tackle box out of the trunk and found a wire musky leader. With his fishing pliers he cut the leader to size and spliced it to the stub of the broken accelerator cable with a pipe cleaner. It worked perfectly.

"Dammit Dave it was a good idea to bring an engineer along now listen to her roar the old girl hasn't run this strong in years well let's get going the road to the lake is just over the top of this hill I think we're almost there," Clifford said.

The road to the lake wasn't over that hill or the next one, but they finally found it — a faint track leading off to the left, almost invisible in the side spill of light from the headlamps.

"Dammit Dave I'm pretty sure this is it let's stick our nose up here and find out jeez it's rough look at that popple right in the middle of the road the bugger must be three inches thick 'course I haven't been down this road in 20 years," Clifford said.

Out came the axe and down went the popple.

"Dave, you're a regular Paul Bunyan wow here comes the wind was that lightning off there to the west yup there it goes again well we better get a wiggle on it's only about a mile to the lake," Clifford said.

It was two miles to the lake, two miles of overgrown trail blocked by four more popples that had to be felled and about a dozen smaller ones that Clifford pushed down with the car and ran over. The branches of the last one tore off the Hudson's exhaust system and left it lying on the trail like a crippled snake.

Liberated from its tailpipe and muffler, the Hudson snarled like a P-51. The western sky was livid with lightning, branches of overhanging trees clawed at the car and a rain of Biblical proportions began to fall. The windshield was soon covered with wet leaves and twigs that jammed the Hudson's feeble wipers.

And then, deliverance. Jolting and bouncing, the Hudson splashed into a small clearing and its headlights shone onto open water.

"Sonofagun Dave we finally made it I knew this was the right road well let's get the tent set up before we drown she's a brand-new rubber-covered Canadian Army surplus mountain tent guaranteed waterproof I don't suppose you've ever set one of these up 'cause I've never had her out of the bag jeez it's windy dammit there go the instructions."

With Clifford holding a dying flashlight, Dad stuck Pole A into Slot B until the reeking, crumbling tent assumed a rough inverted V-shape. Grabbing their bedrolls from the car, they shoehorned themselves into the tent. Exhausted by driving, talking and watching, Clifford fell asleep instantly, but Dad remained awake to reflect on life's rich tapestry.

First of all, it was obvious to Dad that Canadian soldiers had run small in the '40s, because the tent, advertised as a two-man, was only big enough for a honeymoon couple. Never a touchy-feely type, Dad spent the first half-hour trying to edge away from the snoring Clifford, who kept snuggling up like an affectionate golden retriever.

Never a touchy-feely type, Dad spent the first half-hour trying to edge away from the snoring Clifford, who kept snuggling up like an affectionate golden retriever.

Second, he noted that like all items described as "waterproof," the Canadian mountain tent did a better job of keeping water in than out. Before an hour had passed, the condensed sweat and exhalations of two men began dripping down on him from the tent's roof.

Third, he wondered about the identity of the persistent, snuffling, bad-smelling thing that spent half the night trying to open the Hudson's trunk and steal the bacon. A skunk? A bear? Two bears?

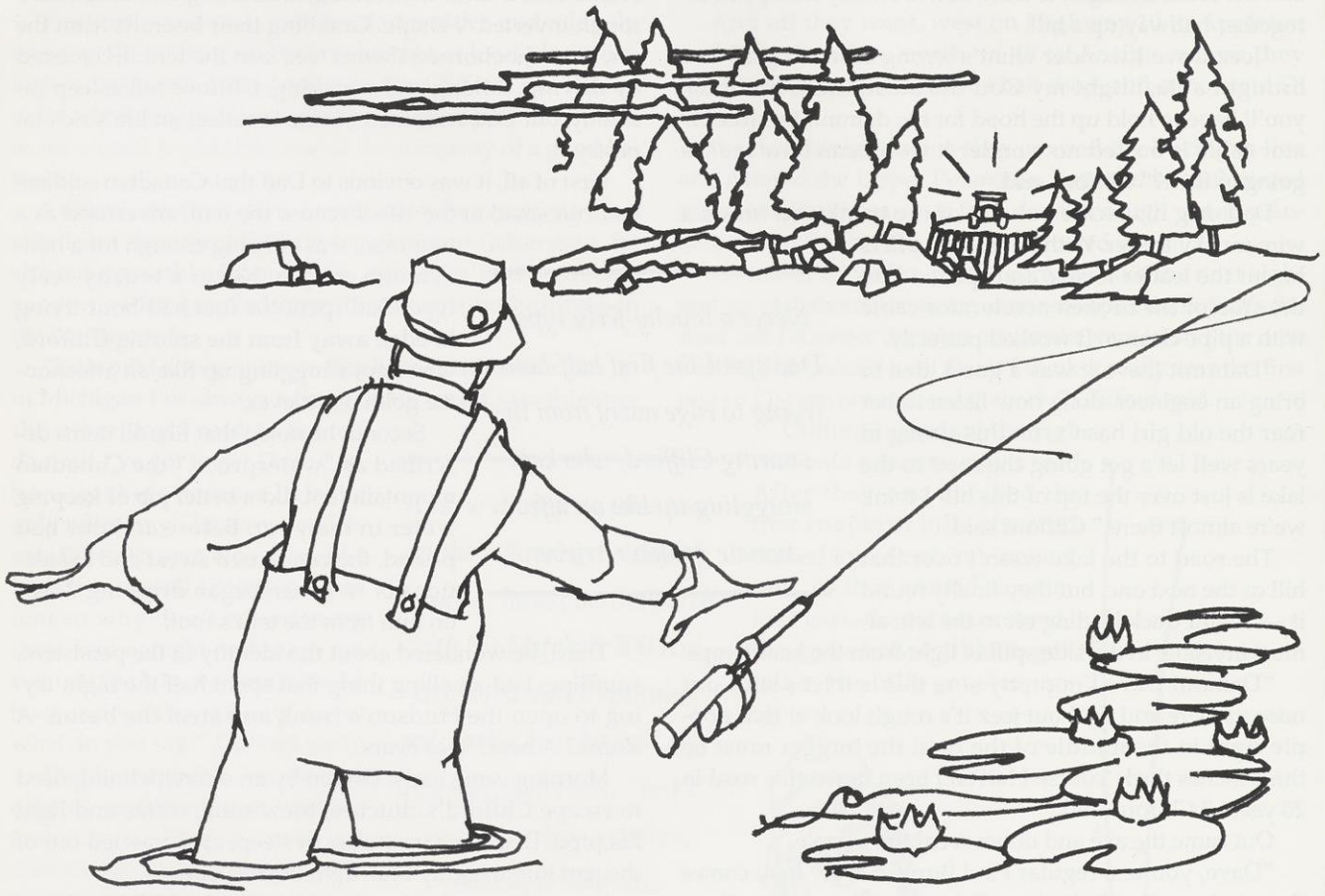
Morning came early. Driven by an overwhelming need to escape Clifford's clutches, brew some coffee and light his pipe, Dad gave up trying to sleep, and crawled out of the tent into the gray-blue light of false dawn.

It was the work of a moment to find a little dry birch bark, and within 20 minutes he had a quart of lake water boiling over a small fire. Sitting on the Hudson's front bumper, Dad sipped a tin cup of gritty camp coffee, sucked down refreshing lungsful of Kentucky Club, and watched fanciful towers of ground fog drift across the lake.

The rain had washed the clouds away, and as the eastern sky turned a rose color, Dad could see that the lake was a jewel, about 100 acres of iron-stained water surrounded by dense stands of cedar and black spruce. Maybe, just maybe, it will be worth it, he thought, as he put his rod together and threaded up the line. Maybe a couple of naive wilderness bass would join them for breakfast.

"Old Sam Peabody, Peabody, Peabody" sang the white-throated sparrows as Dad made cast after cast into the beautiful little lake. No smallmouth were forthcoming, but it hardly mattered. The sun and a gentle breeze eased over the eastern horizon together and brushed golden ripples on the water.

Hypnotized by the birdsong, the glittering water and the rhythm of casting, Dad hardly noticed the first flash of light from the opposite side of the lake. The second flash, on the periphery of his vision, got his attention and he stopped fishing to watch for another. In a few minutes there was a third flash. It was the reflection of the rising sun from the windshield of a fast-moving car.



"Clifford," Dad said, as he prodded the tent from the outside, "there's a highway on the other side of this lake."

"I'm up I'm up jeez Dave there can't be because I walked all the way around it in '35 and there wasn't no other road."

"Well," Dad said, "there is now."

It was a short, quiet breakfast. After two hours of fishing which yielded one angry, stunted rock bass, Dad and Clifford packed up and headed for home. They stopped for gas at a station in Watersmeet, and while Clifford took his turn in the men's room, Dad asked an elderly mechanic for a little Upper Peninsula lore.

"About five miles east and two miles north there's a lake back in the woods that used to have real good smallmouth fishing. Know anything about it?"

"Oh God, don't bother going over there. It was our secret bass lake back in the '20s —- took half a day to walk back into it. But the government cut a trail to the south side in '35, and those CCC boys about fished her out. Then after the war when the new highway got built along the north shore, she just went to hell. Ain't good for nothing but rock bass now."

After two hours of fishing which yielded one angry, stunted rock bass, Dad and Clifford packed up and headed for home.

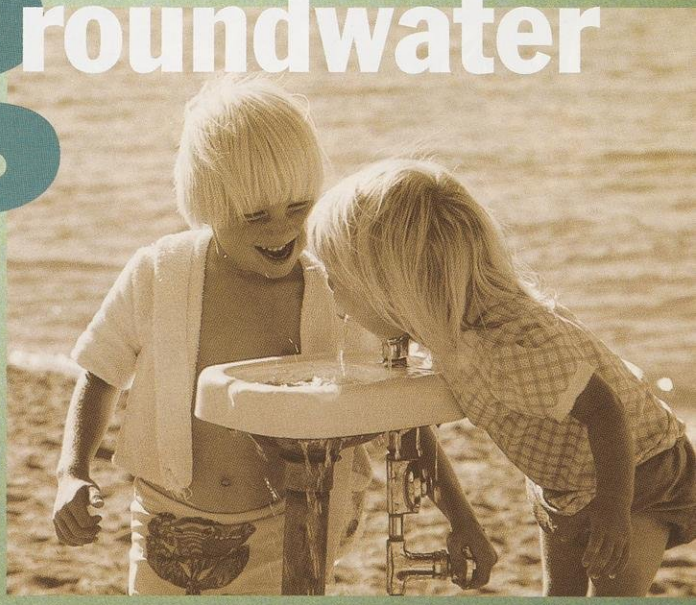
The following Monday noon, as Dad lingered over his hamburgeronion at the counter of the White House, he heard a familiar rapid-fire voice from a booth in the back.

"Dammit Wally I just got back from the best doggone weekend of fishing I ever had you know Dave Crehore well he and I drove up to Michigan to a little bass lake I found when I was working for the government by golly we had to chop our way in but we caught smallmouth like hell wouldn't have it say you know there's a little spring pond not too far from there and nobody's been to it in years it's just full of brook trout and I know you're crazy about them hey let's drive up there this weekend I got a brand new tent just used once and we can take my car I'm telling you you're gonna love it what do you say?"

"Well —," Wally said, as he thoughtfully tapped a Pall Mall on the side of his Zippo… □

Dave Crehore is DNR's public affairs manager in Green Bay. This is his third family story about hunting, fishing and enjoying the outdoors near his childhood home in Manitowoc.

groundwater



Protecting Wisconsin's buried treasure

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Words in **boldface** appear in the glossary on page 32.

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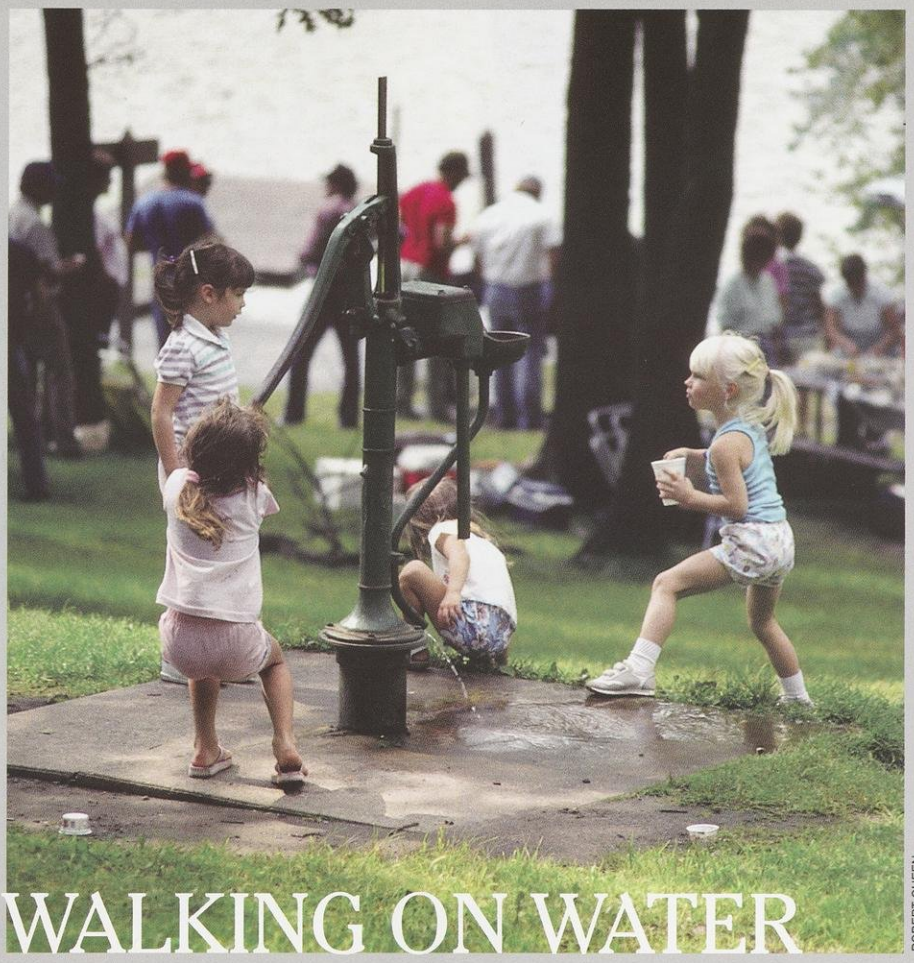
FRONT COVER: On the farm, at home and at play, Wisconsinites draw 256 million gallons of groundwater each day for drinking water and three times that amount for businesses.

DNR PHOTO
(INSET) WISCONSIN DEPARTMENT OF TOURISM

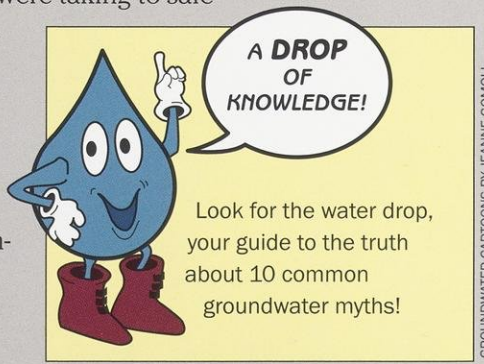


ROBERT QUEEN

WALKING ON WATER

Catching trout in crisp clear streams, shooting the rapids in a canoe or kayak, lazing around the lake in an inner tube, quenching your thirst on a hot summer day — none of these activities would be possible without **groundwater**. Unless you live in one of a few large cities in Wisconsin such as Green Bay or Milwaukee, the water you drink, use for washing, and enjoy for recreation comes from right below your feet. Groundwater is Wisconsin's invisible resource — our buried treasure.

"Groundwater: Wisconsin's buried treasure" was first published in 1983 to educate citizens about the resource we use every day but can't see. In 1989, "Groundwater: Protecting Wisconsin's buried treasure" highlighted the actions state agencies and individuals were taking to safeguard groundwater. This revised edition of "Groundwater: Protecting Wisconsin's buried treasure" will introduce new protection programs, and remind us all that as Wisconsin citizens, we hold the ultimate responsibility for guarding our valuable groundwater resource.



GROUNDWATER CARTOONS BY JEANNE GOMOLL

Using groundwater

Dear Dr. Science: There is an entire science devoted to ground water. How do they grind water and how is it effectively marketed? — Dr. Science, Duck's Breath Mystery Theatre, National Public Radio, August 21, 1986

Welcome to Wees-kan-san — Ojibwa for "gathering of the waters." Each year about 29 trillion gallons of water fall as rain or snow on Wisconsin's 36 million acres. Plants and animals consume some, some is returned to the atmosphere by **evaporation** or **transpiration** by plants, and some flows into rivers, lakes and streams. The rest becomes groundwater by seeping through the soil and into groundwater **aquifers**.

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 759 million gallons of this seemingly endless resource from private and **municipal wells**. Our wells seldom go dry because groundwater is replenished by rain or snow at the rate of six to 10 inches per year.

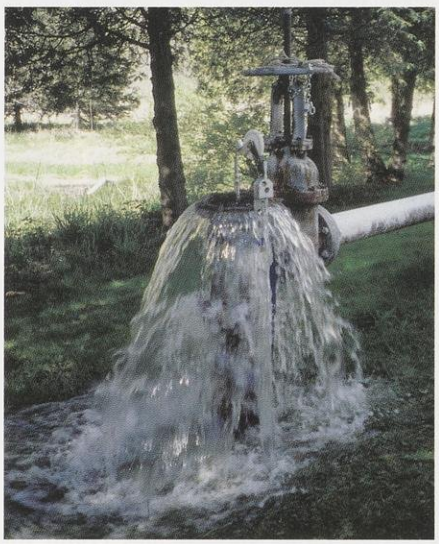
So why be concerned about groundwater? There'll always be pure, clean groundwater for drinking and food processing, for livestock and paper production, for beer-making, car-washing, two showers a day, ice cubes, soda, mineral water, swimming pools and birdbaths, right?

Read on.

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. 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 "precip," finding enough groundwater to supply municipalities in these regions can be difficult.

At last estimate, there were about 750,000 **private wells** operating in the state. In some areas water moves through aquifers very slowly, but private wells can still produce enough water for residential use. You can drill a hole just about anywhere in Wisconsin and find a dependable water supply.



SUE SWANSON

ANDREW DAHL, COURTESY OF THE STATE HISTORICAL SOCIETY OF WISCONSIN

Pure, healthy groundwater is vital to our present, past and future economies.
(above) **An artesian well at the Nevin Fish Hatchery.**
(right) **A Beloit mineral springs 1873–79.**

The supply may be dependable, but that doesn't mean it's drinkable. Groundwater can be contaminated in a number of ways — you'll read about them here. And you'll find out how you can take action at home to protect Wisconsin's buried treasure.

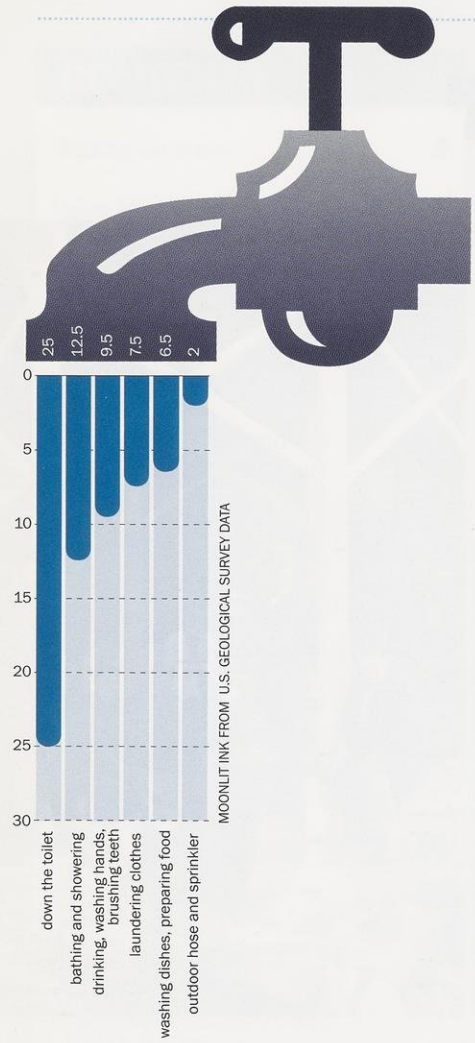
On the home front

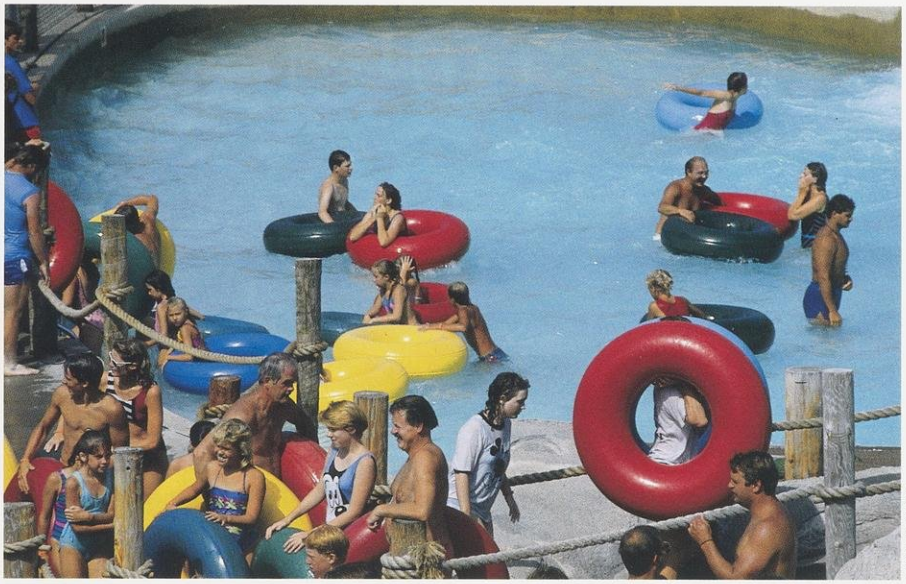
When the well's dry, we know the worth of water. — Benjamin Franklin, 1746

About three-fourths of Wisconsin's residents draw nearly 256 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 diagram on page 4.

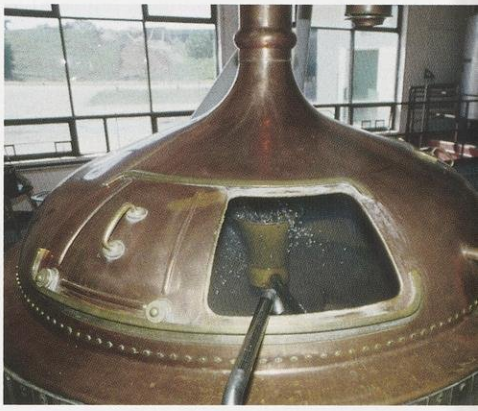
Sixty-three gallons of groundwater per person per day may not seem like much, but there are hidden costs for excessive water use. Your community may have to install new wells or water and sewer pipes to accommodate increasing demand. Pumping more water requires more energy, which costs more money. Treating used water referred to as "wastewater" to strin-





ROBERT QUEEN

(left) **Personal water use averages 63 gallons per day.**
(above) **That does not include groundwater used in water parks or agriculture.**
(right) **Businesses such as beer breweries, dairies and papermaking all use lots of groundwater.**



gent 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.

(For tips on how to protect the groundwater you drink and use, see page 25.)

Thirsty cities

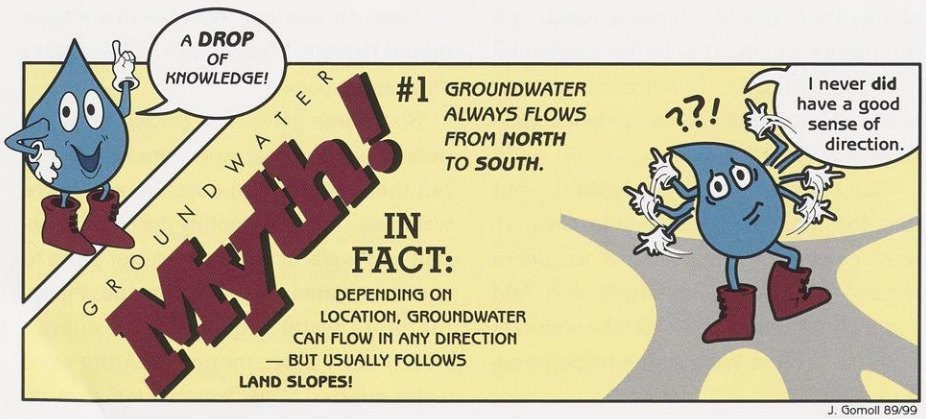
It's used to fight fires, clean streets, fill the local pool, sprinkle golf courses and parks, drench dry boulevard trees, supply commercial customers and satisfy the needs of thirsty residents at home or at bubblers (drinking fountains, to non-Wisconsinites) around town. Ninety-seven percent of Wisconsin's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

Wisconsin's municipal groundwater tab: A cool 314 million gallons per day. The top counties and main users: Dane County (Madison) 47 million gallons per day; La Crosse County (La Crosse), 17 million gallons per day; Rock County (Janesville and Beloit), 21 million gallons per day.

Average daily cost to a family of four in 1999: Less than 75 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, cheese-making, dairy farming, meat processing and brewing — need pure, clean groundwater to make the goods for which Wisconsin is famous.

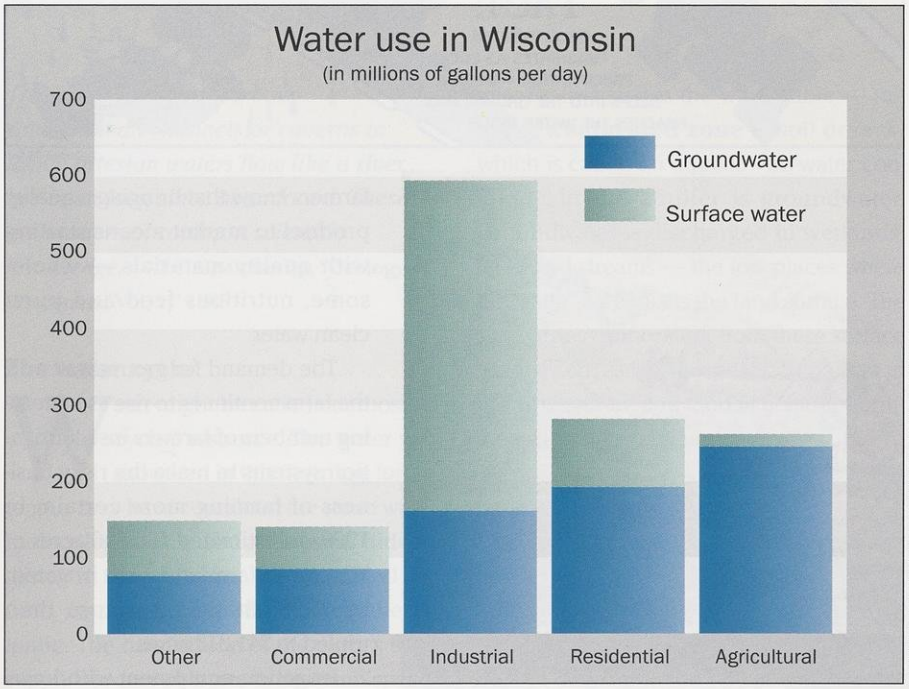


J. Gomoll 89/99

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...scores of the services and products we use daily depend on groundwater.

Fast food soaks it up: It takes 1,400 gallons of water to produce a meal of a quarter-pound hamburger, fries and soda. And so do cars, fast or slow: To produce one gallon of gasoline, six gallons of water are needed.

Commercial and industrial companies draw over 106 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.



MOONLIT INK FROM 1995 U.S. GEOLOGICAL SURVEY DATA

Wet and wild

2,444 trout streams
5,002 warm-water streams
15,057 inland lakes
5,331,392 acres of wetlands.

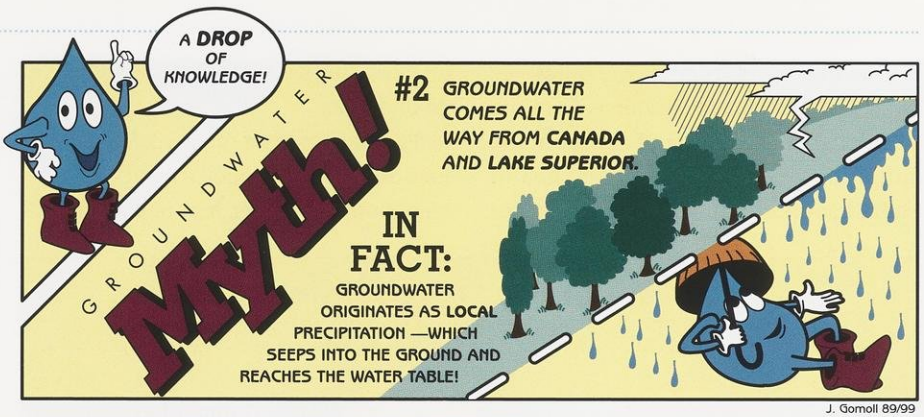
These figures add up to a $7.7 billion boost to Wisconsin's economy, provided by

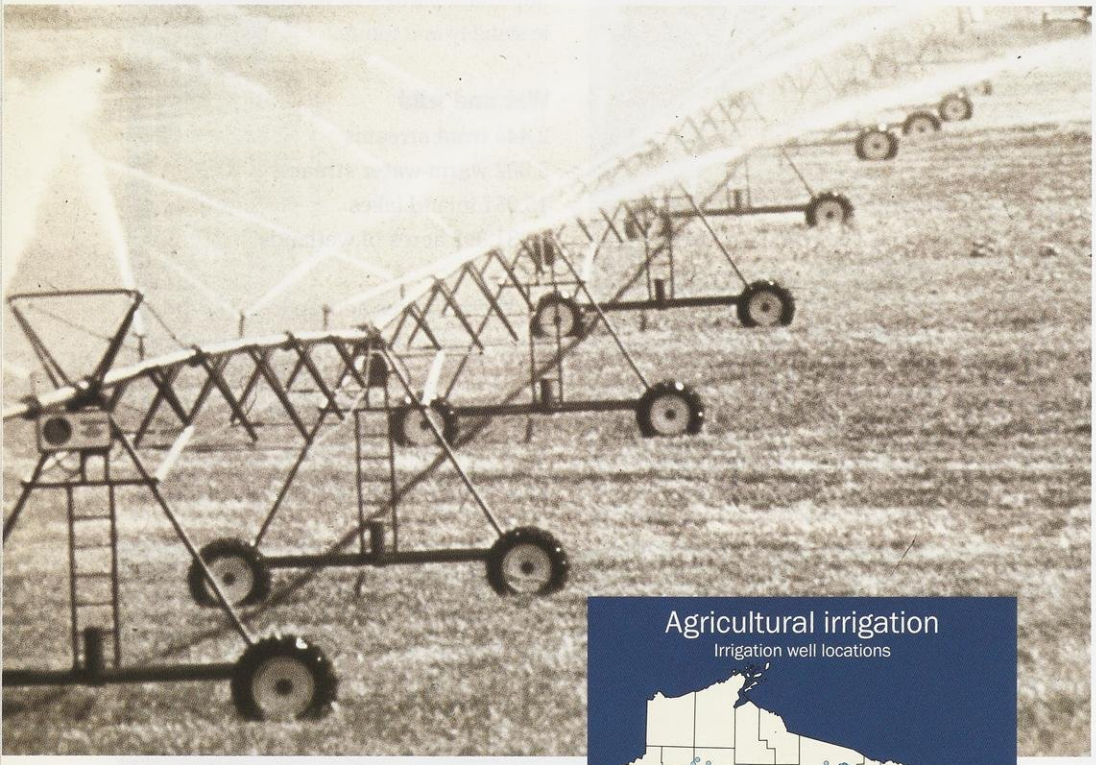
(left) **Groundwater provides most of the drinking water to homes and farms.**
(below) **Rain and snow melt that seep through soil recharge groundwater and are discharged to lakes, streams, rivers and spectacular sights like Amnicon Falls.**

DON BLEGEN

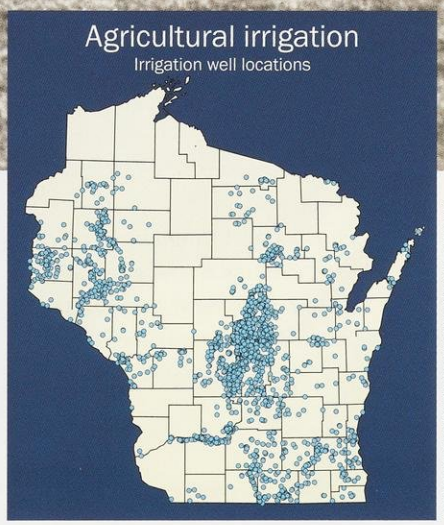
thousands of residents and tourists who visit the state each year to enjoy, among other things, our fabulous water resources. What they don't see is our most fabulous water resource of all: Groundwater.

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





THOMAS V. RIEWE



MICHELLE GREENWOOD, U.S. GEOLOGICAL SURVEY

The number of irrigated acres in Wisconsin has tripled since 1969. Irrigation wells were once only common in the Central Sands vegetable growing region. Now western, southern and southeastern businesses irrigate land as well.

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 — they're replenished by groundwater.

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 1,369,000 dairy cows in the state. How much water will they drink in a year?

If you said 22,485,825,000 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 78 million gallons of groundwater a day to water stock, maintain a high level of sanitation in the milkhouse and provide 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.

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, an estimated 105,526 acres of Wisconsin farmland were irrigated; by 1998, that figure more than tripled to 341,813 acres.

Irrigation equipment withdraws about 167 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.

While irrigation has helped formerly marginal lands turn a profit, there is a cost: Excessive irrigation may leach **nutrients**, fertilizers and pesticides into groundwater. ■

Understanding the resource

The idea that there are vast subterranean channels or caverns in which artesian waters flow like a river has been long since abandoned. These are matters of common scientific knowledge. — T.C. Chamberlin, "Geology of Wisconsin, Vol. 1," 1885

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 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.

Wisconsin receives an average 30 to 32 inches of precipitation per year. Seventy-five percent evaporates or transpires through plants and never reaches surface water or groundwater. 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 inch of water that runs off the land to a stream or lake in gently rolling Dane County, three 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.

Water distribution is governed by a phenomenon known as the **hydrologic**, or **water cycle**, which is kept in motion by solar energy and gravity. Start with a spring shower. As the rain 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. This water eventually reaches the water table — the top of a **saturated zone** of soil or rock, which is called an aquifer. The water contained in the aquifer is groundwater. Groundwater is discharged in wetlands, lakes and streams — the low places where the water table meets the land surface. The sun causes evaporation from these surface waters, and, as water vapor accumulates in the atmosphere and clouds begin to form, the water cycle begins anew.

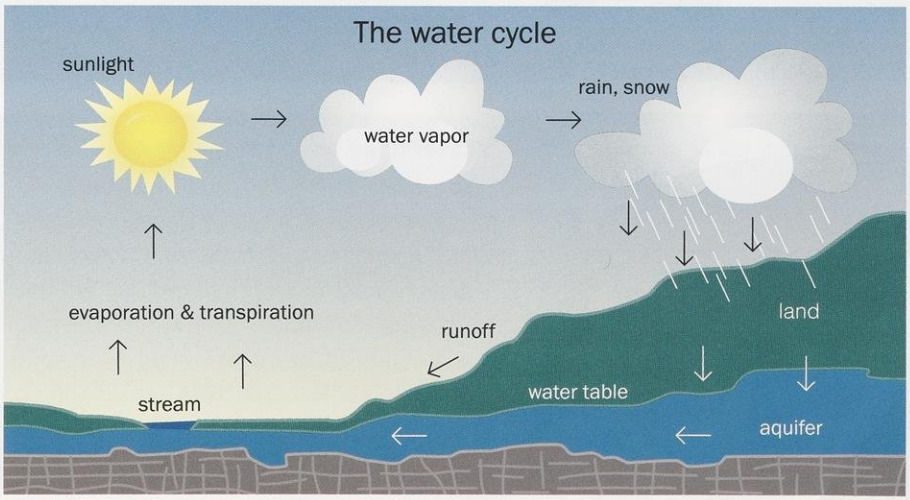
Groundwater on the move

Geology controls the rate of groundwater movement. The size of the cracks in rocks, the size of the pores between soil and rock particles, and whether the pores are connected determine the rate at which water moves into, through and out of the aquifer.

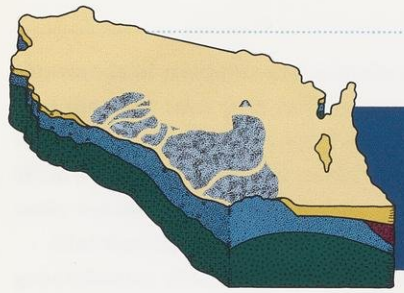
Water generally moves more quickly in coarse sand, sometimes as much as several feet per day. Openings between the grains are large and interconnected, resulting in high **permeability**. Very fine-grained material like clay has many pores where water can be stored, but the pores are so small that moving 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 is always moving toward a surface outlet or "discharge" area, following the slope of the water table. In Wisconsin, the natural movement is from upland **recharge areas** (those places where rain or melt water infiltrates the ground and reaches the water table) 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.**

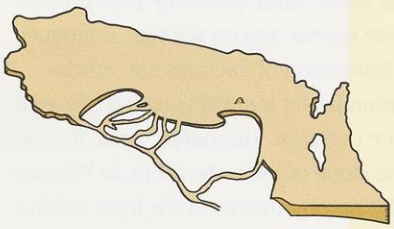
Perhaps you've wondered why some streams continue to flow during dry periods and in winter, when there's no rainfall. Winter stream flow is largely groundwater discharge (called **baseflow**) that remains at a relatively constant temperature year 'round — about 50° F. Streams, and most lakes and wetlands, are constantly replenished during the winter by groundwater from the surrounding uplands. That same 50° F groundwater baseflow is the reason streams stay icy cold in the summer. ■



MOONLIT INK



Wisconsin's aquifers



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 topsoil. These deposits are more than 300 feet thick in some places in Wisconsin.

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 **glacial drift**.

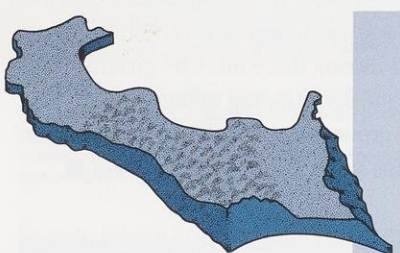
As the ice melted, large amounts of sand

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. The water yield from a **well** in this aquifer mostly depends on the number of fractures the well intercepts. As a result, it's not unusual for nearby wells to vary greatly in the amount of water they can draw from this layer.

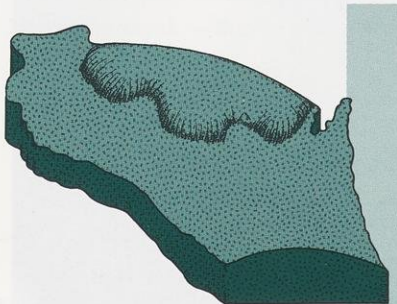
Where the fractured dolomite bedrock occurs at or near the land surface, the groundwater in shallow portions of the eastern dolomite aquifer can easily become contami-



Sandstone and dolomite aquifer

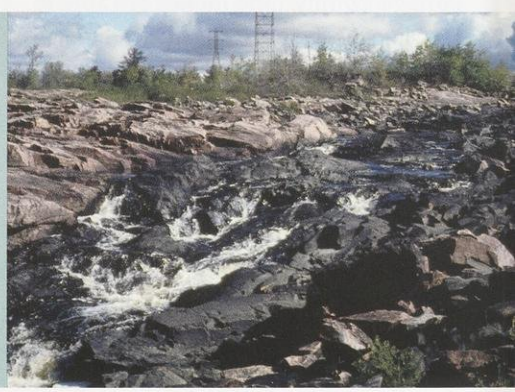
The sandstone and dolomite aquifer consists of layers of sandstone and dolomite bedrock that vary greatly in their water-yielding properties. In dolomite, groundwater mainly occurs in fractures. In sandstone, water occurs in pore spaces between loosely cemented sand grains. These formations can be found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



Crystalline bedrock aquifer

The crystalline bedrock aquifer is composed of a variety of rock types formed during 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, sediments, some of which were rich in iron and now form iron



A rock or soil formation that can store or transmit water efficiently is called an aquifer. Wisconsin's groundwater reserves are held in four principal aquifers: the sand and gravel aquifer, the eastern **dolomite** aquifer, the sandstone and dolomite aquifer, and the crystalline bedrock aquifer.

THOMAS V. RIEWE

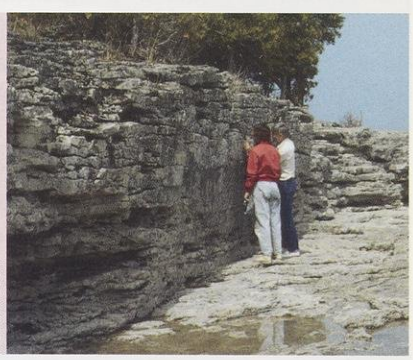
and gravel were deposited, forming "outwash plains." Pits were formed in the outwash where buried blocks of ice melted; many of these pits are now lakes. The sand and gravel aquifer was deposited within the past million years.

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.

nated. In those areas (such as parts of Door, Kewaunee and Manitowoc 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.

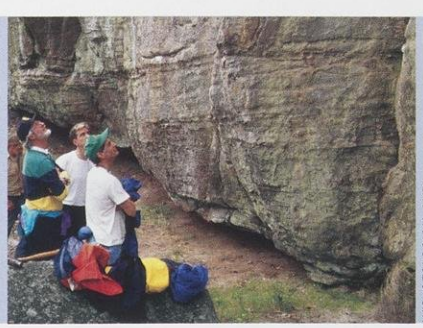
The Maquoketa shale layer beneath the dolomite was formed from clay that doesn't transmit water easily. Therefore, it is important not as a major water source, but as a barrier or shield between the eastern dolomite aquifer and the sandstone and dolomite aquifer.



KEN BRADBURY

coming much thicker and extending to greater depths below the land surface in the southern part of the state.

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



WIS. GEOLOGICAL AND NATURAL HISTORY SURVEY

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.

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, large dairy herds or industries.

Many wells in the crystalline bedrock aquifer have provided good 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. ■

Threats to groundwater

The land ethic simply enlarges the boundaries of the community to include soils, waters, plants and animals or collectively: the land. — Aldo Leopold, "A Sand County Almanac and Sketches Here and There," 1948

You name it — gasoline, fertilizer, paint thinner, bug spray — if it's used or abused by humans and dissolves in water or soaks through soil, it may show up in Wisconsin's groundwater. Urban areas require large quantities of groundwater to serve many people. Activities in urban areas that pose significant threats to groundwater quality include industrial and municipal waste disposal, road salting, and the storage of petroleum products and other hazardous materials.

In rural areas, less groundwater is used and different threats to groundwater quality exist. Animal waste, **septic systems**, fertilizers and pesticides are the primary pollution sources in rural areas. The "Groundwater and land use in the water cycle" poster included here shows how activities on the land interact with the water cycle. Refer to the poster to see how what we do on the ground affects groundwater.

The lifeblood of machinery, gasoline, can contaminate groundwater when emissions, spills and storage tank leaks escape.

ROBERT QUEEN

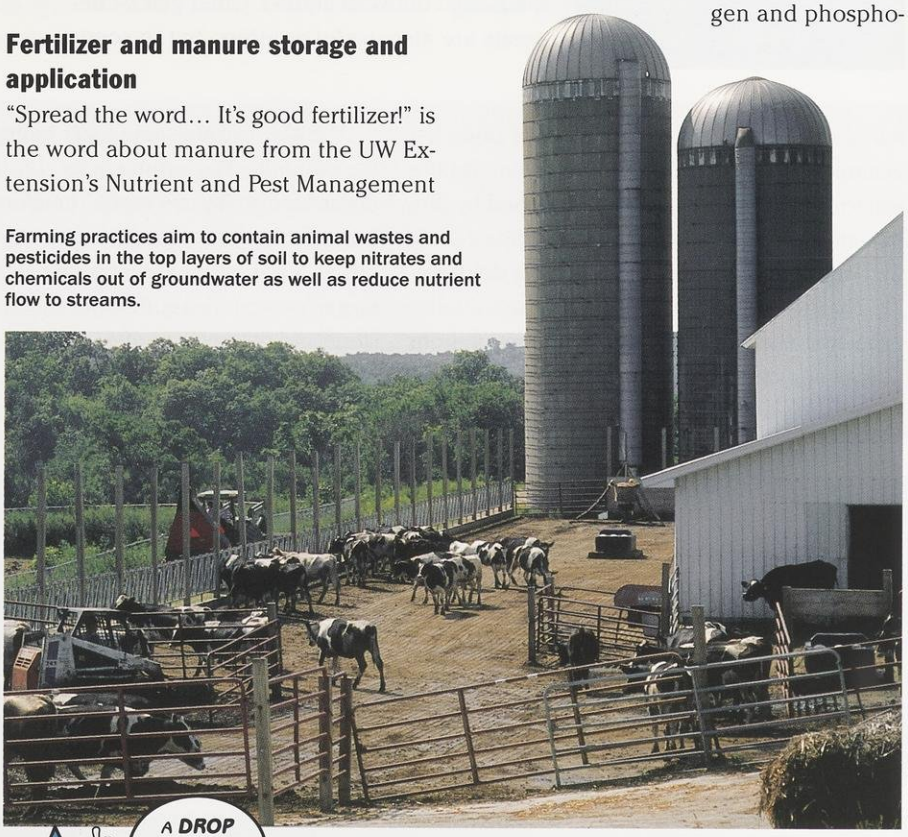
Air pollution is water pollution, too

Particles clouding the air from car exhaust, smokestacks and dust from city streets or farm fields can contribute to groundwater contamination. These particles of hydrocarbons and pesticides settle on the ground, only to be washed into the soil by rain, eventually to trickle into aquifers. And while a rain shower may disperse the particles from the air, the rains can carry the pollutants down into the ground as the water hits land.

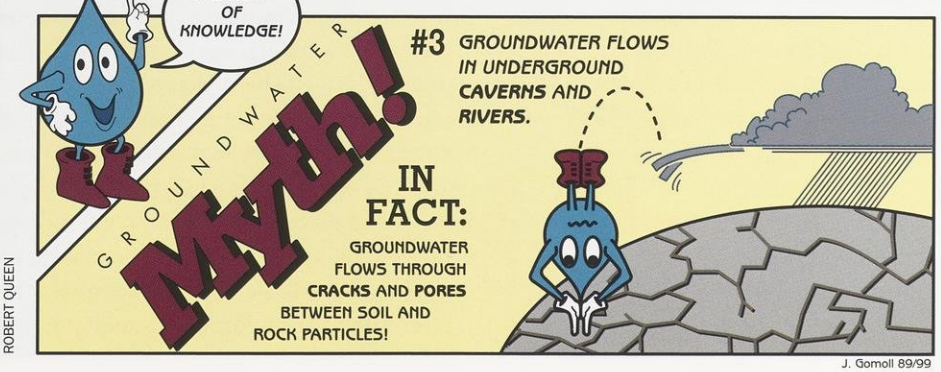
Fertilizer and manure storage and application

"Spread the word... It's good fertilizer!" is the word about manure from the UW Extension's Nutrient and Pest Management Program. To produce good yields, farmers need to apply the nitrogen, phosphorus and other nutrients in manure and fertilizer to their crops. Those nutrients plants can't use will leach into groundwater. Excessive or improper application of manure and fertilizer is Wisconsin's leading source of nitrate pollution in groundwater. Plants can be over-fertilized if farmers don't account for the nutrients contained in the manure they spread on their fields. Proper crediting of the nitrogen and phospho-

Farming practices aim to contain animal wastes and pesticides in the top layers of soil to keep nitrates and chemicals out of groundwater as well as reduce nutrient flow to streams.



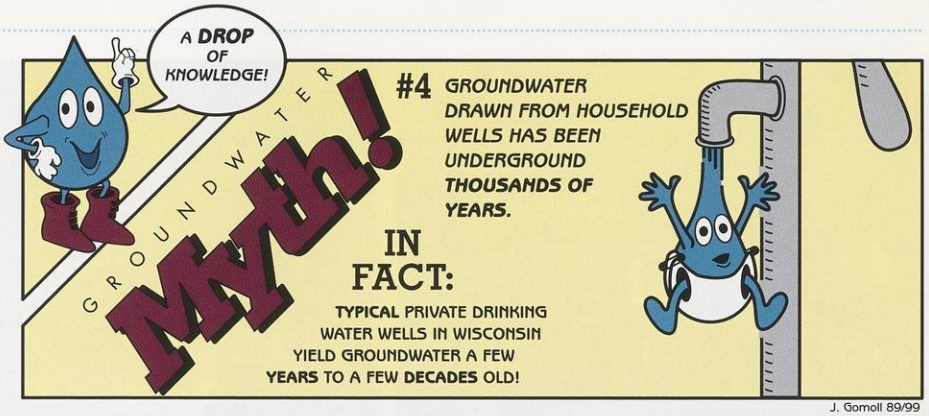
ROBERT QUEEN



J. Gomoll 89/99

rus in manure saves farmers the cost of purchasing extra commercial fertilizer — and also protects groundwater.

About 10 percent of the private well samples analyzed for nitrate in rural areas show groundwater contamination above the state groundwater standard. Infants under six months and pregnant women should not drink water with nitrate levels above 10 parts per million — Wisconsin's groundwater standard. Mixing baby formula with high nitrate water does threaten infants under the age of six months, because 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. Methemoglobinemia, or "blue baby syndrome" can cause suffocation. Using bottled water or water with low levels of nitrate can prevent the condition. Nitrate is not usually harmful to adults or older children, though scientists are currently studying the potential health effects.



ROBERT QUEEN (INSET) DEAN TVEDT

(above) **Light sandy soils that quickly drain water are particularly vulnerable to groundwater contamination. Pesticides need to be sparingly, carefully applied to minimize problems.**
(inset) **These days nurse tanks for pesticides and fertilizers are filled and stored on concrete pads where any spills can be contained from seeping into the ground.**

Use and misuse of pesticides

Insecticides, herbicides and fungicides have been used in Wisconsin agriculture for a long time. These pesticides can reach groundwater when spilled at storage, mixing and loading sites, or when over-applied to fields. "Empty" pesticide containers not properly disposed of are another source of trouble. Just a little spill of most pesticides can have a big impact on groundwater quality. For example, three parts per billion of atrazine in groundwater is enough to increase the risk of cancer in drinking water.

Protecting groundwater from pesticide contamination while maintaining farm profitability isn't easy — too much pesticide and the environment suffers; too little and crop yield goes down. Integrated pest management, or IPM, is a pest control strategy that uses all appropriate control methods (chemical and nonchemical) to keep pest populations below economically damaging levels while minimizing harm to the environment. Here's how it works: Farmer Johnson "scouts" her fields for weeds and pests. After she has identified what is present, she purchases and applies the minimum amount of herbicides and insecticides only in the areas where weeds and bugs are a problem. Farmers using IPM find they spend less on pesticides. It's a bargain for the environment, too.

Landfills

Thanks to your recycling efforts during the last decade, the amount of waste going into Wisconsin's landfills has been reduced by 40 percent. The wastes we can't reuse are disposed of in properly sited, designed, constructed and maintained land-

(LEFT) WENDY WEISENSEL (RIGHT) TRACEY TEODECKI

Ideal landfill locations are in dry areas outside of floodplains, far from surface water and well above the water table. These waste burial sites are underlain with compacted clay soils, perforated pipes to collect leachate and heavy-duty plastic liners to capture gases and liquids before they leak into groundwater.

fills, which prevent **leachate** (the foul liquid that forms when water percolates through solid waste) from polluting groundwater. There are 86 highly engineered licensed landfills in Wisconsin that do a good job of protecting groundwater.

We weren't always so fortunate. In the early 1970s about 2,000 dumps were identified by DNR. Those located near navigable waters, within floodplains, wetlands or critical habitat were ordered closed. Remaining landfills posing a threat to the environment due to hydrogeologic setting or poor operation were required to monitor groundwater and surface water. The monitoring data indicated that some landfills and open dumps were causing groundwater pollution.

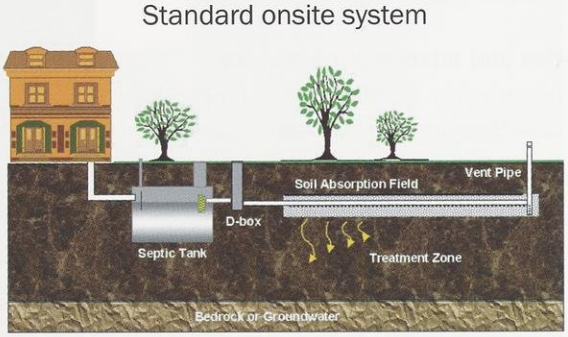
Based on the data, and current state and federal regulations, all landfills are now required to have a composite liner system (a plastic membrane on top of four feet of compacted clay) and a leachate collection system to keep liquid waste out of the groundwater. Municipal dumps that did not meet design standards were closed in 1992.

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 small community sewage plant, where a lagoon may be used as the final step in treatment before purified waste is released to rivers or streams, or applied to land.

Lagoons are sealed with compacted clay or plastic liners. Nevertheless, burrowing animals or movement of the soils over time can cause leaks. Routine inspections are necessary to keep lagoons in good repair. Open-air lagoons also are subject to wet and cold weather, which can interfere with the treatment process.

Some industries dispose of their wastewater by applying it to farm fields. The waste is applied according to how much water and nutrients soil and crops can absorb. If the system isn't managed properly, and too much waste and water are applied to the land, or if the operator fails to adjust



LEROY JANSKE

Septic systems flush wastes into a tank where solids settle to the bottom, liquids percolate through gravel, and soil absorbs organic matter before it reaches groundwater.
(below) **Installing a septic drainage field.**

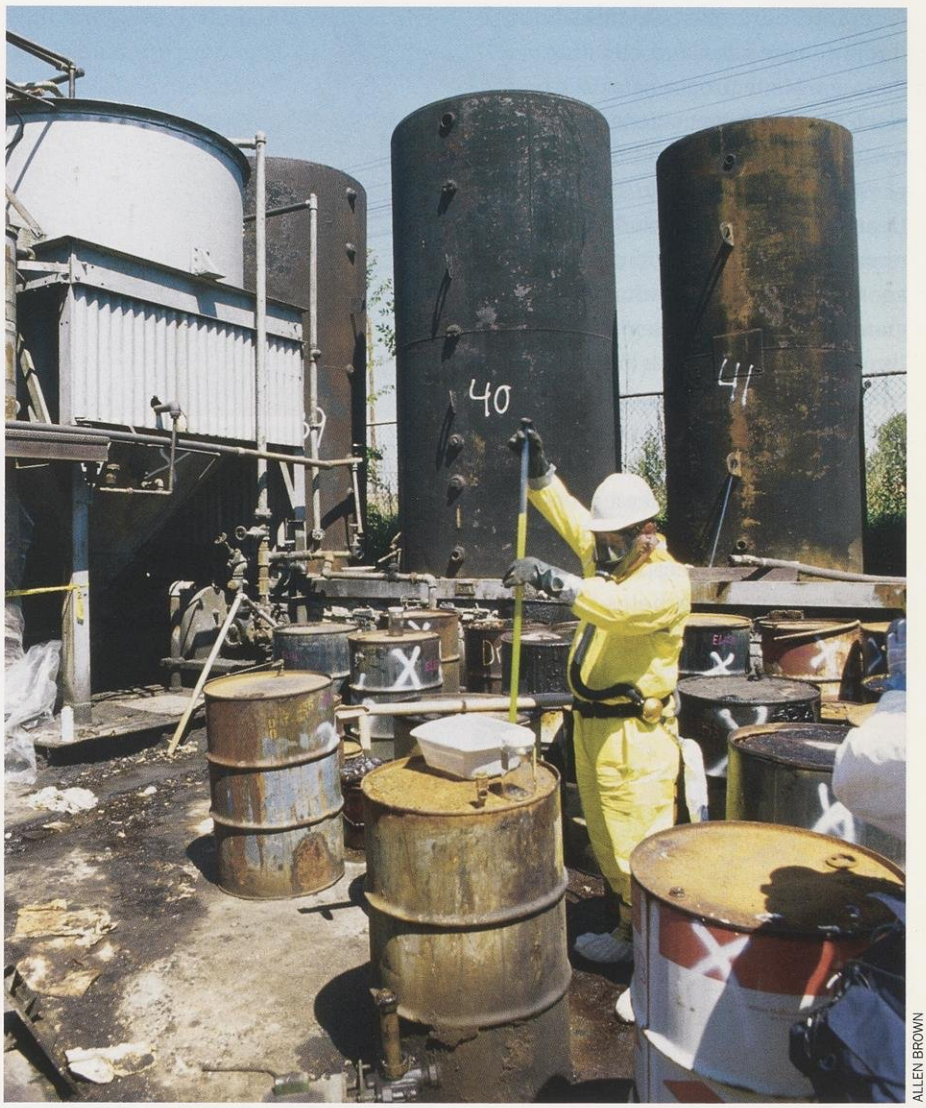
DNR DRINKING WATER & GROUNDWATER SECTION

the amount of liquid applied to account for rainfall, groundwater can be contaminated.

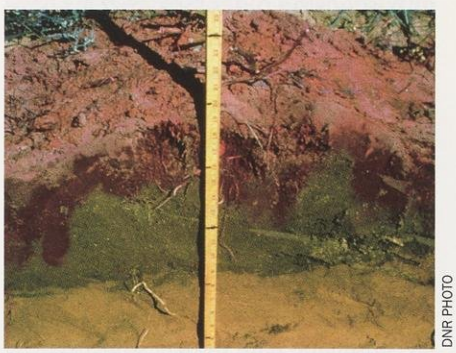
Private onsite wastewater treatment systems

There are almost 690,000 **private onsite wastewater treatment systems** (septic systems) in Wisconsin — serving approximately 30 percent of all households in the state. Most septic systems are located in unincorporated areas. Here's how septic systems work: waste flows from the house to a settling tank where solids settle out. Liquids continue out to an absorption field. Bacteria in the settling tank break down solid waste leaving a **sludge** that needs to be removed periodically by a "honey wagon." The liquid seeps into the soil and is used by plants, or leaches into soils and groundwater.

When systems fail, bacteria, nitrate, viruses, detergents, household chemicals and chloride may contaminate groundwater and surface water, and pose public health threats. Even properly installed septic systems may pollute groundwater if they are not used and maintained correctly. About nine percent of the nitrate reaching groundwater in Wisconsin comes from septic systems. Substances such as paint thinner and pesticides can easily leach to groundwater through the absorption field and should never be flushed down a home septic system. (For tips on maintaining septic systems, see pages 26–27.)



ALLEN BROWN



DNR PHOTO

Inventorying abandoned chemicals stored in leaky barrels. Millions are spent in Wisconsin annually cleaning up such sites and stopping groundwater contamination.
(right) **A soil cross-section shows how tracer dyes poured at the surface seep toward groundwater.**

Spills and illegal dumping of industrial and commercial chemicals

When paint thinners, degreasers, electroplating solutions, dry cleaning chemicals, used oil, and a host of other hazardous materials trickle into the groundwater, they contaminate the precious liquid that keeps us all alive.

Accidents happen — over 1,200 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.

In the past, first responders to the scene of a spill would attempt to eliminate a fire or safety hazard by flushing the spilled material to a ditch or sewer — bad news for the environment. Thanks to better training, most response efforts now focus on containing and removing the hazardous material to a proper disposal facility. This protects both groundwater and surface waters from becoming contaminated.

An undetermined number of spills go unreported, their presence a secret until area wells become polluted. Although there are strict regulations governing the transport, storage, and disposal of toxic and hazardous wastes, illegal dumping of dangerous compounds continues. Problems from past practices that occurred before regulations were in place still surface periodically.

The threat to groundwater from these toxic products is real. That's why state and

federal resources are devoted to finding these sites and cleaning them up. Many programs exist to clean up sites, from the federal Superfund program to address the worst sites in the nation, to the state cleanup program that includes spill response, leaking underground storage tanks, the state Superfund program, and a focus on cleaning up "brownfields." Brownfields are properties that have been abandoned or are underutilized because of actual or perceived contamination. By cleaning up and reusing these properties, we protect surrounding "green fields" from being developed and paved over. This helps keep groundwater replenished, reduces urban sprawl, and prevents future contamination of clean areas.

ROBERT QUEEN

DNR DRINKING WATER & GROUNDWATER SECTION

An aggressive program aims to locate, replace or remove buried tanks that can leak stored fuels. Few tanks leak this badly, but even small amounts of gasoline make water unfit for use in residences, businesses and for animals. Cleanups are expensive costing on average more than $50,000.

Leaking underground storage tanks

People in the environmental cleanup business call them LUSTs; for all of us, it spells trouble. Many old leaking underground storage tanks that used to hold gasoline, diesel and fuel oil have slowly corroded and released their contents into the soil and groundwater. Over 13,000 of Wisconsin's older tank systems have leaked as rust took its toll on the tanks and dispensing lines. Even small leaks have caused significant groundwater contamination. Many small leaks went undetected for years. It only takes a little gasoline in water to make it undrinkable; larger quantities seeping into wells or basements can cause explosions.

Property owners and their environmental consultants have been at work cleaning up LUST leaks. Regulations, in place for 10 years now, will help prevent future problems. Rules adopted by the Department of Commerce require that tank systems have corrosion protection, leak detection systems, and spill and overfill containment devices. Older tanks are required to either be upgraded to current standards or to be emptied and removed. The soil is sampled under commercial storage tanks that are removed.

The nature of cleanup operations has changed significantly over the years. Monitoring petroleum contamination as it breaks down into harmless by-products has in many cases replaced soil excavation and groundwater "pump and treat" at locations where the contamination is not spreading.

Abandoned and drainage wells

Years ago, wells were dug by hand with picks and shovels. Hand dug wells were gradually replaced with "well pits" — a six to 10-foot-deep hole through which a well was drilled or driven. Both types are now being replaced by wells that provide more sanitary water.

What happens to the old well can determine how the new well functions. If old wells are not properly filled with cement, bentonite clay or other impermeable materials, they provide a direct channel for pollutants from the surface to groundwater and to other nearby wells. Many thousands of old wells no longer used, but still open at the soil surface threaten Wisconsin's groundwater. Whenever you see an old windmill in the country, it's likely there's an abandoned well underneath. Wisconsin law allows well owners to abandon certain types of wells using procedures developed by the DNR. Licensed well drillers and pump installers are routinely hired to fill old wells. (See page 28 for more information on abandoning wells.)

Drainage wells are used to draw water off a section of wet ground by piercing a clay layer and allowing surface water to run directly into groundwater. Drainage wells have been prohibited in Wisconsin since 1936, but they do turn up occasionally, often when a problem is discovered in a well at a nearby home or farm.

Sources of natural contamination

Minerals existing naturally in soils and rocks dissolve in groundwater, giving it a particular taste, odor or color. Some minerals, such as calcium and magnesium, are beneficial to health. Radium, radon gas, uranium, arsenic, barium, fluoride, lead, zinc, iron, manganese and sulfur are undesirable ingredients found in Wisconsin groundwater. Naturally occurring radioactivity in groundwater, including uranium, radium and radon, has recently become a concern in Wisconsin. Radioactive contaminants expose those drinking the water to risk of cancer. The state now tests groundwater for radioactivity. Recent sampling has detected **radionuclides** in some north central Wisconsin groundwater. **Gross alpha activity** and radium have also been found in water supplies in east-

ern Wisconsin. The EPA has set drinking water standards for radium and radon.

The problem posed by most natural contaminants is aesthetic rather than safety. Iron is found throughout the state. It stains plumbing fixtures and laundry, and can give drinking water an unpleasant taste and odor. Excess levels of fluoride, manganese, sulfur, lead and arsenic are less common and more localized. In some parts of Wisconsin the groundwater is naturally acidic and can corrode pipes and plumbing, leading to elevated levels of lead and copper in drinking water.

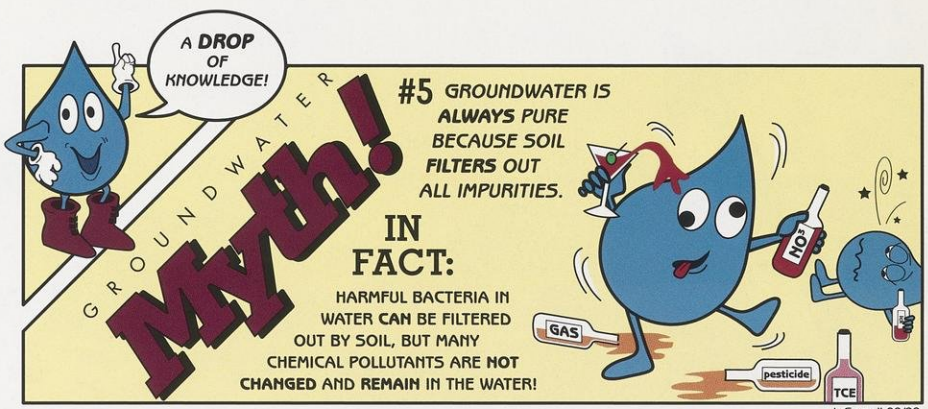
Overuse

Despite a general abundance of groundwater in Wisconsin, there is growing concern about the availability of good quality groundwater for municipal, industrial, agricultural and domestic use, and for adequate baseflow to our lakes, streams and wetlands. Natural shortages of groundwater have occurred due to weather conditions and geologic setting (e.g., prolonged drought and crystalline bedrock aquifers with low yields). Human activities also cause quantity problems. Groundwater withdrawals in the Lower Fox River Valley, southeastern Wisconsin and Dane County have caused substantial declines in groundwater levels. Human-caused pollution has limited groundwater use in some areas of the state such as Wausau, where industrial pollutants were present in the only aquifer able to supply water to the city. The presence of naturally occurring substances in groundwater such as iron, sulfate or arsenic also limit groundwater availability in some areas. And, when large areas of land are paved over, there is less space for water to seep into the ground and recharge our aquifers.

Groundwater cleanup

Groundwater contamination can be linked to land use. What goes on the ground can seep through the soil and turn up in drinking water, lakes, rivers, streams and wetlands. Tracking down and stopping sources of pollution can be expensive and time consuming. It's usually impossible to completely remove all traces of a pollutant and clean up the aquifer to a usable condition. The cost of even a partial cleanup can be enough to empty the deepest pockets.

Who pays the enormous cost of groundwater cleanup? Logically, the owner or operator of the facility causing the pollution should shoulder the cleanup cost. What happens when the owner is bankrupt, out of business or dead? Then, taxpayers must step in. Federal and state money is used for cleaning up sites and enforcing laws governing disposal of wastes.

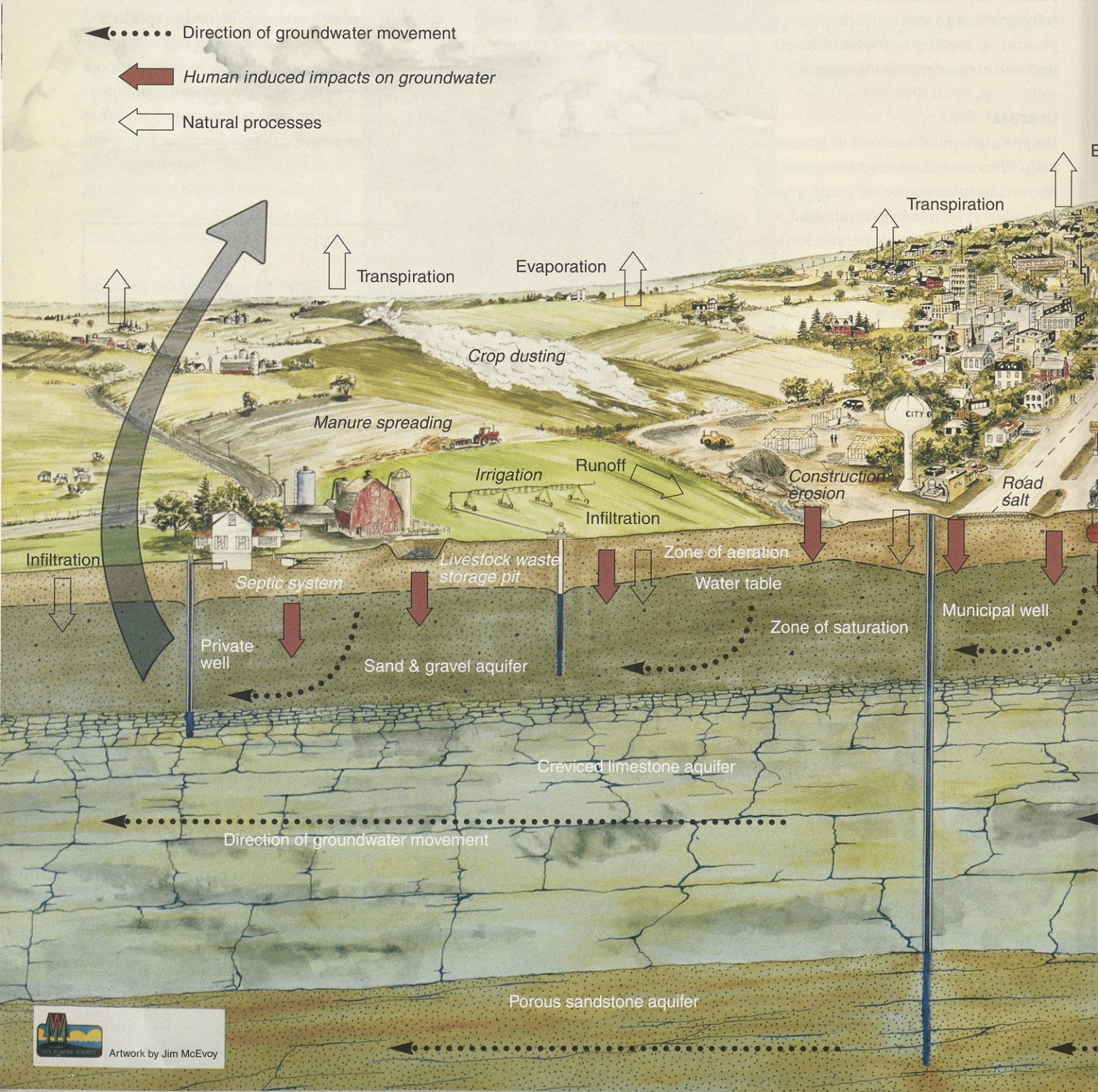


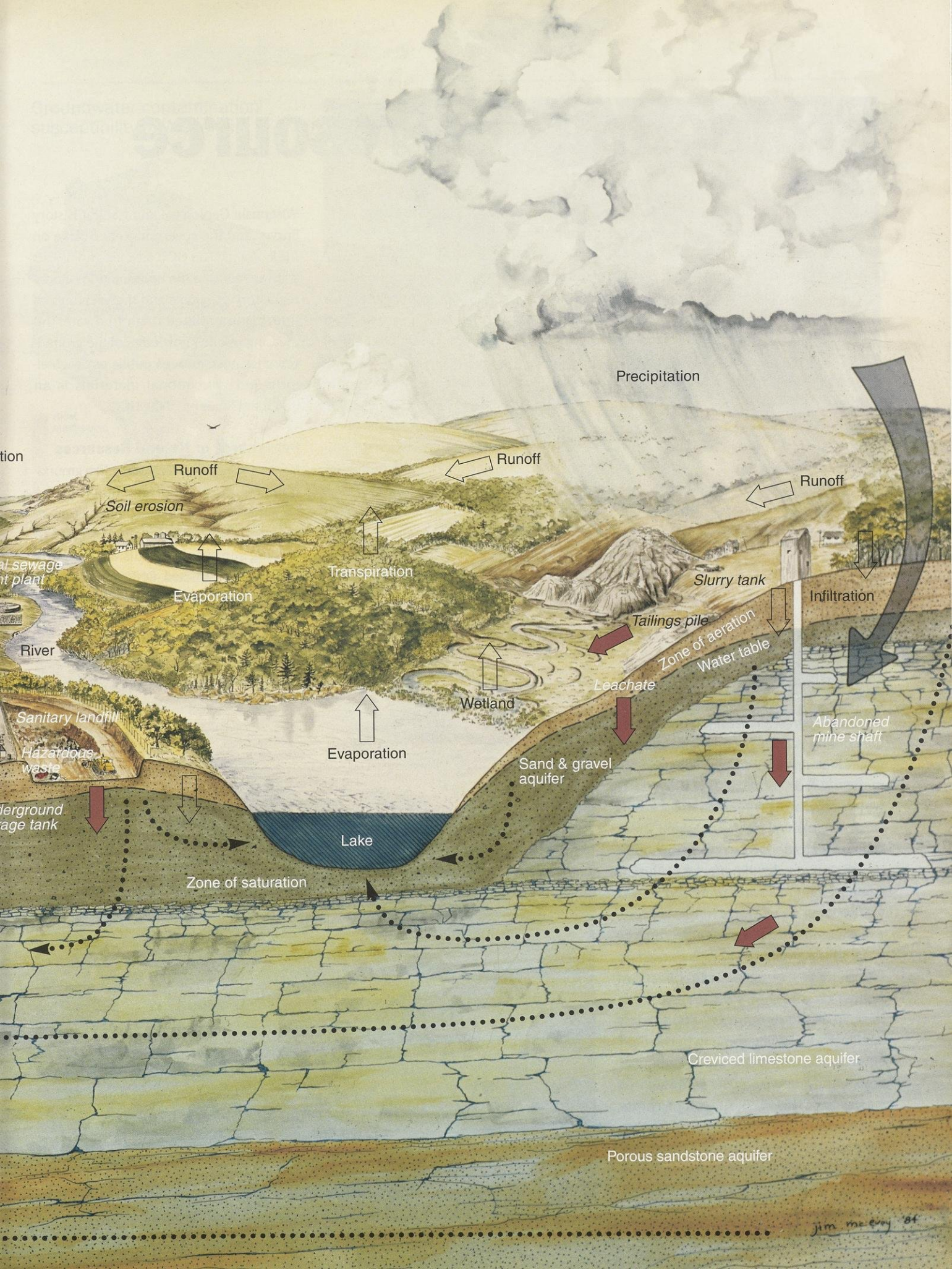
STATE HISTORICAL SOCIETY OF WISCONSIN

Old wells provide a direct pipeline for surface contaminants to reach groundwater. By code, wells must be filled with cement or bentonite clay before they are considered properly abandoned.

When it comes to groundwater, the best strategy is prevention. Prevention means looking at the many ways we pollute groundwater, and finding methods to keep those pollutants at bay. Landfills and wastewater lagoons need to be sited, designed and operated to prevent **infiltration** to groundwater. Illegal dumping must be prosecuted to the fullest extent of the law. Pesticides must be applied according to need and label instructions, and nutrients should be applied in carefully calibrated amounts to enhance crops without damaging the environment. With vigilance and care, we can protect our buried treasure. ■

Groundwater and land use in the water cycle




Precipitation
Runoff
Runoff
Runoff
Soil erosion
Transpiration
Evaporation
Slurry tank
Infiltration
Tailings pile
Zone of aeration
Water table
River
Wetland
Leachate
Sanitary landfill
Abandoned mine shaft
Hazardous waste
Evaporation
Sand & gravel aquifer
Lake
Zone of saturation
Creviced limestone aquifer
Porous sandstone aquifer
jim mcevoy '84

Protecting the resource

"Waters of the State" includes all those portions of Lake Michigan and Lake Superior within the boundaries of Wisconsin, and all lakes, bays, rivers, streams, springs, ponds, wells, impounding reservoirs, marshes, water courses, drainage systems and other surface water or groundwater, natural or artificial, public or private, within the state or its jurisdiction. — Chapter 144, Wisconsin Statutes.

Wisconsin's Groundwater Law

Groundwater protection emerged as a major concern in the late 1970s as interest groups, spurred on by events like Love Canal in New York and the detection of the pesticide Aldicarb in some Wisconsin private wells, debated how to protect groundwater in an industrial and agricultural society. On May 4, 1984, Chapter 160 of the Wisconsin Statutes was signed into law.

Chapter 160, dubbed the "Groundwater Law," has been called the most comprehensive regulatory program for groundwater in the country. All state agencies involved in groundwater protection must adhere to numerical standards that define the level at which regulatory agencies must act to clean up pollutants in groundwater. These standards are defined not only by public health, but also by the effect a pollutant can have on the environment and public welfare.

One of the most important features of Wisconsin's groundwater law is something that is not in it — aquifer classification. Aquifer classification involves looking at the use, value or vulnerability of each aquifer and allowing some to be "written off" as industrial aquifers not fit for human consumption. Wisconsin said "no" to aquifer classification. The philosophical underpinning of Wisconsin's groundwater law is the belief that our groundwater is capable of being used for citizens to drink, and must be protected to assure that it can be.

The Groundwater Coordinating Council

When you think about all the diverse activities and events that can affect groundwater, it's no surprise that the responsibility for managing our buried treasure is delegated to many different government agencies. Cooperation is the key — and the Groundwater Coordinating Council (GCC) is the group turning the key. Since 1984, the GCC has served as a model for interagency coordination among state government officials, the governor, and local and federal governments.

Representatives from the departments of Natural Resources; Commerce; Agriculture, Trade and Consumer Protection; Health and Family Services; Transportation; the University of Wisconsin System; Wisconsin Geological and Natural History Survey and the governor's office serve on the council. The GCC advises and assists state agencies in the coordination of nonregulatory programs and the exchange of information related to groundwater. Increasing public knowledge of the groundwater resource through public outreach efforts and educational materials is an important function of the GCC.

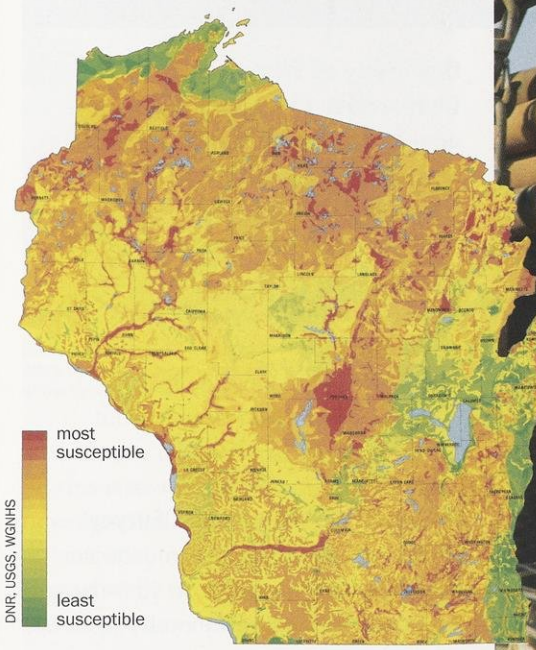
Department of Natural Resources

It's only natural that a resource like groundwater receives a lot of attention from the Department of Natural Resources. From insuring that the water you drink is clean to making sure new landfills are properly sited and constructed, DNR staff are there. Groundwater activities carried out by the

Field surveys examine how groundwater discharge affects aquatic life.

ROBERT QUEEN

Groundwater contamination susceptibility in Wisconsin



DNR, USGS, WGNHS

ROBERT QUEEN

For each new well drilled, a report detailing soil types, soil depths, bedrock and groundwater elevation is sent to the DNR and Wis. Geological and Natural History Survey. The information helps to map subsoil geology and groundwater movement.

DNR encompass protecting the resource, cleaning it up and making sure that public health and environmental standards are set and met.

Protecting groundwater means preventing what goes on the ground from going into groundwater. By looking at soil and rock types, thickness of soil and rock layers, and depth to groundwater, DNR engineers, hydrogeologists, and specialists can make decisions about where waste can be spread, or if a landfill can be safely installed at a particular site. The map of Groundwater Contamination Susceptibility in Wisconsin — put together by DNR, the United States Geological Survey and the Wisconsin Geological and Natural History Survey — shows areas of the state that are more (and less) sensitive to contamination because of the soil and rock overlying the groundwater.

At sites that have contaminated groundwater, DNR staffers must find and remove the source of pollution and determine how far contamination has spread. To do this, they use groundwater monitoring wells to collect samples for chemical analysis. When the boundaries of the contamination are known, the difficult job of cleaning up the groundwater can begin. Some sites take years and millions of dollars to clean up. In the case of groundwater, a drop of prevention is truly worth a gallon of cure.

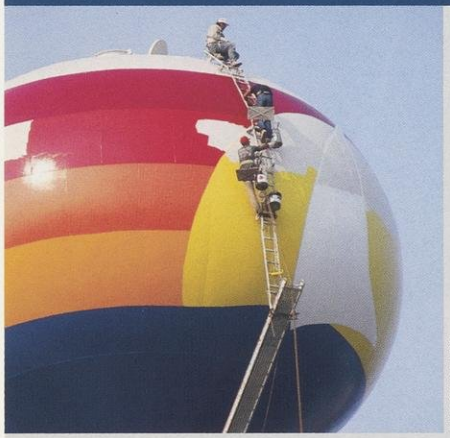
One way to insure safe drinking water is to protect the area around water supply wells from sources of contamination. Wellhead protection is a relatively new program allowing municipalities to restrict land use around public water supply wells. Industrial sites and wastewater lagoons don't belong next to drinking water wells.

DNR's Source Water Assessment Program identifies land areas that contribute water to public wells, conducts inventories of potential contaminant sources, and determines the susceptibility for each public water supply. The assessments will assist water system operators in preparing wellhead protection plans.

Wisconsin Geological and Natural History Survey

Since 1854, staff at the WGNHS has cataloged Wisconsin's geology, **hydrogeology**, soils, biology and other natural resources. The Survey is the principal source for maps and records about Wisconsin groundwater and related geology. It supplies counties and regional planning agencies with information to make land use and wellhead protection decisions. Research conducted at the Survey helps state agencies manage Wisconsin's groundwater more effectively. The Survey reviews, sorts and catalogs about 18,000 well construction reports yearly. A collection of well cuttings and rock samples from about 300 wells per year are housed and described by the Survey — "hard" evidence of what's hidden below ground. County studies of geology and

Who's in charge of groundwater?



ROBERT QUEEN

Department of Natural Resources

- regulates sewage lagoons, municipal and industrial wastewater systems
- regulates landfills, solid waste and hazardous waste disposal
- regulates environmental consequences of mining
- responds to hazardous spills
- regulates public drinking water systems
- regulates well drilling
- provides water quality planning
- sets drinking water standards
- monitors groundwater, samples well water
- sets state groundwater quality standards
- issues permits for animal waste management
- administers the land recycling (brownfield) program
- educates school children and adults about groundwater

Wisconsin Geological and Natural History Survey

- maps and inventories groundwater resources and geological formations
- writes technical reports and assists regulatory agencies
- monitors groundwater levels and water quality
- educates about hydrology and groundwater resources

Department of Transportation

- conducts road salt and groundwater research
- regulates road salt storage

Department of Health and Family Services

- holds public meetings on contaminated water supplies
- recommends enforcement standards for substances of health concern
- investigates health effects from contamination
- inspects water supplies at restaurants, hotels, motels and campgrounds

Department of Commerce

- inspects and keeps records on underground storage tanks
- enforces septic system regulations
- approves home water treatment devices
- runs the brownfield grant program
- educates business and landowners about tank laws

Department of Agriculture, Trade and Consumer Protection (DATCP)

- regulates pesticide use and cleanup
- inspects fertilizer and pesticide storage facilities
- inspects water supplies of food processors and Grade A dairy farms
- licenses water bottlers
- educates food and agricultural interests about groundwater
- researches where pesticides have entered groundwater
- oversees farm nutrient management

University of Wisconsin

- researches the occurrence, effects and prevention of groundwater pollution
- educates students and working professionals about groundwater issues
- maintains water resource references

University of Wisconsin Cooperative Extension: UWEX county offices and the Central Wisconsin Groundwater Center at UW-Stevens Point

- tests private wells
- educates homeowners and local government about groundwater issues
- provides community outreach
- conducts applied research about groundwater

United States Geological Survey

- researches surface and groundwater interactions
- monitors groundwater levels

State Lab of Hygiene

- analyzes private well water samples
- researches virus and pathogen occurrence in groundwater

County government

- issues permits and inspects septic systems
- with DATCP, establishes standards for manure storage pits

ROBERT QUEEN

You

- ensure proper use and disposal of household chemicals
- maintain wells and septic systems
- stay active in community land use issues
- report illegal or abandoned waste sites to DNR
- participate in community recycling programs

ROBERT QUEEN

Road salt used to be stored in huge uncovered piles that were handy, but polluting when rain and snow created a salty brine.

BOB PEARSON, WIS. DEPT. OF TRANSPORTATION

Attractive shelters like these in Wyocena keep road salt dry until needed.

groundwater are produced for use by anyone interested in the groundwater **hydrology** of a specific area.

Department of Transportation (DOT)

Salt keeps Wisconsin's highways safe but it can be a source of groundwater pollution. The Department of Transportation has set standards for the storage of road salt. Storage sites must have an impermeable base and cover, and a holding basin must be constructed to contain runoff. DOT works with DNR and Commerce staff to clean up groundwater pollution from petroleum storage tanks and other hazardous waste sites along DOT right-of-ways, and where new roads and bridges are planned. They also set guidelines for how often and how much salt is applied to roads in winter.

Groundwater research verified how quickly nearby contaminants washed pollution through a sinkhole into groundwater and seeped out to a discharge area. Pollution spreads wide, deep and quickly where the rock is fractured near the surface.

DNR DRINKING WATER & GROUNDWATER SECTION

Department of Health and Family Services (DHFS)

Who do you call to find out if pollutants in your well or drinking water supply are a health risk to you and your family? Chances are, you contact your local health department. If they don't have the answer, the toxicologists at the DHFS can help you. The DHFS provides health information and advice on contaminants to individuals, and to state, county and local government agencies. When groundwater pollutants affect a community, DHFS staffers work with residents and participate in public meetings to let citizens know the risks associated with contaminants in the water supply. They advise how to best protect families and drinking water.

DHFS protects groundwater and the people who drink it by recommending standards to DNR for substances in groundwater that can cause health problems. The agency conducts studies on the harmful effects of chemicals to determine "how much is too much." It also works with DATCP to determine how new pesticides will break down in groundwater and what health risks are associated with these compounds.

Department of Commerce

Ensuring that underground and aboveground storage tanks don't leak keeps staff at Commerce busy. The agency keeps records on over 180,000 tanks used to store gasoline, fuel oil and other products. If a tank does leak, the department is there to help with the Petroleum Environmental Cleanup Fund (PECFA). The fund provides

ROBERT QUEEN

ROBERT QUEEN

Manure control in barnyards, careful fertilizer and pesticide applications, and tilling methods that minimize exposed soil can reduce chemical, nutrient and bacterial flow from farms to groundwater.

money to reimburse owners for part of the cleanup costs of leaks from petroleum product storage systems and home heating oil tanks.

Commerce has an interest in another kind of tank — septic tanks. With the assistance of local and county officials who issue permits and/or conduct regular inspections, Commerce helps protect groundwater.

Commerce also helps individuals, businesses, local development organizations and municipalities revive abandoned industrial sites or "brownfields" by providing grant money for site assessment and cleanup. Since the program's inception in 1997, 321 acres have been revitalized. This translates into 2,800 new jobs at 26 different locations throughout the state.

J. Gomoll 89/99

Department of Agriculture, Trade and Consumer Protection (DATCP)

Pesticides and nutrients can leach to groundwater, causing risks to human health and the environment. DATCP is responsible for regulating most aspects of agrichemical application, storage and cleanup in Wisconsin. To promote the proper handling, storage and safe use of farm chemicals, pesticide applicators and sellers must complete a certification program and be licensed by DATCP. Field staff regularly inspect if storage and mixing facilities comply with groundwater protection regulations. If a spill does occur, money and staff are available to help with the cleanup.

The Nutrient Management Program helps prevent groundwater pollution by providing funding to counties to help farmers write nutrient management plans. Nitrogen can leach into groundwater if manure and fertilizers are applied to crops in excess of what is used by plants. The Agricultural Clean Sweep program provides funding to counties for collection and disposal of farm chemicals. Farmers can safely get rid of old chemicals for free.

University of Wisconsin-Extension

The wise use of the groundwater resource is a priority for the University of Wisconsin–Extension. Traditionally, extension agents and specialists provided farm families with the tools needed to improve the quality of life. Today their role has evolved into maintaining farm profitability while protecting the environment and conserving natural resources. Extension agents provide outreach to farmers, school children, public officials and interested citizens on water treatment devices, wise land use policy such as wellhead protection, and other groundwater topics. With offices located in each county, outreach can be tailored to local needs. Extension promotes private and public partnerships to conserve and protect our water resources.

The Nutrient and Pest Management Program's crop plots on working farms promote the careful use of manure and pesti-

cides. The Farm·A·Syst program helps farmers identify and correct risks to groundwater around farmsteads.

Educational institutions

From university classes on hydrogeology to State Fair displays, education is the most important tool we can use to safeguard groundwater. Colleges and universities offer courses at the undergraduate and graduate levels to prepare students for careers in hydrogeology, wastewater management, soil science and other disciplines vital to groundwater protection. They also conduct basic research on groundwater development, movement and cleanup technologies. Vocational and technical colleges offer associate degrees in fields related to agriculture and water resources management. Environmentally safe methods of farming are taught in UW agricultural "short courses." Basin educators provide land and water resources outreach in the state's major river basins.

United States Geological Survey — Water Resources Division (USGS)

Keeping tabs on the amount of groundwater in Wisconsin is the job of the USGS Water Division. Starting in 1946 with just a few wells, the USGS, in cooperation with the Wisconsin Geological and Natural History Survey, now collects water level measurements in over 170 Wisconsin wells. Some of the wells are measured daily using electronic recorders; others are measured weekly, monthly or quarterly. The data serve as a starting point for evaluating the effect new wells and land development will have on groundwater levels, wetlands, streams and lakes. For example, a study of the Lower Fox River Valley, which includes Green Bay and the Fox Cities, showed that relocating wells and manipulating pumping rates could provide more water while keeping groundwater supplies more stable.

Wisconsin State Laboratory of Hygiene (SLH)

The Wisconsin Laboratory of Hygiene provides water tests and analyses to private well owners and state agencies. (See page 30 for information on well testing.) Researchers conduct basic groundwater research for state agencies and the U.S. Environmental Protection Agency, to help determine public water supply policy. An extensive survey of viruses in groundwater across the state of Wisconsin and in parts of Minnesota and Maryland is being conducted at SLH. The results of this survey will shed light on the extent of virus occurrence in groundwater, and help determine whether or not public water suppliers using groundwater will be required to treat their water for viruses as part of EPA's Groundwater Rule.

Research: A closer look at groundwater

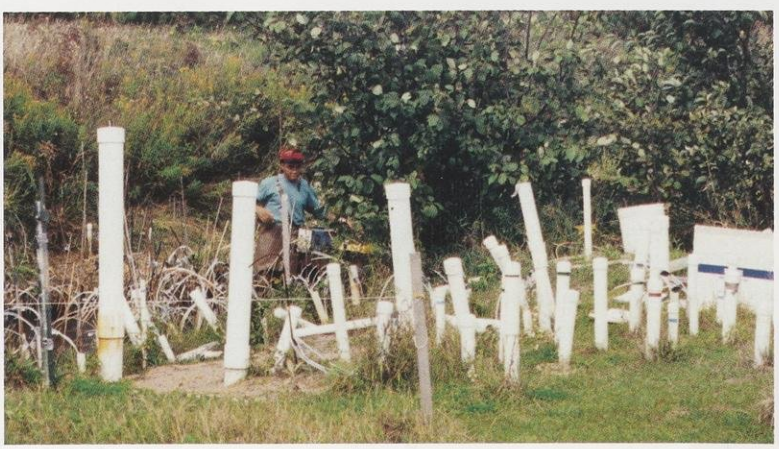
Figuring out what's going on underground isn't easy when you're stuck up above — that's why research is crucial to groundwater protection. As new information from surveys, tests and experiments filters in, the picture becomes more complete. With a more complete knowledge of the resource, decisions on groundwater use can be made with more confidence.

Two kinds of research are being conducted by state agencies. *Basic research* is done to discover new information about groundwater. *Applied research* uses basic research to solve specific problems, and develop or improve methods, products and materials used in groundwater management.

The top priority for basic research is figuring out how pollutants move and change

ROBERT QUEEN

(left) **Students measure chemical and physical conditions of surface waters to gauge the water's health.**
(below) **Similarly, hydrogeologists install whole fields of wells to measure pollution flow rates and estimate if contaminants will threaten water supplies or streams.**



DAVE JOHNSON

DNR PHOTO

(above) **Research can benefit both surface waters and groundwater.**
(right) **Trained lab technicians analyze groundwater for bacteria and chemicals.**

DNR PHOTO

in groundwater. Understanding how contaminants move around underground, and how minerals and organisms in soil and groundwater alter pollutants will help with future cleanup efforts. The effects different land uses have on groundwater quality and quantity are also hot topics in groundwater research. Protecting groundwater from contamination by managing land use can insure clean drinking water and healthy lakes, rivers, streams and wetlands.

The University of Wisconsin system plays a lead role in conducting groundwater research. UW researchers are developing new technologies for cleaning up groundwater. Bioremediation, or using living organisms to degrade or transform hazardous organic contaminants, is being studied to determine if it can replace costlier cleanup methods. The impact of land use on groundwater is being studied on individual farm fields and in entire watersheds. How contaminated groundwater affects surface waters and the organisms that live in them is also an important research topic.

DATCP hydrogeologists find out what areas of the state are vulnerable to pesticide and nitrate pollution and which pesticides are present in groundwater by testing samples of water from monitoring wells throughout Wisconsin. A recent survey of private wells conducted in areas that have adopted the "atrazine rule" — which prohibits the use of the herbicide within a one-mile radius of wells that have greater than three parts per billion of atrazine and its metabolites — showed some decline in the levels of the chemical. Laboratory technicians develop techniques for analyzing water samples for new pesticides and their breakdown chemicals.

Extension also conducts applied research to inform citizens about what they can do to protect groundwater. For example, the Central Wisconsin Groundwater Center at UW-Stevens Point conducts research on agricultural impacts on groundwater. The center also works with the UW-Stevens Point Environmental Task Force Laboratory to educate private well owners about their well systems and drinking water quality.

At the State Lab of Hygiene, researchers study the source and occurrence of the pathogens *Cryptosporidium* and *Giardia* in groundwater. The SLH is also involved in a survey of the Fox River as part of a Superfund Site assessment. The lab analyzed water samples and minnows taken from the river for PCBs. In conjunction with DNR, SLH is assessing the impact of landfills on groundwater. The lab is testing water from wells near landfills for the presence of 75 different volatile organic chemicals.

How groundwater and surface water interact is studied by the USGS at several Wisconsin locations. Knowing how lakes, streams, rivers and wetlands are replenished by groundwater will give a better idea of the effects of land use on water quantity and quality. Other areas of research include mercury contamination and control of barnyard runoff to streams.

Research priorities for the WGNHS include understanding groundwater recharge; examining how groundwater flows through fractured bedrock in areas such as environmentally sensitive Door County; determining the best methods for identifying wellhead protection zones; determining the hydrogeologic properties of landforms such as the Maquoketa shale (an important barrier protecting deeper groundwater); and studying the hydrogeology of Wisconsin's aquifers. Applied research includes hydrogeologic and engineering properties of glacial materials, and identifying hydrogeologic units throughout Wisconsin.

Since 1972, DOT has monitored the effect of road salt on groundwater by sampling wells at 20 sites located along highways. Other research projects include evaluating different de-icers, and determining salt application rates. In cooperation with the USGS, DOT is investigating how groundwater changes when wetlands are created or restored. ■

How to protect the groundwater you drink and use

When water chokes you, what are you to drink to wash it down? — Aristotle, Nicomachean Ethics, 384-322 B.C.

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 and plentiful. Here are some ways to cut back on water use and protect groundwater:

Conservation

A waster of water is a waster of better. — old Irish adage

Use water-saving devices and appliances: Since 1992, new toilets manufactured in the U.S. use only 1.6 gallons of water — much less than the 6 gallons each flush used to consume. If you have an older toilet, 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. Low-flow faucet aerators (for either inside- or outside-threaded faucets) mix water with air and can reduce the amount of water flowing from your sinks.

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. Adjusting or replacing the inexpensive float arm or plunger ball can often stop toilet leaks.

Drinking water: Keep a pitcher of drinking water in the refrigerator to quench your thirst without running the tap.

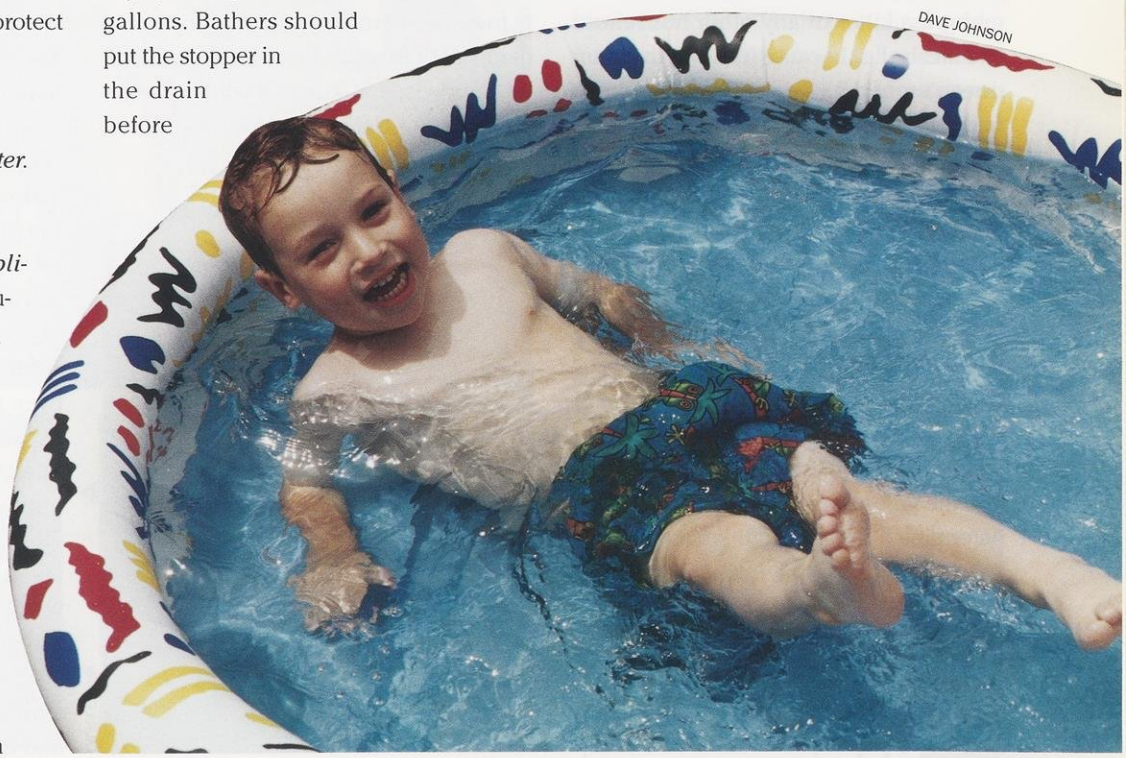
Bathing and showering: A water-saving showerhead can cut the amount of water used to about three gallons per minute without sacrificing the feeling of a good drenching. Turn off the water while soaping up during a shower to save extra gallons. Bathers should put the stopper in the drain before running the water, then mix cold and hot for the right temperature. Turn off the tap while you shave or brush your teeth.

Dish washing: If you wash dishes by hand, don't leave the water running while washing them.

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.

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

Lawn care: Water your lawn slowly, thoroughly and as infrequently as possible. Water at night to minimize evaporation and help reduce high demands on water sup-



DAVE JOHNSON

TRACEY TEODECKI

ROBERT QUEEN

Homeowners can protect groundwater too.
(left) **Take unwanted cleaners, paints and pesticides to Clean Sweep hazardous waste collection sites.**
(right) **Don't let soils, paint wastes oils or antifreeze drain into storm sewers.**

plies during the day. Consider reducing the size of your lawn by planting trees, shrubs and ground covers.

Waste minimization

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 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 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 Clean Sweep events in your community; call your DNR regional office, County Extension office or DATCP for details.

Lawns: Reduce or eliminate the use of lawn pesticides and fertilizers. A significant amount of these chemicals can leach into the groundwater. Test your soil first to determine if it needs additional nutrients. If you do fertilize, do it in the first week of May or after September 15.

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.

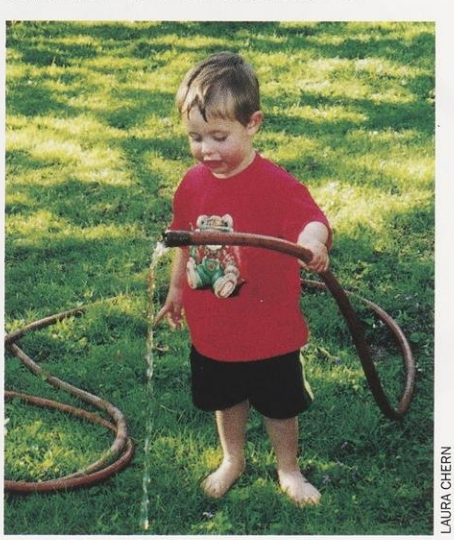
Biodegradable soaps and cleansers: Go easy on groundwater! Use soaps and household cleansers that are nontoxic and biodegradable. Or try these environmentally friendly alternatives: Baking soda on a damp cloth to scrub sinks, appliances and toilet bowls; a mixture of white vinegar and water for cleaning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

Dishwashing: Use the minimum amount of detergent needed to clean plates, glasses and silverware satisfactorily. Choose a non-phosphate automatic dishwashing detergent.

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 treatment plant or your septic system. Compost your kitchen waste and use it to mulch yard plants and hold moisture in the soil.

For more ideas, request the pamphlet "Better Homes and Groundwater" (publication number WR-386-95) from the DNR Bureau of Drinking Water and Groundwater, Box 7921, Madison, WI 53707-7921. Or call 608/266-6669.

Clean water — we all need it for a lifetime!



LAURA CHERN

Take care of your septic system

Even properly sited, permitted, constructed and maintained septic systems can pollute groundwater, especially if the soil is highly permeable or the water table is close to the surface. They all fail after about 20 to 25 years of use. You can keep your septic system in good working order by following these four tips:

1. *Be cautious about what you put in.* Ordinary amounts of bleaches, lye, soaps and detergents will not harm the system,

but household chemicals like paint thinner, drain cleaner, solvents, gasoline, oil and pesticides should NEVER go into a septic system. Once released in the absorption field, these toxic products can leach into groundwater and into our water supply.

Never flush bones, coffee grounds, vegetable peelings, fruit rinds, disposable diapers, sanitary napkins, tampons, bath oils, cigarette butts or other materials that do not break down easily into a septic tank.

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

2. *Have your septic tank inspected once a year.* A septage pumper can measure 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.

Hire only licensed septic tank pumpers to clean out your tank. They should pump through the manhole, inspect inlet and outlet baffles for damage, and service any outlet filters that may be installed. County sanitarians will have the names of licensed 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. *Go easy on your system.* Don't do more than three loads of laundry per day (a dishwasher cycle equals one load). Minimize the use of your garbage disposal.

Properly locate and construct wells

Wells can be a safe, dependable source of water if sited wisely and built correctly. Here are five points to remember:

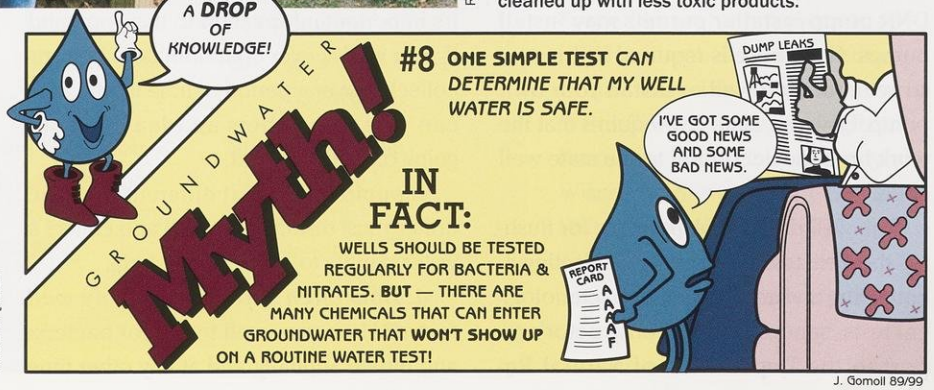
1. *Ask questions if you plan to drill a new well or intend to purchase property with an existing well.* Talk to your neighbors: Do they have any problems with their wells? How deep are wells in the area? Were there ever any contaminated wells in the area? How was the contamination taken care of? How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

Talk to local government officials: What local laws govern 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 gradi-

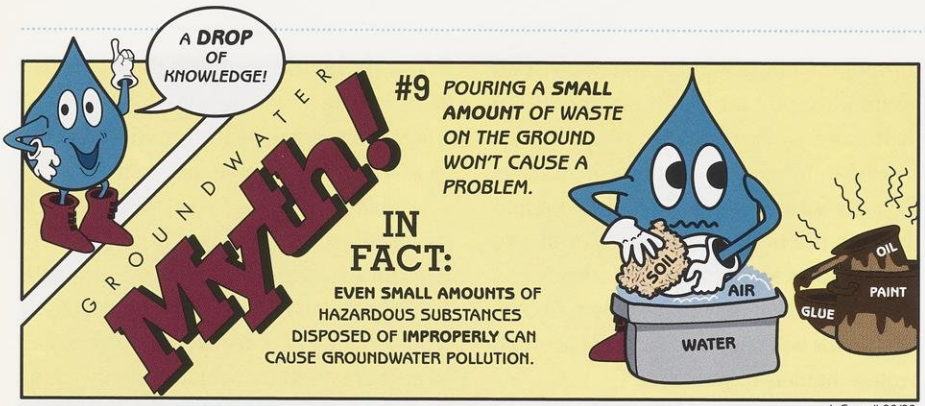
ROBERT QUEEN

ROBERT QUEEN



J. Gomoll 89/99

Teach children early to build lifelong habits that protect resources.
(left) **A school project shows how food wastes, leaves and grass settle down into rich compost.**
(below left) **A lot of household grime can be cleaned up with less toxic products.**



J. Gomoll 89/99

ROBERT QUEEN

State well codes dictate how to drill and install wells to protect both the water supply and groundwater.

ent and as far from these potential sources of contamination as possible.

3. *Hire reputable, experienced, licensed installers.* Only people registered with the Department of Natural Resources and holding current well driller permits should drill wells. Only people holding DNR pump installer permits may install pumps. 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 responsible 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 providing the owner with a copy. This document contains a record of the soil and rock layers penetrated by the well; lists the work performed and materials used; and the unique well number assigned to your well so the DNR can keep a record over time of your well water quality. It's important information to have on hand if your well is ever contaminated. Reports collected over a period of time in one area can give researchers an idea of what's going on underground.

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 nitrate annually, and at any other time if a change in odor, taste, color or clarity causes you to suspect contamination. Check for nitrate when infants or pregnant women use the water. (See page 30, "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 regional water supply staff, county sanitarian or local well driller can show you how to close off the old well to prevent groundwater pollution. For a copy of the pamphlet "Well Abandonment" (publication number DG-016-98rev) write DNR Bureau of Drinking Water and Groundwater, Box 7921, Madison, WI 53707-7921 or call 608/266-6669.

What else can you do?

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. Call 1-800-943-0003 if you see someone dumping waste illegally or find an old dumpsite.

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. To find out about hearings, call (608) 266-0848.

Keep up with local land use and waste disposal issues. Housing, commercial development, highway construction and landfills 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. ■

Who can answer my questions about groundwater?

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

1. **DNR water supply specialists** at the six regional offices can tell you more about the Wisconsin Well Code, show you how to disinfect your well, explain sources of contamination, sample wells, and give advice on drinking water problems and the proper disposal of toxic household products. Or visit the DNR website at: www.dnr.state.wi.us/

2. **The Wisconsin Geological and Natural History Survey** has maps, well construction reports and other information on aquifers and geology. For a list of WGNHS publications, write Wisconsin Geological and Natural History Survey, 3817 Mineral Point Rd., Madison, WI 53705-5121. (608) 262-1705. Or visit their website at: www.uwex.edu/wgnhs/

3. **Your county University of Wisconsin-Extension office** can help plan safe, functional farmyards and rural homes. 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, or visit their website at: www.uwex.edu/

4. **The Department of Commerce** has the details on proper septic system operation. Write Commerce, Division of Safety and Buildings, 201 W. Washington Ave., P.O. Box 7969, Madison, WI 53707-7969 and ask for publication SBD-7009, "Is the grass greener over your septic system?" Visit their website at www.commerce.state.wi.us/

DEAN TVEDT

Well water should be sampled and tested periodically for signs of bacteria, nitrate and any chemicals that may be used in your area.

5. **The Department of Agriculture, Trade and Consumer Protection** offers information on best management practices for farms and atrazine prohibition areas. Write DATCP, 2811 Agriculture Dr., Madison, WI 53708-8911. (608)224-5002. Their web address is: badger.state.wi.us/agencies/datcp/arm/armhome.htm

6. **The Central Wisconsin Groundwater Center** is a clearinghouse for information on groundwater issues statewide, with a strong focus on Wisconsin's Central Sands area. The center maintains a database of private wells tested through the UW-Stevens Point Environmental Task Force Laboratory, conducts applied research, and offers educational materials and programs. Write CWGC, College of Natural Resources Room 224, University of Wisconsin-Stevens Point, Stevens Point, WI 54481-3897. (715) 346-4270. Visit the center's website at: www.uwsp.edu/groundwater/ ■

DNR Regional Water Supply Specialists

Northeast Region
1125 N. Military Ave.
Box 10448
Green Bay, WI 54307-0488
(920) 492-5800

Northern Region
810 W. Maple St.
P. O. Box 309
Spooner, WI 54801-1256
(715) 635-2101

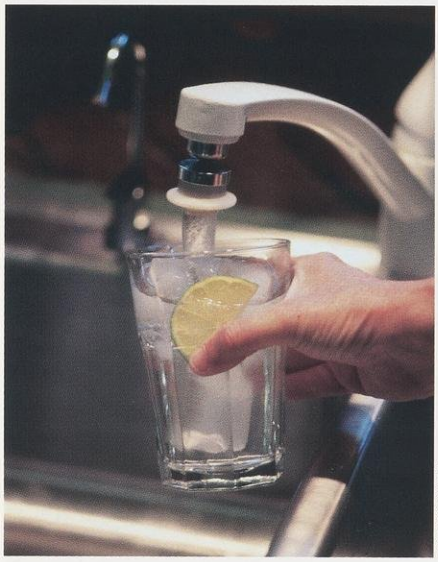
West Central Region
1300 W. Clairemont Ave.
P. O. Box 4001
Eau Claire, WI 54702-4001
(715) 839-3700

Southeast Region
2300 N. Dr. Martin Luther King Jr. Dr.
P. O. Box 12436
Milwaukee, WI 53212-0436
(414) 263-8500

South Central Region
3911 Fish Hatchery Rd.
Fitchburg, WI 53711-5397
(608) 275-3266

Northern Region
107 Sutliff Ave.
P. O. Box 818
Rhinelander, WI 54501-3349
(715) 365-8900

How safe is my drinking water?



ROBERT QUEEN

Every user of well water should know something about the source and underground motions of his water supply. In this way he may guard against contamination. — C.F. Tolman, 1937, from the first textbook on the subject entitled "Ground 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 safe 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 public water system, your water utility will mail a "**Consumer Confidence Report**" to you each fall. The report will include information on the source of the utility's drinking water, the treatment used to purify water, any contaminants that have been found in drinking water, and the potential health effects of those contaminants. Reports will also identify where additional information about the water supply can be found and how citizens can become involved in protecting water sources. Utilities must provide updated reports for their consumers annually.

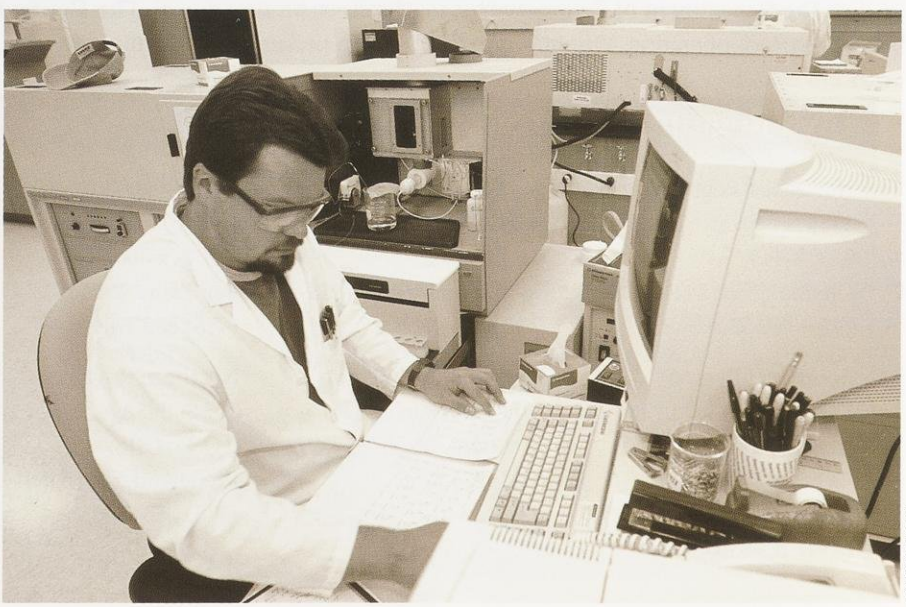
Private well owners should have their wells tested periodically. If you have reason to believe chemicals have contaminated your water, contact your DNR private water supply specialist to investigate. Private laboratories do tests for chemical contaminants, such as volatile organic compounds or pesticides. 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. The cost will range from $30 to $1,000, depending on the number and type of chemicals analyzed and the test methods.

The State Laboratory of Hygiene will test your drinking water for several pollutants including bacteria, nitrate or fluoride. The bacteria, nitrate and fluoride tests can be made from the same sample bottle of water and cost $17.00 each in 1999. For a test kit, call the lab at (800) 442-4618 or write the State Laboratory of Hygiene, Environmental Health Division, 2601 Agriculture Dr., P.O. Box 7996, Madison, WI 53707-7996. Private labs will also do these tests.

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, spills or waste dumping.

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. Contact the DNR Bureau of Drinking Water and Groundwater, at P.O. Box 7921, Madison, WI 53707-7921 or call (608) 266-6669 for literature on private well operation.

Most private wells are tested for signs of bacteria, an early indicator that pollutants may be reaching a well. Traces of chemicals, metals, fuels and other pollutants can also be tested for if you suspect nearby sources may affect your well and surrounding groundwater.



ROBERT QUEEN

PHOTOS THIIS PAGE BY ROBERT QUEEN

Both private labs and the State Lab of Hygiene analyze well water samples.
(inset) **Mail-order kits are available. Check the Yellow Pages under "Water Analysis." The kits shown here will test well water for bacteria, metals and organic chemicals.**

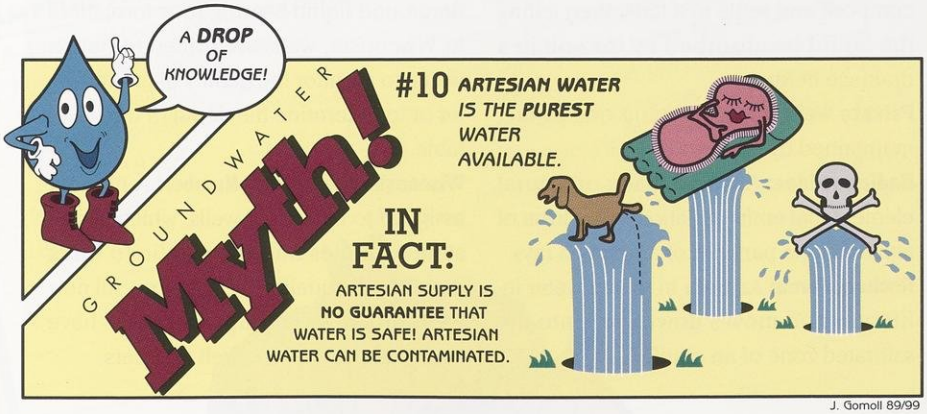
If high nitrate is the problem, the well construction and location should be checked. Use safe water that's known to be low in nitrate for pregnant women and infants under six months old.

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.

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. ■



J. Gomoll 89/99

Groundwater glossary

Aquifer: A rock or soil layer capable of storing, transmitting and yielding water to wells.

Baseflow: That part of stream discharge from groundwater seeping into the stream.

Consumer Confidence Report: A report, required under the amendments to the Safe Drinking Water Act, which lists contaminants found in community public well water systems, water treatment methods, devices used and potential health effects.

Discharge area: An area in which groundwater flows toward the land surface and escapes as a spring, seep or baseflow, or by evaporation and transpiration.

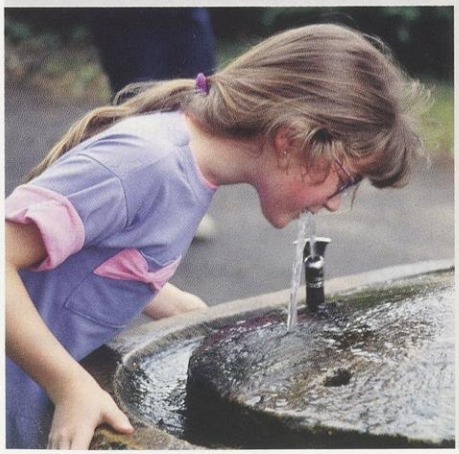
Dolomite: Calcium magnesium carbonate, a common rock-forming mineral. Many rocks in Wisconsin referred to as limestone are actually dolomite.

Evaporation: The process by which water is changed from a liquid or solid into vapor.

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 and on the earth.

Glacial drift: Sediment transported or deposited by glaciers or the water melting from a glacier.

Gross alpha activity: Decay of radionuclides in natural deposits. Can be either radium or uranium.



ROBERT QUEEN

Groundwater: Water beneath the surface of the ground in a saturated zone.

Hydrogeology: The study of groundwater and its relationship to the geologic environment.

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.

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).

Municipal well: A well serving more than 25 people for at least 60 days of the year.

Nutrients: Compounds of nitrogen, phosphorus and potassium that promote plant growth.

Permeability: The capacity of rock or soil to transmit a fluid, usually water.

Private onsite wastewater treatment system (POWTS): Also called a septic system. Used to treat household sewage and wastewater by allowing the solids to decompose and settle in a tank, then letting the liquid be absorbed by the soil in a drainage field.

Private well: A well serving one home, maintained by the owner.

Radionuclides: Any manmade or natural element that emits radiation in the form of alpha or beta particles or as gamma rays.

Recharge area: An area in which water infiltrates and moves downward into the saturated zone of an aquifer.

Runoff: Precipitation not absorbed by the soil.

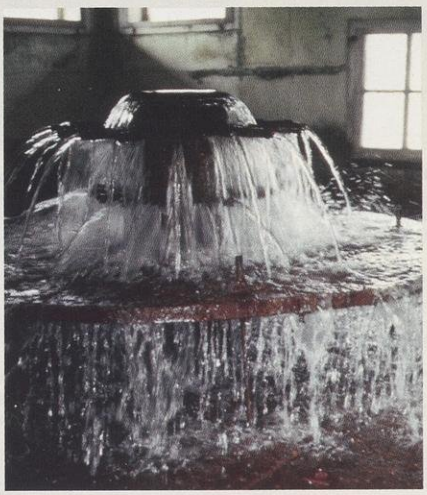
Saturated zone: The part of a water-bearing layer of rock or soil in which all spaces, large or small, are filled with water.

Septic system: See "private onsite wastewater treatment system (POWTS)"

Sludge: Sediment remaining after wastewater has been treated.

Transpiration: The process by which plants give off water vapor through their leaves.

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

Watershed: The land area from which surface runoff drains into a stream system.

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.

Wisconsin Unique Well Number: A number assigned to individual wells, which allows state agencies and the public to track groundwater quality through time. All new wells drilled since January 1, 1988 have been assigned unique well numbers.

OVER OPEN FIRE

ROBERT QUEEN

Add a pinch of variety to your campside cuisine.

David L. Sperling

Casseroles and cobblers, muffins and muskies, our readers have found ways to savor them all over a campfire. Last October we asked you to share recipes that added zip and flavor to typical camping fare. We asked you to push aside the weenie roast and s'mores (well, maybe the weenies!) long enough to dish up a fireside meal that complements the beauty of the outdoor scenery and the camaraderie of the campground. We sought your secret libations, appetizers, main courses, side dishes and desserts that add pleasure and memories when you fire up the hardwoods to do your cooking ringside.

Here's what we learned: Most of you are content to drink water. We didn't get one entry for a new drink. I figured somewhere out there, someone had concocted a potable called "Popple Punch," "Woodland Sangria," or "Meet Mother Nature" that made the stars shine on a cloudy night. We didn't even get a "bug juice" recipe! Ah well, I guess that will have to wait for another contest.

We were also a bit surprised that campers didn't flood us with appetizer recipes. In a land that has raised the cheese ball and pickled fish to a fine art, among a people who make homemade smoked food out of darn near anything that flies, runs, swims or slithers, we got no entries in the appetizer department. What is this? Don't tell me that when campsite #54 and #52 get together for a little pinochle or sheepshead that the host opens up a bag of cheese curls, rolls back the lid on some cheap sardines and says. "Dig in!" That's not the Wisconsin hospitality I know. All right, so you are hampered without your toothpicks, blender and broiler. You must be packing some dill pickles, a stick of summer sausage and a few good crackers.

Similarly, we didn't receive any recipes for spicy dishes. Do you back away from the peppers and hot sauces because it's a long walk for a pitcher of water? I can see that I'm going to have to resurrect my "Burning Ring of Fire" veggie dip and the secret ingredients in "Sneaky Pete's Sweet and Sour Texas Two-Alarm Venison Chili," which will melt a topping of cheese even after the chili has been refrigerated.

In other areas of the menu, you did just fine. Here are some of the better offerings that brighten up the dawn and bring on the evening when you say "Flame on!" Thanks for sharing them.

SURE-FIRE FIRE STARTERS

paper fiber egg cartons
wood shavings from untreated lumber
paraffin
3-lb. coffee can
one wire hanger

Melt paraffin in double boiler to prevent fires. Place wood shavings in each depression of the egg carton and pour hot paraffin over the shavings. Break apart the starters into 12 pieces when cool.

Cut the bottom out of the coffee can and snip notches in the bottom with some tin snips. Drill two small holes across from each other in the top of the can and bend the end of the hanger to secure it. Place two "eggs" in the bottom of the coffee can. Add charcoal or wood and light. The fire will be ready in about 10 minutes.

CAMPFIRE STIR FRIES

8–10 strips of bacon, cut into one-inch pieces
1 medium onion, sliced or diced
1 tablespoon butter
6–8 medium potatoes (new potatoes or small baking spuds)
salt
pepper

Take peeled or unpeeled potatoes and slice into 1/8" rounds. Fry bacon in a 10–12" fry pan. Add onion to pan when bacon is about half done. Lower heat slightly and add butter. After butter melts, stir and add potatoes, salt and pepper to taste. Cover pan. Stir every 5–10 minutes until potatoes are done. Serves 4–6 people. This is a great side dish for a fresh fish dinner.

Ralph Heiser
Baraboo

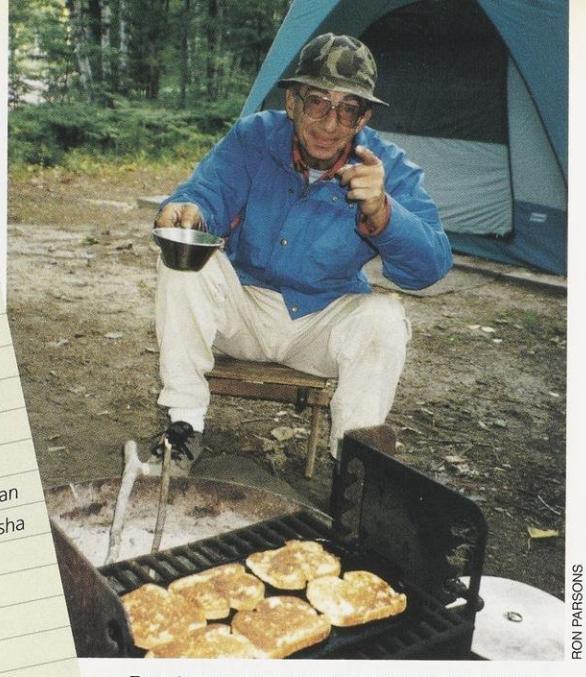
Editor's Note: *Seasoned Dutch oven chefs tell me that an oven placed over a bed of hot coals and topped with 6–8 coals will maintain a steady temperature of about 350°. Gently stoke the fire to maintain even heat during the cooking process.*

CAMPERS BREAKFAST

1 lb. bacon, diced
1 large onion, finely diced
1 green pepper, seeded and diced (optional)
2 lbs. frozen hash browns or leftover baked spuds
12 eggs
1 lb. sharp cheddar cheese, shredded
2 tablespoons water

Sauté bacon, onion and green pepper in an open Dutch oven. Add shredded potatoes. When potatoes are crispy brown on the bottom, use a big spoon to press 12 round depressions in the potatoes where egg nests can be placed. Add one egg per nest. Season with salt and pepper. Sprinkle sharp cheddar over the eggs. Add two tablespoons of water. Put the lid on the Dutch oven and transfer 10–12 hot coals or embers on top lid. Remove the oven from the fire. Wait about 20 minutes before checking that the eggs are done. Serve with fruit, ketchup, coffee and juice. Serves 5–7 adults.

Sally Magnan
Waukesha



RON PARSONS

French toast never tastes better than hot off the campfire griddle.

CHICKEN-PINEAPPLE ORIENTAL SUPREME

1 tablespoon oil
2 lbs. chicken breast, boneless and cut into 2 x ½-inch strips
1 small can pineapple chunks in juice
½ C soy sauce
1 teaspoon salt
½ teaspoon pepper
1 teaspoon paprika
½ C brown sugar, firmly packed
½ C water
¼ C cornstarch
1 C water
1 large can Chinese-style vegetables
3–4 cups hot, cooked rice

In a large covered pan or Dutch oven, heat the oil and brown the chicken. Add pineapple and juice, soy sauce, salt, pepper, paprika, brown sugar and water. Cover and simmer for 30 minutes. Dissolve cornstarch in 1 C of water. Add the cornstarch mix to the casserole, stir and simmer another 10–15 minutes. Stir in the vegetables, heat thoroughly and serve over hot rice. Serves six.

Steve Blattner
Waukesha

SWEET AND SMOKY BROCCOLI SALAD

2 bunches broccoli
1 C sunflower seeds
1 C raisins
1 small bunch green onions, chopped fine
10 slices of bacon, chopped into small pieces

dressing:
1 C salad dressing
1 tablespoon fresh lemon juice
1 teaspoon sugar
salt and pepper to taste

At home, cut broccoli tops into small flowerets and place in a sealed bag or bowl with the sunflower seeds, raisins and chopped green onions. Mix the dressing at home ahead of time and store in a sealable bag or container.

At campsite, make the salad at least two hours ahead of serving time. Combine the vegetables and the dressing. Fry the bacon, drain, let it cool and add the bacon to the salad mixture. Shake the bag to distribute the dressing at least three or four times before serving. Serves 8–10.

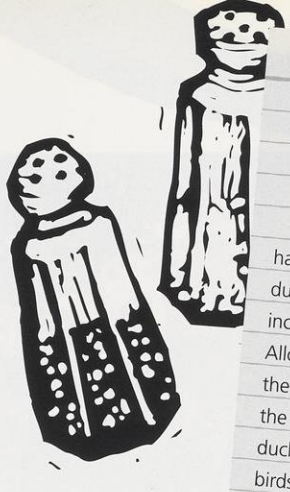
ROBERT QUEEN

CHILI PIE

2 lbs. ground beef
1 tablespoon butter
½ teaspoon chili powder
1 15 oz. can of tomato sauce
1 medium onion, chopped
1 15 oz. can of chili beans
½ teaspoon salt
one 6 oz. box of cornbread mix made according directions (small amount of milk and one egg)

Brown onion in the butter. Add beef, brown it and drain off the fat. Add beans, chili powder, salt and tomato sauce. Cook 15 minutes in a covered Dutch oven. Mix cornbread as directed on package and spoon it over the meat and bean mixture. Replace the lid and cook for 20–30 minutes. Serves six.

Steve Blattner
Waukesha



BAKED MUSKIE

one large muskie (nine pounds or more)
salt
pepper
Stuffing mix:
1½ lbs. stale bread, cubed
1 onion, chopped
1 bunch parsley, coarsely chopped
1 can tomato soup
1 can full of milk (fresh or reconstituted dry milk)

Build a fire in an 18-inch-deep hole, that is longer than your fish and about two-feet wide. Gut and scale the muskie. Rinse the fish thoroughly and sprinkle the interior cavity with salt and pepper.

In a large bowl, combine the stale bread, onion and a generous amount of parsley. Fold the can of soup and an equal amount of milk into the stuffing mixture. The stuffing should be on the wet side. Using a large needle and white thread sew down the gill covers and stitch the fish's mouth shut. Stuff the fish with the stuffing mix and then sew the stomach cavity shut.

Wrap the fish in four or five layers of dry newspaper, folding the paper in at the head and tail. Truss the entire fish with string (the way you would tie up a rolled roast). Soak a dozen or more sheets of newspaper in water until they are saturated. Wrap the fish as before tying it securely with string. Tie the muskie to a board that is a few inches larger than the fish and about two feet wide.

Remove hot coals or embers from the pit, set the wrapped muskie in the pit and cover with the hot coals. Add wood to your fire and keep adding wood while the fish cooks.

Allow at least two hours for a nine-pound fish. Remove coals, unwrap the fish and serve.

Irene LeTourneeau Regorrah
Cable

From "Wisconsin Cook Book" by Karin Marple Wade, Golden West Publishers, 4113 N. Longview Ave. Phoenix, AZ 85014

CHARLIE'S CHICKEN IN A BLACK POT

2 tablespoons dried basil
4 teaspoons paprika
1 teaspoon onion powder
½ teaspoon garlic powder
1½ teaspoons salt
½ teaspoon ground pepper
1 C prepared barbecue sauce
12 oz. of beer
4 chicken breasts, skinned and cubed.

Combine dry ingredients, rub into chicken breasts and store in your cooler on ice at least two hours. Combine barbecue sauce and beer in the Dutch oven, add marinated chicken and cook for about 60 minutes in the covered Dutch oven. Serves four if ladled over hot rice.

Gary J. Laib
Poynette

ROAST WILD DUCK

6–8 ounces of canned orange juice
2–3 wild ducks, cleaned
water
salt & pepper

Build a good-sized fire of oak or maple about a half-hour before you want to start cooking the ducks. Preheat the Dutch oven by placing about an inch of water in the bottom and placing the lid on. Allow the flames to die down so they don't touch the pot, but you can still see a bit of flame. Remove the Dutch oven from the fire, open, season the ducks with a little salt and pepper then place the birds in a single layer in the pot. Pour three ounces of orange juice over the birds and add a little water if the oven is dry. Cover and cook 20 minutes. Check the ducks and add another three ounces of orange juice and water, if necessary. Baste the birds, cover the oven and continue cooking another 20 minutes. Check again. As the fire burns down during the last 20 minutes, place the oven down in the coals, but check the birds more often to avoid burning. When the ducks are nicely browned they are done. Overcooking will dry them out.

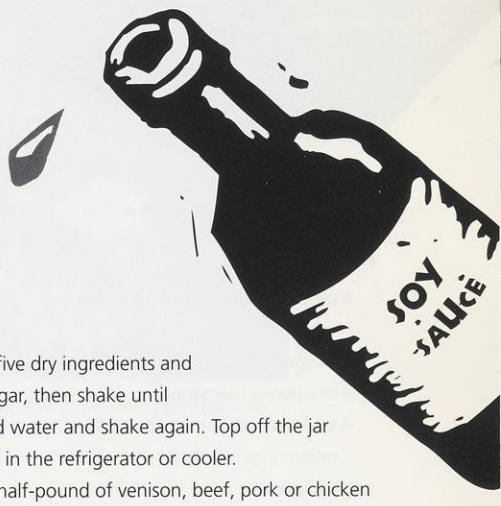
Woodcock are also good done this way and should only take half as much time.

Serve with baked potatoes that were wrapped in foil and buried in the coals, or cook a packaged rice or pasta mix according to the package directions.

Ron and Juanita Parsons
Menasha

ANY MEAT STIR FRY

½ C corn starch
¼ C brown sugar
2 teaspoons ground ginger
¼ teaspoon minced garlic
½ teaspoon ground red pepper
½ C light soy sauce
¼ C cider vinegar
2 C chicken broth
½ C dry sherry
½ C water
3 cups hot, cooked rice



In a quart jar, combine the first five dry ingredients and shake. Add the soy sauce and vinegar, then shake until blended. Add the broth, sherry and water and shake again. Top off the jar with more broth and keep covered in the refrigerator or cooler.

To serve three people, brown a half-pound of venison, beef, pork or chicken in a pan and remove the meat from the pan.

Put about two tablespoons of oil in a large pan and heat over the fire. Add one pound of stir-fry vegetables like carrots, broccoli, water chestnuts, peas, bok choy or celery. Cook about 10 minutes until tender. Add meat and one cup of the stir-fry sauce. Heat and serve over rice.

Neil Steinagel
Merrill

FOUR CHEESE CHICKEN AND PASTA

3 cans cream of celery soup
½ soup can of dry white wine
1½ soup cans of water
1 C each of grated romano, parmesan, Swiss and mozzarella cheese
4–5 boneless chicken breasts, cubed in bite-sized pieces.
3 stalks celery, chopped
1 medium onion, chopped
½ bag frozen peas (optional)
4 oz. can mushrooms, drained (optional)
4 C of medium pasta shells, cooked according to package directions
salt and pepper to taste

Put soup, water, wine, celery, onion and chicken in a 12-inch Dutch oven, cover and bake over hot coals for an hour. In a separate pot, boil water, salt it, cook the pasta shells, rinse and set aside. After the vegetables and chicken have cooked for 30 minutes, add the cheeses and stir. Cook 15 minutes then add cooked pasta shells, peas and mushrooms. Leave the lid off and stir the mixture until thoroughly heated. Add salt and pepper to taste. Serves four.

Gary J. Laib
Poynette

SWEET SOUR SKILLET DISH

1 lb. Italian sausage, cut into one-inch slices
1 teaspoon oregano
⅓ C brown sugar
⅓ C cider vinegar
6 C shredded cabbage

2 large red apples, cored and sliced

In a 10-inch skillet, cook sausage over low heat. Add oregano and cook until the sausage is browned. Stir in brown sugar and vinegar. Add cabbage and cover. Bring to a boil, then move to the edge of the fire until it simmers for 10 minutes. Add apples, stir, cover and cook for three more minutes. Serves four.

Steve Blattner
Waukesha

DNR PHOTO

Bowhunters take a breakfast break in Juneau County, September 1953. Good food and good company in the outdoors make a lifetime of memories. Cook up your own specialties!

BALSAMIC CHICKEN OR GAME HENS

¼ C balsamic vinegar
1 tablespoon olive oil
1 tablespoon dried basil
black pepper to taste
½ teaspoon salt
3 cloves garlic, crushed
2 Cornish game hens, cut in halves *or*
4–6 boneless chicken breasts
2 boxes of wild rice mix and water

Blend the first six ingredients and pour over the hens or chicken breasts in a 12-inch Dutch oven and heat about 90 minutes.

While the birds are cooking, prepare the wild rice mixture in a 10-inch Dutch oven and bake covered about an hour. Ladle about 1½ cups of rice mix on a plate, top with poultry and sauce. Serves four. You can also cook the chicken, cube it and stir the meat into the rice as it cooks.

Gary J. Laib
Poynette

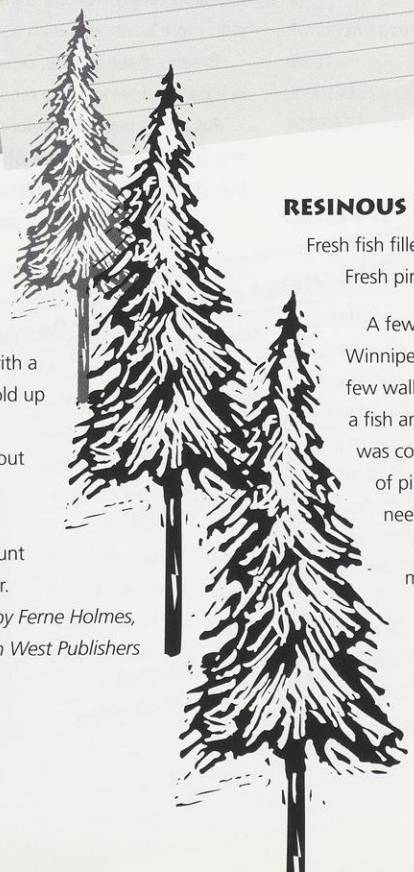
FISH IN FOIL

4 pan-size trout (about 10 inches), cleaned
4 lemon or lime slices
4 teaspoons margarine
4 tablespoons canned French-fried onion rings, crushed
garlic powder
4 tablespoons dry white wine
aluminum foil

Place each fish on a separate piece of aluminum foil. Put a lemon or lime slice, one teaspoon of margarine, and one-half tablespoon of crushed onion rings in the body cavity of each trout. Sprinkle each fish with garlic powder, a half-tablespoon of crushed onion rings and a tablespoon of wine. Wrap the foil around the fish with a double seam down the long side of the packet. Fold up the ends to form leak-proof seals.

Cook the packets over hot coals until done, about 10-15 minutes per side. Turn the packets often to prevent burning. Remove from fire and let sit a minute or two before opening to reduce the amount of hot steam released from the packet. Serves four.

From "Easy Recipes for Wild Game and Fish," by Ferne Holmes, Golden West Publishers



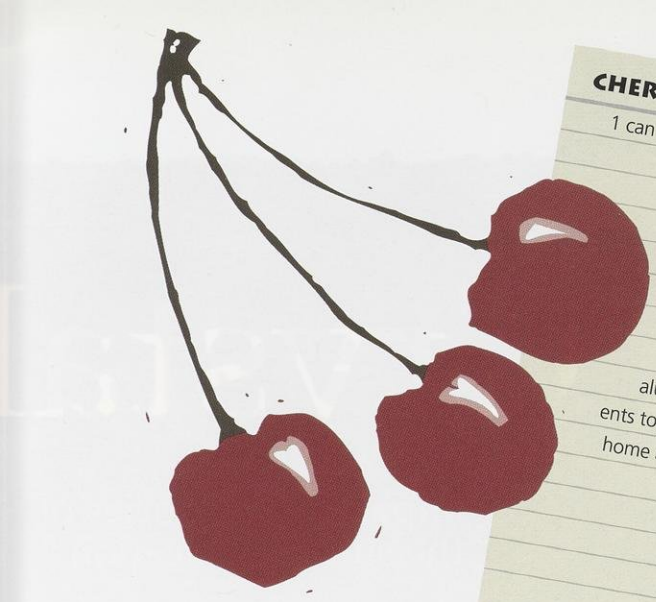
RESINOUS FISH

Fresh fish fillets
Fresh pine needles

A few years back our family was canoeing 500 miles northwest of Winnipeg. We had no cooking utensils, but we were hungry and had a few walleye on the stringer. We pulled ashore, built a small fire, filleted a fish and cut a few saplings to roast the fish over the fire. After hers was cooked, my daughter accidentally dropped her fish onto a carpet of pine needles. She picked it up brushed it lightly to remove the needles and ate it.

"Hey Dad, this really tastes good," she said. I thought she was making the best of things, but she persuaded me to take a bite. She was right. The pine needles gave the fish a nice, distinctive flavor. Since then we have done this purposely many times and have not been disappointed. Add fresh needles to the fire or a cast iron pan during the last few minutes of cooking.

Dr. J. Birney Dibble
Eau Claire



CHERRY CRUMBLE

1 can cherry pie filling
½ C margarine
½ C flour
⅔ C brown sugar, packed
⅔ C quick oats
½ teaspoon cinnamon

Spread pie filling in an 8"x8"x2" aluminum pan. Mix remaining ingredients together until crumbly or do this at home and bring the mixture in a sealed plastic bag. Sprinkle the mixture on top of the pie filling. Line the bottom of the Dutch oven with foil to catch spills. Place the aluminum pan on a trivet and in the Dutch oven. Cover and bake 15–20 minutes until the dessert is bubbly. Works equally well with other flavors of pie fillings.

This recipe from "Outdoor Illinois magazine," May 1999

PINEAPPLE UPSIDE-DOWN CAKE

½ stick butter, melted
1 C brown sugar
1 large can pineapple rings
a few maraschino cherries
1 packaged cake mix (yellow, white or lemon) prepared according to package directions

Melt butter on the bottom of the Dutch oven. Add brown sugar and mix to form a liquidy paste. Drain pineapple and place rings on the bottom with a cherry in each. Pour cake batter over the pineapple layer. Cover with a lid and place 8 to 10 coals on the lid. Take the Dutch oven off the fire. Don't start checking if the cake is done for at least 20 minutes. When done, remove lid and invert the Dutch oven over a large plate. Serves 8–10 adults or 5–6 Scouts!

Sally Magnan
Waukesha

ROBERT QUEEN

Casseroles and fish steam up hot and tasty in foil-wrapped packets, but nothing will improve the flavor of a wet sneaker!

Coffee goes down better with a fresh cake or muffin cooked campside.

ROBERT QUEEN

LAZY COBBLER

1 large can of sliced peaches
1 package white cake mix
butter
cinnamon

Preheat the Dutch oven, then remove from heat. Pour peaches with the syrup from the can into the oven. Sprinkle the dry cake mix on top of the fruit. Place several small pats of butter on top and sprinkle with cinnamon. Put lid back on oven and cook over moderate coals for about 45 minutes.

Steve Blattner
Waukesha

David L. Sperling edits Wisconsin Natural Resources *and perfected the apartment s'more — one-half graham cracker topped with one-half chocolate bar and a marshmallow. Light the marshmallow with a butane lighter and extinguish the flambéed confection with another piece of chocolate and graham cracker. Bon appetit.*

The Crystal

The family never unpacked memories of "the summer vacation."

Story and photos by Donna Krischan

Our special memories of Wisconsin's Northwoods are anchored to both a time and a place. My family spent many of its two-week summer vacations camping at Crystal Lake near the town of Sayner in Vilas County. It's a beautiful little lake with sand beaches and crystal clear water. I still stop by every year, usually in fall, and walk through the campground. On our route, my mind's eye still sees the faces and hears the voices of people who shared our wonderful time more than 20 years ago.

For us, "the vacation" was always two weeks in August, usually the same two weeks. Preparations would begin well ahead of time. Camping and fishing gear came out of storage. We were tent campers! None of that trailer stuff. The old wooden "kitchen" my dad had built was always the first thing packed because it was so huge. Before Dad hoisted it into the boat with other gear, Mom would fill it with cooking supplies, dinner-

Mom and Dad at the pump that was the gathering point for the simple pleasures of camping at Crystal Lake. The park attendants are still friendly and the Fallison Lake Trail is still beautiful in every season.

Lake pump

ware and food. She baked for weeks ahead of time. I especially remember chocolate chip cookies, oatmeal cookies, and the sweet rolls she called "ding-a-lings." You'd think she was baking for an army, and in truth, she was! Her family and hordes of friends met every year at the campsites.

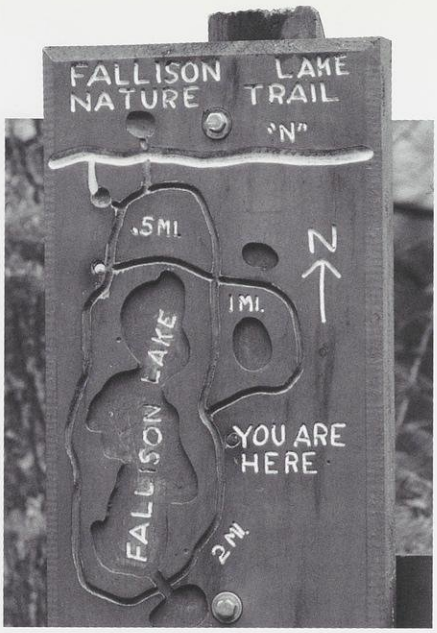
Counting the days to this trip was unbearable…worse anticipation than Christmas Eve. Everyone went to bed early the night before because we would get up at 3 a.m. We always stopped for breakfast at the same cafe in Antigo. My sister and I hated breakfast food, so we always ordered a cheeseburger (which never failed to embarrass our dad).

The most welcome sight was the end of the journey — the check-in station at Crystal Lake where the wait ended and the fun began. For two weeks we'd swim, hike, water-ski, fish, sing around the campfire, pick blueberries and catch up with old friends. Regardless of the weather, we'd have a great time. One year, it rained 14 out of the 16 days we camped, but it didn't dampen our spirits a bit (well, maybe a little). Good fishing always called Dad back to Allequash Lake. Mom made stacks and stacks of blueberry pancakes. There were huge ski parties on Big

Muskellunge Lake. We would run through the campground and round up kids who wanted to water-ski. Many a kid learned to ski behind Dad's little red boat! The Fallison Lake Nature Trail beckoned and always provided something new to discover whether it was trees downed by beaver or a large beaver lodge in sight of the trail.

A few years ago in fall, we visited Crystal Lake with my parents. It was cold. It snowed, and it didn't matter. I could see it in their eyes — transported to a comfortable time when they were young, times were good and friends surrounded us. We visited the original red water pump — epicenter of the campground. When Mom and Dad first camped there, the grounds consisted of eight campsites clustered around this hand pump. It was a tiny getaway place. Now hundreds of sites fill the space between Crystal and Muskellunge lakes.

As we strolled through the campground, Mom and Dad pointed out sites they had used and remembered where their friends pitched their tents.



A fall visit rekindled memories of summer vacations and special moments spent in a favorite spot.

They told the old stories, some from before my time. We visited Allequash Lake and found the site of our ski parties on Big Muskellunge. We remembered some of the "big" events — like the year my mom's sister visited or when my brother cut his foot on a piece of glass.

This year, my husband and I visited Crystal Lake in summer. We sat and watched the children playing on the beach and swimming. We talked with several young families. We learned that the campground is still creating great memories, but now for other families.

I always call my sister when I'm at Crystal Lake. She thinks I'm teasing her. Actually, I just want to share the experience and, for the moment, drag her back here with me to reminisce. Before my husband and I leave, we hike the Fallison Lake Nature Trail, where there are still signs of beavers.

Some people warn about living in the past, but we're not grasping to reclaim our youth. We know you need to move on and create new memories. I just like to come back to search again for the contentment that can be kindled by a place and an old red pump. □

Donna Krischan is a professional photographer from Big Bend specializing in landscape and garden photography.

Help yourself to cleaner lakes

Volunteers in the Self-Help Lake Monitoring Program take it upon themselves to see how their lakes measure up.

Story and photos by Maureen Janson

July in Wisconsin doesn't get much hotter. At 7 a.m. it's already 85 degrees and humid. Scott Szymanski, lake monitoring coordinator for DNR's Northeast Region, has arranged an early morning meeting in the tiny town of Mt. Morris in Waushara County. The volunteers we'll soon meet are part of DNR's Self-Help Lake Monitoring Program, which invites interested citizens to regularly measure water clarity and the chemical make-up of lakes, and thus contribute to long-term environmental trend data. That invitation has been extended far and wide: from 150 volunteers in 1986, Self-Help now boasts over 700 volunteers monitoring 570 lakes.

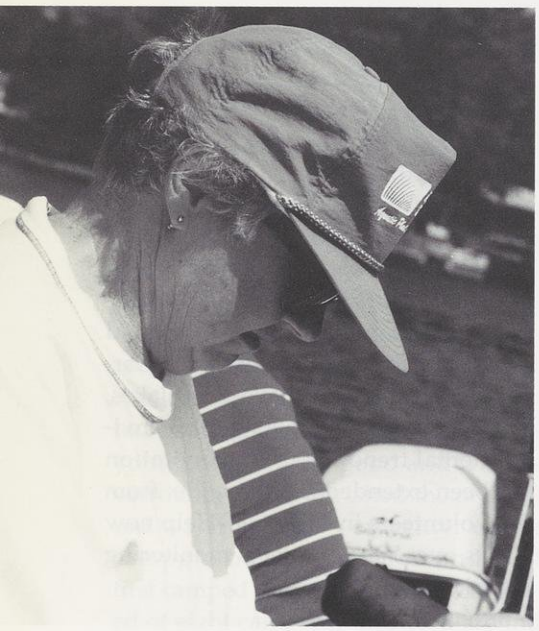
Morris Lake's monitors

This morning we meet Nils and Lois Dahlstrand, 20-year residents of Morris Lake. They welcome us into their meticulous kitchen and lead us to an impressive display of charts and graphs Nils has generated to reflect 13 seasons of monitoring. He'll use them to demonstrate water clarity changes to other residents at a lake district meeting next week.

On the Morris Lake Chain of five small lakes, only Emerald Lake is named. The others are locally referred to as Lakes A, B, C, and D. We cruise through all five, noticing fragrant water lilies, basking turtles and a great blue heron drying its wings in the sun. Scott gives us a basic lesson in aquatic plant identification and determines that the milfoil we see is "the good stuff," not the nuisance Eurasian water milfoil. Nils tells us the lake's vegetation has been selectively harvested since 1983. "The lake district owns its own plant harvester," says Nils, who was instrumental in obtaining funds to purchase the harvester. "And we even cut places for boats to get close to the shore for fishing."

After forming a lake association in 1976, Nils was elected lake commission-

Readying the boat for a trip to test water clarity and nutrient balances. Long-term monitoring provides early warning if lake conditions change.



We feel good learning about our lake and helping others contribute to lake protection — *Lois Dahlstrand*

er in 1979 when the association became a district (see sidebar). "I had three goals," he says. "To educate people by publishing a newsletter, to fix the dam, and to document water quality, which is how we got involved in Self-Help."

We make our way into Lake D to take a Secchi disk reading. Italian astronomer and Jesuit priest Pietro Angelo Secchi invented the black-and-white clay disk in 1865. Now made of metal, the Secchi disk is lowered into the water until its alternating black and white quadrants are no longer visible. The depth of this disappearance indicates the density of floating plants or suspended sediments, and serves as a possible early warning that human activity is affecting the lake.

The disk drops 14.5 feet — a good reading for this lake. "Our clearest year yet!" Lois remarks. Next, Nils drops a vertical water sampler down to measure the water temperatures at various depths. While Lois records the data, Nils collects and bottles water from three feet below surface for on-shore chlorophyll tests.

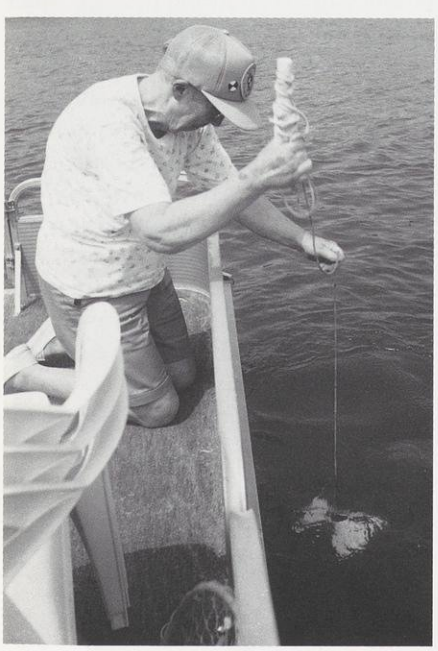
In the Dahlstrand kitchen, Nils filters water to send to the State Lab of Hygiene for chlorophyll analysis to help estimate the lake's algae population. Chlorophyll, the green pigment in algae, reflects the amount of nutrients in a lake, which may change depending on lake uses, shoreline development, and other factors.

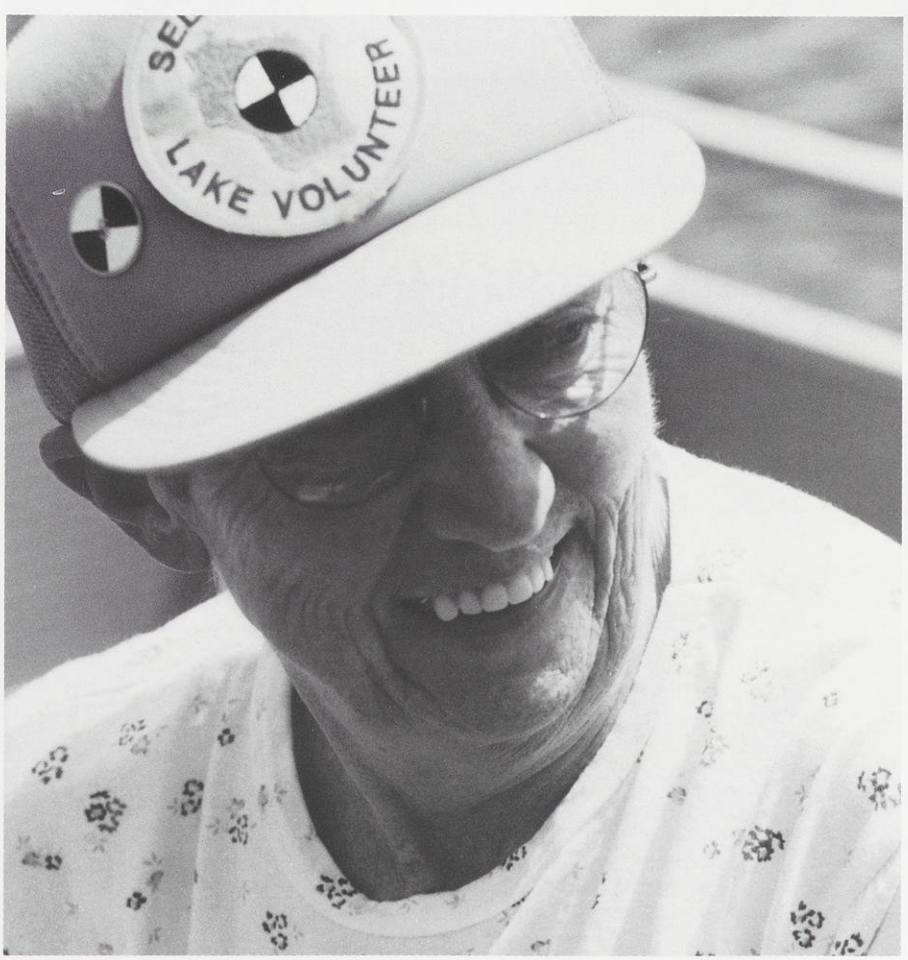
The Mt. Morris Lake Management District worked to replace its dam in 1995. During construction, the dam broke, causing extremely low water levels. "Our lake district was very involved in the dam," says Nils. "We wanted to get as many people to help as possible because they could learn something about the lake. And education is so very important. So we raised a good portion of the money to help repair it."

Nils plans to keep the lake district members informed of monitoring endeavors. "We want to know what's going on with our lake," he says. "And we want others to know about it too."

Monitoring work complete for the day, Nils provides Scott and me with copies of the results that he has graphed, and Lois sends us off with homemade oatmeal and hickory nut cookies.

Julia Buehler lowers a Secchi disk to measure water quality on Hancock Lake. She and her grandson take their measurements by canoe most weeks.





Bob Gayhart and Reid Hundermark collect water samples and note water temperatures for the tests they will conduct on shore. More than 700 people volunteer as lake monitors each year.

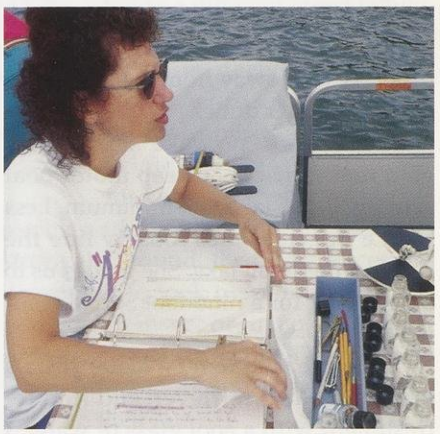
How lake neighbors organize

There are several ways to organize property owners, area residents and other lake users to protect and improve lake quality. Two of the more common approaches are forming a lake association or a lake district.

A **lake association** is a voluntary "friends" group with formal membership comprised of those who own land on the lake, use the lake or want to get involved with communities to better these public resources. The goals of lake associations include organizing lakeside communities to maintain, protect or improve the quality of a lake, a chain of lakes, its fishery and its watershed. Associations may raise money or have dues to finance lake improvements. Since the organization is voluntary, all those owning lakeside property are not necessarily members of a lake association.

A **lake district** is a special-purpose unit of government. Property owners within the district pay fees, usually as part of their property tax bill, which finance the district's activities. Lake district property owners elect commissioners who approve budgets and contracts. A city or village must consent to have its lakefront and nearshore properties included in a lake district.

Lake districts have the legal power to make contracts, buy or sell land, take out loans and accept grants. Towns, villages and cities can delegate authority to the district to make lake improvements and regulate some of the touchy social issues on water use like determining which boating equipment can be used on the water, safety requirements, boat operator requirements, travel on frozen lakes and other recreational conditions. The district's officers are usually elected by district members and additional representatives may be appointed by the counties and towns encompassed in the lake district.



Joy Krubsack reads testing steps. Each monitoring group gets a notebook telling how tests should be done to get reliable results.

A helping hand for Hancock Lake

Julia Buehler, Self-Help volunteer on Hancock Lake in Waushara County, greets us at the door of her lakefront home. Stifling heat and humidity leads Scott to question spending the afternoon in a boat exposed to intense sunshine. But Julia is ready to go, sporting a light blue cap decorated with Self-Help patch and pin.

Julia usually paddles out in her canoe, sometimes alone and sometimes with her 10-year-old grandson Jordan, but today we borrow a DNR motorboat and start with a shoreline cruise and tales about the lake. It's quiet. Our boat makes the only sound and we see no one except two children fishing from the far shore. An area resident since 1962, Julia moved five years ago to a lakefront home constructed on the foundation of the house that her grandparents built in 1894.

"My grandpa would go out in the winter and aerate the lake," she tells us. "He'd drill holes in the ice so the fish wouldn't die. A creamery operated over there till the 1950s," she says, pointing to the north shore. "Over there we still find bones from the slaughterhouse that used to dump its waste."

For ten seasons, Julia has been monitoring both Hancock and nearby Fish lakes. The best thing about it for her is that "I can get away from the phone!" Julia retired after 40 years of nursing in Wood County, but she's now serving

her second two-year term as Hancock village president. A dip of the Secchi disk takes her away from the increasing demands of her duties.

Hancock is a "no wake" lake. Julia is glad that restrictions keep motor boat activity on the lake to a minimum. Less than a dozen homes loosely line the shore of the small lake. She guides us to a deep spot for a nine-foot Secchi reading today.

At home, we meet Willie, Julia's graying golden retriever, and find refreshment with a cool glass of water. I ask why she monitors. The response is matter of fact. "I just like to do it. And I'm going to keep doing it until I can't get into the boat any more!"

Teaming up to protect Pine Lake

First thing in the morning, Reid Hundertmark already wears a coat of sunscreen. "If I don't do this, my dermatologist zaps me!" he chuckles. We meet his nephew, Bob Gayhart, also a homeowner and volunteer monitor on Pine Lake in Shawano County.

There's a strong breeze today as we load monitoring gear onto the pontoon boat and head down the shore to pick up Joy Krubsack, the third member of this tightly knit volunteer team that's been a part of Self-Help for nine years.

Joy, an eighth-grade earth science and social studies teacher in the Clintonville district, sits on deck at a card table with the Self-Help manual out, reviewing protocol aloud and lining up bottles for dissolved oxygen testing. Reid, a retired social studies teacher and Bob, retired from AT&T, work the water sampler. While one lowers it, the other calls out temperatures, then fills the small bottles. By the time Joy has added manganese sulfate to each bottle to help convert the oxygen to iodine, Bob and Reid have reeled in the next sample.

All three volunteers grew up in nearby Clintonville and had known each other from their involvement in the Cloverleaf Lakes Protective Association. "We wanted to know more details about how our lake was doing," says Bob. "That's why we began monitoring."

"We haven't seen much change in nine years," adds Joy. "When we first started monitoring though, we had oxygen even at the deepest levels. Since 1990, we have had no oxygen at the deep water levels." She shows me the graphs she has maintained of Pine Lake data for the past nine years. Certain plants and fish need high oxygen levels to live, so insufficient oxygen can alter underwater composition and cause fish to die.

Of the three lakes Scott and I have visited, Pine is the largest and sees the most use. But Joy, Bob and Reid believe that the water is important for recreation and along with their lake association, are very tolerant of activities on and around the lake.

Back on land, Bob carefully prepares the phosphorus sample by adding acid while Reid titrates to find the concentration of oxygen in the samples of lake water. Phosphorus levels show the amount of nutrients a lake contains. The more phosphorus, the more plants and algae present. With three people, the sampling process goes quickly. "To monitor by yourself would take a lot longer, and would be boring," Joy comments.

Just when the last of the dissolved oxygen readings is complete, the sky becomes very dark and clouds quickly roll in. As rain pelts down hard, we scramble to Reid's garage for our goodbyes, thankful to have completed our monitoring in dry weather.

•

Years of data collection are necessary to determine whether a lake has degraded or improved. Through involvement in Self-Help, Nils and Lois, Julia, Joy, Reid and Bob have taken an active role in the future of Wisconsin's lakes. With a large number of volunteers sharing the knowledge they gain statewide, awareness of lake ecology continues to expand. As Lois said: "Participating in Self-Help makes us feel good about the knowledge we have gained about our lake. And there is great gratification in being able to share that knowledge and help others contribute to the protection of lakes." □

Bob Gayhart tests oxygen and phosphorus levels which indicate how well lakes can support fish and aquatic bugs as well as measuring how fast the lake is aging.

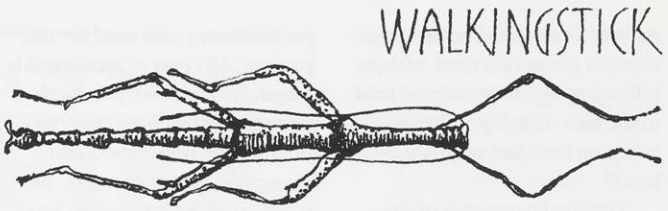
Since 1997, Maureen Janson has worked for the Self-Help Lake Monitoring Program in DNR's central office in Madison. She writes and edits the quarterly Lake Monitoring News and lives on Lake Monona in Dane County.

For information about Self-Help Lake Monitoring, contact:
Susan Graham, FH/3
Self-Help Lake Monitoring
Wisconsin Department of Natural Resources
P.O. Box 7921
Madison, WI 53707
(608) 266-8117

continued from page 2

Our resident walking sticks are slow-moving, plant-eating insects that usually feed at night on oak leaves, but will dine on hazelnut and cherry. During the day they rest, remaining motionless for hours while posing as twigs. Their antennae and front legs stretch out rigidly before them while their hind legs may be extended backward. Their stance and cryptic coloring are so deceiving that they are difficult to find.

Young nymphal walking sticks, which hatch in spring, are green at first, then mimic maturing twig colors, darkening to brown with each of four molts that end in late summer.



Walking sticks mate in August. A female lays her 100 eggs singly which rain indiscriminately upon the forest floor. The 3mm-long, oval, seed-like eggs overwinter in the ground litter. Some eggs hatch the following spring, many others take two years to hatch. The small, green nymphs must climb the oaks to feed on fresh leaves.

Walking sticks belong to the same insect order as grasshoppers (Orthoptera) but to a different insect family, the Phasmatidae. The family name is derived from the Greek word, *phasm,* which means apparition, an appropriate, accurate description for an insect that wants to resemble a stick. Deception is its means of survival. If found, the insect forces the discoverer to look twice to decide if it really is an insect or just a twig. Both predators and people are likely to miss the creature on second glance and continue on their journey. □

Anita Carpenter keeps a close eye on nature's comings and goings near her Oshkosh home.

Readers Write

ON AGING DAMS

We were privileged to reprint "Dammed if you do and damned if you don't" by Katherine Esposito (April 1999) since one of the dams in question, the Orienta Falls dam, is located in our area. It was timely and of interest to our readers. You did an excellent job of reporting on the problems associated with aging dams. The detail and presentation of both sides of the issue was extremely well done. I appreciate the time you put into this article and the depth in which it was reported.

Barbara Gardner, Publisher
The Connection
Port Wing

DETERRING GEESE

"Making peace with geese" (December 1998) interested me as I was a refuge manager for the U.S. Fish & Wildlife Service for 28 years. Most of that time was spent establishing resident flocks of Canada geese on various federal wildlife refuges.

One thing I learned early is that all waterfowl have a great fear of all avian predators. Peregrine falcons, golden eagles and snowy owls are predators that I know will kill Canada geese. Surprisingly I have never seen a bald eagle kill a Canada goose, possibly because given a choice, bald eagles prefer fish. I have seen a bald eagle fly right past a flock of Canada geese when they were all heading for their nightly roost. I have also seen a golden eagle knock a Canada goose right out of the air in flight, which is an awesome sight.

Nesting peregrine falcons would be effective deterrents to a flock of Canada geese, ducks or pigeons. A resident pair of bald eagles would probably also be effective.

Local flocks of Canada geese can rapidly become a nuisance when they have no natural predators. Why not consider introducing natural predators to balance things up a little? Along that line, I've often wondered if boys with model airplanes patterned after a hawk or eagle might scare away geese.

David C. McGlachlin
Beloit

ON-WATER SAFETY

I have a cabin up north and a Sea-Dooer ran into my pontoon boat when he was showing off. The accident didn't hurt my boat much, but it ripped off the front of his craft, which he had just gotten.

My friends in the area and I all have some type of personal watercraft (PWC). I've been looking up the accident rates with PWCs and maybe I can tell my friends about it just to make them think. Most of them are good drivers, but all of us have a crazy streak. I want to keep my friends for a lifetime and I don't want to lose them to something so dumb [as an accident on the water].

Holly
Montrose, Mich.

HAPPY CAMPERS

I thought you would like to get some positive feedback on the new reservation system. The service was excellent. For instance, I was informed that the site I had first requested was sloped and would be unacceptable for my camper. Under the old system, either our request would have been returned or we would have arrived only to find we had reserved a site we could not use.

After making another request, I was told the site we wanted was not available. By adjusting our arrival date by one day, we could reserve the site we wanted. I hope the new system stays in place.

Scott Green
Green Bay

For years I have wanted the state parks system to respond more quickly on reservations. Sure the first few days were rough, but we persevered, got through and made our reservations. The reservationist was clear, concise, professional and informative. Thank you for the new system. It works.

Jane Niggemann
South Milwaukee

Hats off to DNR staff for taking on this new reservation system. It will make matters more convenient for all of us once the bugs are worked out. I am looking forward to the e-mail system.

Sandy Heidel
Onalaska

WARDING OFF TICKS

During this Lyme disease season, the Food and Drug Administration (FDA) would like to alert your readers to some developments in diagnosing and preventing Lyme disease.

First, the FDA is concerned about potential misdiagnosis of Lyme disease based on results of commonly marketed blood tests. These tests detect antibodies to *Borrelia burgdorferi,* the organism that causes Lyme disease, but they should be used only to support a clinical diagnosis. It is im-

portant for consumers to understand the limitations of these tests and to be active participants with their clinicians in any diagnosis of Lyme disease.

Second, FDA recently licensed the first vaccine (tradename Lymerix) to aid in preventing Lyme disease. The new vaccine is approved for use in persons 15 to 70 years who live or work in grassy or wooded areas where infected ticks are present. Three doses of the vaccine given over a period of one year are needed. Since the vaccine is not 100 percent effective, preventive measures are still necessary.

Although these products are important tools in the fight against Lyme disease, education in preventing, detecting and treating Lyme disease remains a vital component of any Lyme disease program.

To decrease the chance of being bitten by a tick:

- Avoid wooded, brushy, and grassy areas, especially in May, June, and July.
- Wear light-colored clothing, so that ticks can be seen more easily.
- Wear long pants and long-sleeved shirts.
- Wear shoes that cover the entire foot.
- Tuck pant legs into socks or shoes and tuck shirts into pants.
- Wear a hat for extra protection.
- Spray insect repellent containing DEET on clothes and exposed skin other than the face, or treat clothes with permethrin.
- Walk in the center of trails to avoid brush and grass.
- After being outdoors, remove clothing. Wash and dry it at hot temperatures.
- Do a careful body check.

Dr. Lireka P. Joseph, Director
Office of Health and Industry Programs
Food and Drug Administration

DOG TRIALS AND CAPTIVE WILDLIFE

Something in your article about captive wildlife ("Caged, penned, swapped and sold," February 1997) has been bothering me since I read it. The last page shows a photo of a duck with its bill and wings immobilized held in the face of a dog. What is going on here and why is it legal?

The final paragraph of the story states that legislative hearings on proposed revisions to captive wildlife laws were expected to be scheduled in the winter of 1997 and spring of 1998. Any update?

I thought the article was very thought provoking.

Janna L. Davis
Kaukauna

The picture showed a dog trial in which hunting dogs follow scent and are judged on their abilities to find a hidden animal, hold point or retrieve. Taping prevents the ducks from flapping away and also protects their wings during such field trials. Unless birds are shot as part of the field trial, these game farm birds survive, the tape is subsequently removed, and they rejoin the captive flock.

Revisions to state captive wildlife policy were approved in the State Assembly last session, but the bill died in a State Senate committee. We believe similar legislation will be introduced again this session.

NIX TO STICKERS

I found the information in your February issue interesting, as usual. However, I find it somewhat incongruous at a time when we read of shortages of funds for natural resource projects, wardens, etc. that we are wasting money printing the silly little stickers that accompanied the magazine.

Please don't continue to tell me that license fees and other items need to be increased when you waste our money on this sort of drivel.

James R. Sakar
Milwaukee

Many others wrote to tell us they enjoyed the stickers and are using them to plan outdoor activities, as we intended. By the way, no tax money was used for this project. All costs to produce this magazine (salaries, production, printing and mailing) are covered by our subscribers and those who sponsor inserts. We considered the stickers an economical alternative to printing a calendar since readers could use them on any calendar as a reminder to make time for enjoyable days outdoors.

RESIDENT SWANS

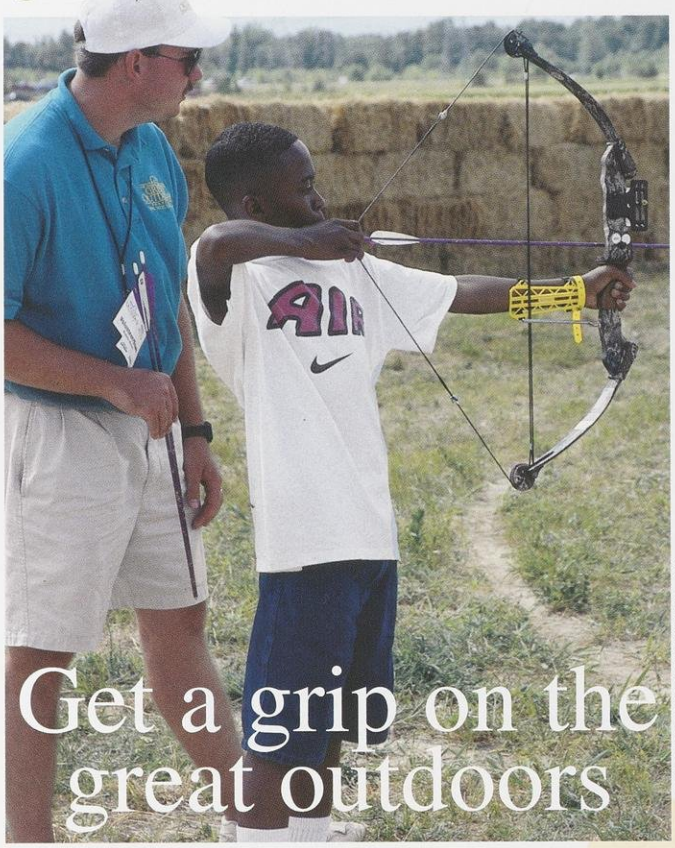
On my semi-annual trips to Wisconsin I look forward to visiting my brother's lakefront property. A pair of swans has been nesting and raising young in a marshy area across from his house. We look forward to watching them each time. My brother informed me last fall that the male of the pair disappeared and hasn't been found, even after many folks searched for him. In watching these birds over several years, I'm sure the male did not just leave his family. Does Wisconsin investigate these losses? Will the female return with a new mate? Will the offspring return? I'd sure like to read about these great birds' habits in your magazine.

Ernest L. Hagness
Portland, Tex.

The swans in your photo are mute swans (Cygnus olor) judging from the size and the orange bills. They are technically considered feral swans rather than truly wild birds. These birds were domesticated centuries ago and are still raised in domestic flocks in England. Most mute swans in North America escaped from domestic flocks and adapted to the wild. They are protected and can't be hunted, but that doesn't mean there would be an investigation for a "missing" bird.

Given the prevalence of these birds in lakes and parks in the city and the country, I doubt a warden or wildlife manager would investigate what happened to a particular bird unless you had direct evidence or an eyewitness account of foul play. It would be difficult to determine if the bird died of natural causes or moved out of the area. We carried an article about mute swan management ("Deceptive elegance") in February 1993. Like many species, mute swans have adapted well to urban areas and in some places have displaced native swans.

WISCONSIN TRAVELER



DIANE JOLIE, DUCKS UNLIMITED, INC.

Get a grip on the great outdoors

Admit it: Sometimes, the great outdoors isn't so great. More than a few of us, your doughty TRAVELER included, have had our comeuppance on a scree-ridden trail, or been humbled by the intricacies of a clinch knot at the end of a No. 8 hook.

Call it skill, call it competence, call it knowledge — whatever the term, you need it to meet the outdoors head-on. When you've got it, confidence follows, with delight not far behind.

So make plans to be in Oshkosh on the weekend of August 27–29 for the **Ducks Unlimited Great Outdoors Festival.** The three-day event held on the city's spacious EAA Convention Grounds offers hands-on experience for a variety of outdoor activities and skills.

Don't be misled by the sponsor's name. Although Ducks Unlimited itself does focus on the sport of waterfowl hunting, this festival encompasses outdoor experiences beyond the business end of a shotgun barrel, aiming to educate visitors on the need to preserve wildlife and protect habitat for the enjoyment of generations to come.

At different "sporting villages" within the festival grounds you can try out equipment, talk to experts, and take part in sessions on everything from gun cleaning, low-impact camping, duck calling and fly tying to waterfowl migration, wildlife art and wetland conservation. Never used a bow and arrow? Here's your chance to aim for Olympic-style targets. Imagined yourself scaling a cliff to get a better perspective on the landscape during a hike? Try climbing the rock wall, and you'll feel what it's like to find barely visible footholds on the way up. Test-drive off-road vehicles and learn about proper handling and safety. And see how accurate a shot you *really* are when the sporting clays start to fly.

Spend the weekend in Oshkosh to celebrate the outdoor lifestyle and hone your skills. Admission: Adults — $10 one day, $18 two days, $25 three days; children 6–12 — $5, $8, $12; children under 6 and dogs on a lead — free. See the DU website at http://www.ducks.org/5x/gef/ for more details about this event.

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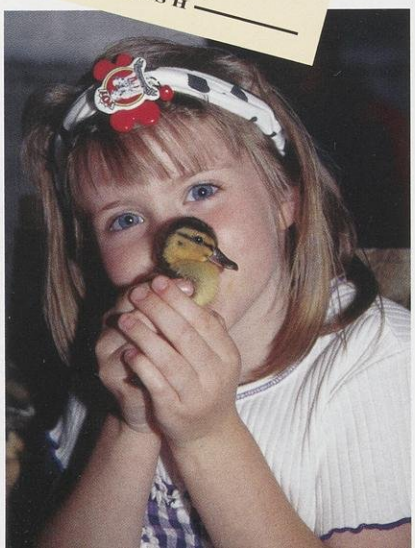
Wisconsin is indeed a many-faceted state. Consider the difficult choices you'll have to make over the first weekend of September:

In Allenton, seven miles west of West Bend, concertina enthusiasts from around the globe will flock to play and polka during the **1999 World Concertina Congress Jamboree Festival,** Sept. 3–5. Besides having a general all-around good whoop-de-doo, you can buy, sell and trade the instruments. 414/629-5232.

Over in Prairie du Sac, more than 250 competitors will flip their chips and go for glory in the annual **Wisconsin State Cow Chip Throw,** Sept. 3–4. The competition is open to all. 608/643-4317.

Don't forget the **Wilhelm Tell Festival.** Since 1938, the good burghers of New Glarus have staged "Wilhelm Tell," the drama of Swiss independence; 1999's performances are scheduled for Sept. 4–6. The elaborate outdoor production is in English on Saturday and Monday; Sunday's performance is in German. 1-800-527-6838.□

THE DUCKS UNLIMITED GREAT OUTDOORS FESTIVAL 1999 OSHKOSH



LEE D. SALBER, DUCKS UNLIMITED, INC.

JANEEN JOY

(above) Enjoy some outdoor theater. Is it "V" for Victory or the notch atop Wilhelm Tell's noggin? Find out at the September 4–6 festival in New Glarus.
(left and top left) Try out new outdoor skills at the Great Outdoors Festival in Oshkosh, August 27–29.

Wisconsin, naturally

Kohler Park Dunes State Natural Area

Notable: This site contains active and stabilized sand dunes, one mile of beach, and several interdunal wetlands along the Lake Michigan shoreline in Sheboygan County. In autumn, the skies above the dunes are often frequented by migrating raptors.

How to get there: From the junction of Highways 43 and V, about 3 miles south of Sheboygan, follow the signs to Kohler-Andrae State Park. Park at the Sanderling Nature Center and follow the boardwalk into the natural area. Note: A state park sticker is required. *Wisconsin Atlas:* page 47, grid C7.

Fall in Wisconsin

Worth its weight in gold

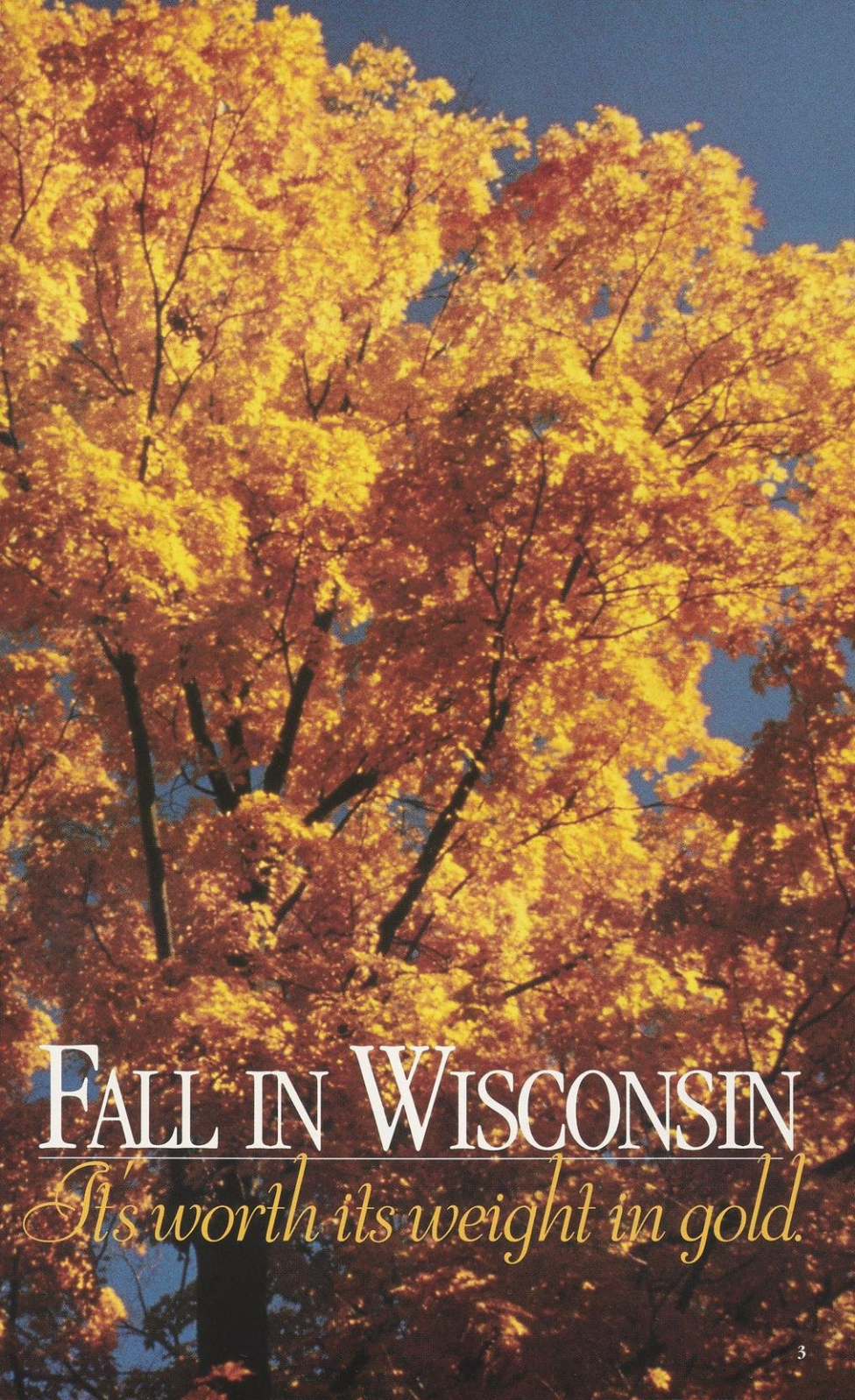
The pulse of Wisconsin quickens in fall. Lakes and rivers sparkle, the moon shines brighter, and crisp leaves crunch underfoot. The sun dances on glorious color: splashy orange, blazing red, burnished copper and smoky gold. There's no better place to experience the season.

FRITZ ALBERT

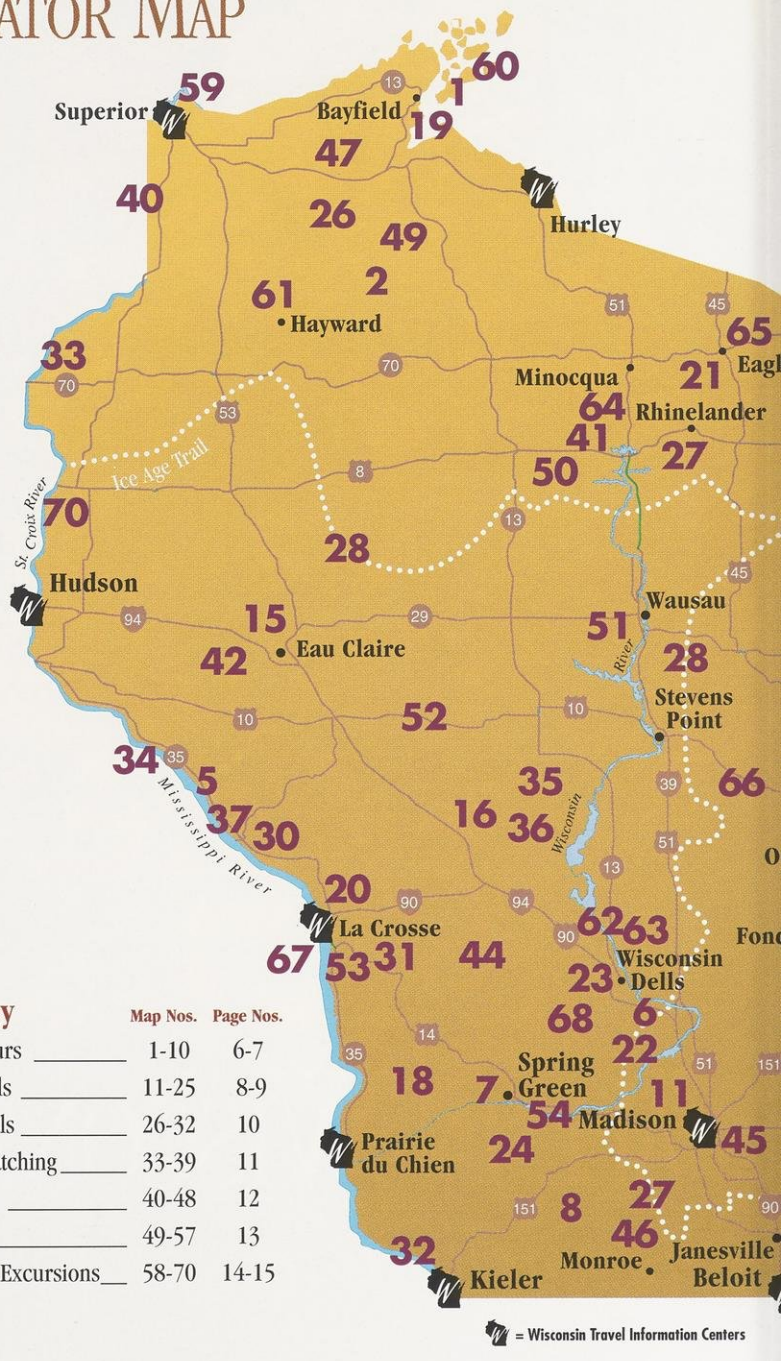
TOURISM PHOTO FILE

In Wisconsin, brilliant colors are the backdrop for a cornucopia of autumn activities as abundant as the harvest is large. Savor the season with an auto tour or aboard a century-old train. Stroll a city park, take in a fall festival and stop at a roadside stand chock-full of fresh fruits and vegetables. The fish are biting and the golf courses still beckon.

"Colorama." It begins in mid-September along Lake Superior and throughout the Northwoods, then sweeps down over the middle of the state from the Mississippi River to the Door County peninsula a few weeks later. By late October, southern Wisconsin's farmlands and rolling hills are awash in vibrant hues.


FALL IN WISCONSIN
It's worth its weight in gold.

Locator Map



Map Key

	Map Nos.	Page Nos.
Driving Tours	1-10	6-7
Fall Festivals	11-25	8-9
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Wildlife Watching	33-39	11
Bike Trails	40-48	12
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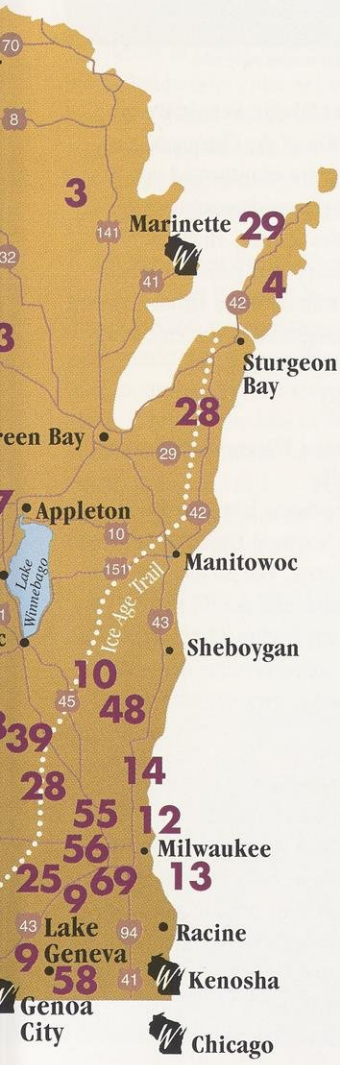
This map identifies activities in the guide. Numbers identify specific locations.



Fall Color Map

Peak fall colors travel throughout Wisconsin during September and October. For weekly color reports and additional scenic locations around the state, call the **Wisconsin Fall Color Hotline** **1-800-432-8747** or visit the Department's Web site at **travelwisconsin.com**

Historical & Wildlife Highway Signs

As you travel in Wisconsin, look for these road signs that identify the location of heritage sites and watchable wildlife sites.

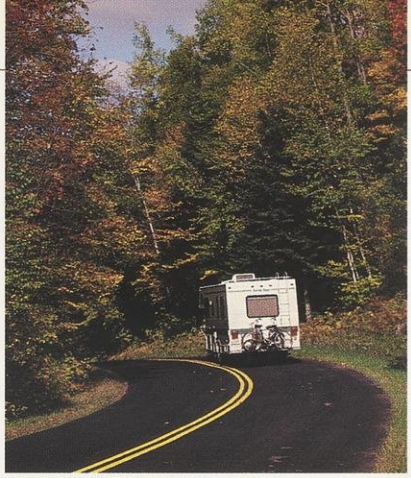
The Fall Road Show

It's as simple as hopping in the car and heading out. Every corner of the state offers vistas, forests, river valleys, farm fields and pumpkin patches with resplendent fall color.

1 Apostle Islands National Lakeshore/Lake Superior Shoreline
Foliage lines the Lake Superior Shoreline along Highway 13 from Superior to Ashland. Highlights include colorful woodlands, the wild Brule River, the Red Cliff Indian Reservation and a great view of the Apostle Islands National Lakeshore. (715/779-3397; www.nps.gov)

PHILLIP OLSON

Raspberry Island Lighthouse in the Apostle Islands.



RJ & LINDA MILLER

A blaze of color waits around every turn.

2 The Great Divide Scenic Byway
The wooded hills of the Chequamegon National Forest are transformed into a brilliant canvas, providing some of the state's best color touring. Highway 77 traverses the forest and passes through lake country, with 29 miles (from Hayward to Glidden) designated as a scenic byway. (715/762-2461, 715/264-2511, 715/634-4821)

3 Northeastern Wisconsin's Forests and Waterfalls
Thousands of pristine lakes surround drivers in the Northern Highland-American Legion State Forest. The Nicolet National Forest is brilliant, and the rivers of Marinette County feature 12 waterfalls, one of the largest concentrations statewide. (1-800-236-6681; www.dnr.state.wi.us)

4 Door County
Door County's enchanting landscape erupts with color. The county boasts more miles of shoreline, state parks and lighthouses than any other in the United States. Plus, fall hues provide a glorious backdrop for fruit orchards, artist colonies and coastal towns. (1-800-52-RELAX, 920/743-4456; www.doorcountyvacations.com)

5 The Great River Road

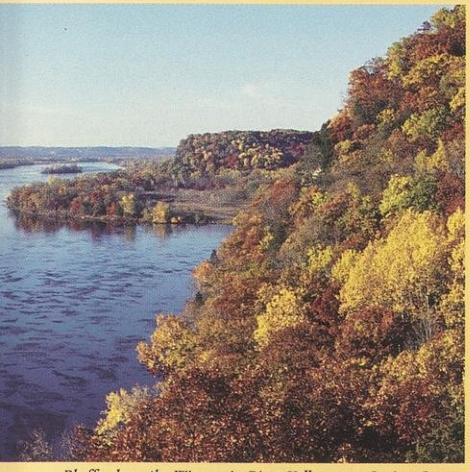
Offering some of the best scenery of any drive in the country, Wisconsin's Great River Road, Highway 35, follows the course of the Mississippi River for approximately 240 miles from Dickeyville to Prescott. The river bluffs dazzle with color. Towns up and down the route celebrate the fall harvest with festivals. (1-800-372-2737)

6 Devil's Lake State Park and the Baraboo Hills

The beauty of Devil's Lake State Park is intensified by fall's color show. Five-mile-long South Shore Road/South Lake Road winds through the park and boasts 500-foot bluffs, rugged hills and a crystalline lake. (608/356-8301; www.dnr.state.wi.us)

7 Spring Green Valley Tour

The drive along Highway 23 between Dodgeville and Spring Green is one of the most scenic in southwest Wisconsin. Taliesin, architect Frank Lloyd Wright's home, is built in the hills of the Wisconsin River Valley. The House on the Rock's Infinity Room, a 218-foot-long glass walkway, stretches over the Wyoming Valley, 156 feet below. (1-800-947-2799)



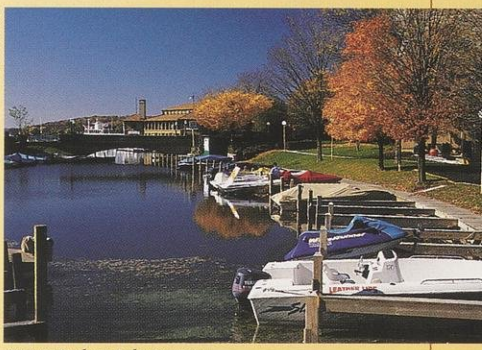
DON DAVENPORT

Bluffs along the Wisconsin River Valley, near Spring Green.

8 Ethnic Settlements & Old World History

A tour of southwest Wisconsin's rolling hills and valleys combines dramatic scenery with historic sites and the small towns of Monroe, New Glarus, Mineral Point, Belmont and Platteville. (1-800-947-2799)

DON ABHAMS



Riviera Park on Lake Geneva.

9 Lake Geneva

The charming area of Lake Geneva offers several paved rustic roads that blaze with colorama - all off Highway 50. The 10-mile-long South Road treats drivers to views of farmland, glacial Kettle Moraine topography and antique rail fencing. Snake Road winds past historic mansions of another era. Cranberry Road features curvy, hilly terrain that stretches past marshes and wildlife. (1-800-345-1020)

10 Kettle Moraine Scenic Drive

Maples and sumacs burst into bold red along this 125-mile route, marked by green acorn-shaped signs. It connects the Northern and Southern units of the Kettle Moraine State Forest. In the Northern Unit, 60-foot-tall Parnell Tower boasts an ideal vantage point; farther south, Holy Hill yields a remarkable perspective on the colorful countryside. (414/594-6200, 920/533-8322)

Experience the Season

Fall is Wisconsin's festival season, when the bounty of the harvest calls communities to celebration. From apples, cranberries and wine to ethnic traditions, people statewide find plenty of reasons for revelry.

11 Dane County Farmer's Market in Madison, through the first week in November

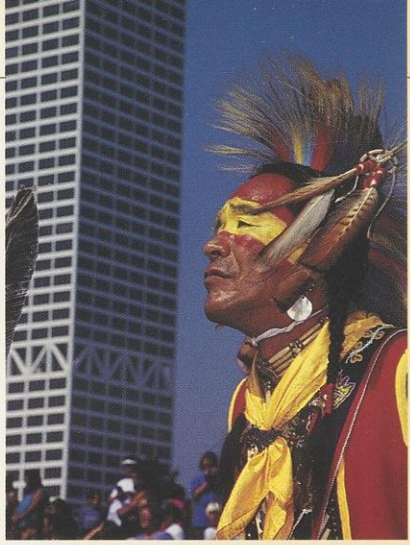
Held each Saturday on the Capitol Square, the outdoor market boasts an impressive array of bakery, cheeses, fresh produce, and other farm products. (1-800-373-6376; www.madfarmmkt.org)

12 Indian Summer in Milwaukee, Sept. 10-12

Native American flute and drum music, powerful dancing, colorful costumes and fun are featured in the largest Native American festival in the nation. Enjoy craft demonstrations and traditional American Indian foods. (1-800-837-FEST; www.indiansummer.org)

13 Bavarian Oktoberfest in Milwaukee, Sept 11-12, 18-19 and 25-26

The oldest Oktoberfest in the Midwest showcases traditional Bavarian culture. Brass bands, "Schuhplattler" dancers, sing-alongs, yodeling, and hearty German foods and beer. (414/462-9147)



DONALD ABRAMS

Indian Summer Festival in Milwaukee, September 10-12.

14 27th Annual Wine and Harvest Festival in Cedarburg, Sept. 18-19

Grape-spitting and apple-bobbing contests, a "Swine on Harvest Moon" pig roast, a farmer's market and horse-drawn wagon rides are all part of this old-fashioned, family-friendly event. (1-800-587-1386; www.cedarburg.org)

15 Harvest Festival in Eau Claire, Sept. 18-19

Visitors to this festival find displays of fine art and antiques, gourmet food, a fall harvest market and live entertainment. (1-888-523-FUNN; eauclaire-info.com)

16 27th Annual Cranberry Festival in Warrens, Sept. 24-26

Tour flooded cranberry bogs, sample cranberry products from pies to jams, browse hundreds of antique and arts and crafts booths, and delight in a festival parade. (608/378-4200)

17 Octoberfest in Appleton, Sept. 25

This is Wisconsin's largest one-day festival, with four entertainment stages, hundreds of arts and crafts booths, food and family activities. (920/734-3377; www.appletondowntown.org)

18 Annual Apple Festival in Gays Mills, Sept. 25-26
More than 20,000 people flock to this annual event. In the heart of apple country, enjoy all kinds of apple products, arts and crafts displays, a parade and a flea market. (608/735-4341, 608/735-4810)

19 Apple Festival in Bayfield, Sept. 30-Oct. 3
On the shores of Lake Superior, Bayfield celebrates the local apple harvest. Travelers find all kinds of apple treats, from gourmet pies and strudels to sundaes and cider. (1-800-447-4094; www.bayfield.org)

20 La Crosse Oktoberfest, Oct. 1-7
An annual harvest celebration steeped in German tradition. Authentic German food, music, arts and crafts, parades, carnival rides and a 100-mile bike race are just some of the festivities. (608/784-FEST; www.oktoberfestusa.com)

21 20th Annual Cranberry Fest in Eagle River, Oct. 2-3
Come see the "World's Largest Cranberry Cheesecake." Visitors can eat, drink, wear, bake and decorate with cranberries and tour the bogs to see the harvest. (1-800-359-6315; www.eagle-river.com)

Warrens Cranberry Festival, September 24-26.

RJ & LINDA MILLER

22 Wollersheim Winery Grape Stomp Festival in Prairie du Sac, Oct. 2-3
Enjoy the grape stomping, grape-spitting and cork toss contests; then taste the fruits of the wine makers' labor. (1-800-VIP-WINE; www.wollersheim.com)

Oktoberfest in La Crosse, October 1-7.

23 Autumn Harvest Fest in Wisconsin Dells, Oct. 14-17
Pumpkin-carving and scarecrow-stuffing contests, wagon rides, and an arts and crafts fair amuse people of all ages. (1-800-22-DELLS; www.wisdells.com)

24 Studio Tour of Working Artisans, Oct. 15-17
Traveling scenic rural roads, visitors can follow a map to the studios of more than 35 artisans in four communities. Spring Green/Dodgeville (608/588-7049), Mineral Point (608/987-2963), and Baraboo (608/356-7805).

25 Autumn on the Farms in Eagle, Oct. 16-17
Experience the rhythms of a fall day on several 19th century farmsteads at Old World Wisconsin, an outdoor living history museum. Period costumes, cooking, winter storage and fieldwork methods. (414/594-6300)

Take a Hike

With spectacular colors and crisp autumn air, it's a perfect time to explore the state on foot.

RJ & LINDA MILLER

Copper Falls State Park, near Ashland on the North Country Scenic Trail.

26 Rainbow Lake Wilderness Area, North Country National Scenic Trail near Drummond
Five wilderness lakes nestled in the woods provide a surprise for hikers along this 6-mile trail in the Chequamegon National Forest. (715/762-2461)

27 Nicolet National Forest, headquarters in Rhinelander
Thirty-two designated hiking trails through this expansive northeastern forest showcase classic Northwoods scenery – tall hardwoods and pines, rock outcroppings and open meadows. (715/479-2827; www.fs.fed.us/r9/cnnf)

28 Ice Age Trail, from Potawatomi State Park in Door County to Interstate Park in St. Croix Falls
Hikers can travel more than 600 miles through 31 Wisconsin counties to see imprints of melting glaciers and dazzling hues. (414/278-8518, 1-800-227-0046; www.iceagetrail.org)

29 Peninsula State Park in Door County
A hike along nearly 20 miles of trails reveals hardwood forests and towering limestone bluffs that overlook this popular park's vast sandy beaches. (920/868-3258; www.dnr.state.wi.us)

30 Perrot State Park in Trempealeau
Brady's Bluff offers one of the best views of spectacular fall color and great sunsets along the Mississippi River. (608/534-6409; www.dnr.state.wi.us)

31 Norskedalen Nature and Heritage Center in Coon Valley
Four miles of hiking trails wind through 400 acres untouched by glaciers. Fearless trekkers are invited to brave the "Goulees in the Coulees" Haunted Halloween Hike, Oct. 28-29. (608/452-3424)

32 Wyalusing State Park in Bagley
Walkers can catch sight of wild turkeys, eagles, deer and other wildlife in this 2,673-acre park which overlooks the Mississippi and Wisconsin rivers. Indian mounds and caves can be seen on its variety of trails. (608/996-2261; www.wyalusing.org)

For more information about hiking locations, contact the Wisconsin Department of Natural Resources Bureau of Parks and Recreation at 608/266-2181.

RJ & LINDA MILLER

Winged silhouettes at sunset.

WILD IN WISCONSIN

Hundreds of thousands of migrating geese and other birds flock to the state's fields and wetlands before continuing on their seasonal migrations.

33 Crex Meadows Wildlife Area in Grantsburg
Each October, Sandhill cranes, Canada and Snow geese, ducks and eagles flock to this 30,000-acre preserve of marsh, woodlands and prairies. (715/463-2896)

34 Swan Watch at Rieck's Lake Park in Alma
Nearly 3,000 migrating Tundra swans and other waterfowl, passengers on the Mississippi River Valley "flyway," rest here annually – where the Buffalo River joins the Mississippi – from mid-October through November. (608/685-4249, 608/685-3330; www.mwt.net/~swanalma)

35 Sandhill Wildlife Area in Babcock
Early risers have the best view of the 3,000 to 5,000 Sandhill cranes that gather at Gallagher Marsh from mid- to late October. (715/884-2437)

36 Necedah National Wildlife Refuge in Necedah
Part of the historic glacial Lake Wisconsin, this 44,000-acre refuge attracts thousands of migrating Canada geese, Tundra swans and ducks. (608/565-2551; www.fws.gov/r3pao/necedah/)

37 Trempealeau National Wildlife Refuge in Trempealeau
This 5,700-acre refuge, surrounded by the Mississippi and Trempealeau rivers, provides feeding and resting areas for migrating ducks, geese and swans. An observation deck overlooks the marsh. (608/539-2311)

38 Horicon Marsh in Horicon
Horicon Marsh is known worldwide for its migrations of birds and waterfowl. Each fall, more than 250,000 migrating Canada geese, ducks, swans, cranes and heron find respite in the marsh's 32,000 acres of wetlands. (920/387-7860, 1-800-937-9123; www.dnr.state.wi.us)

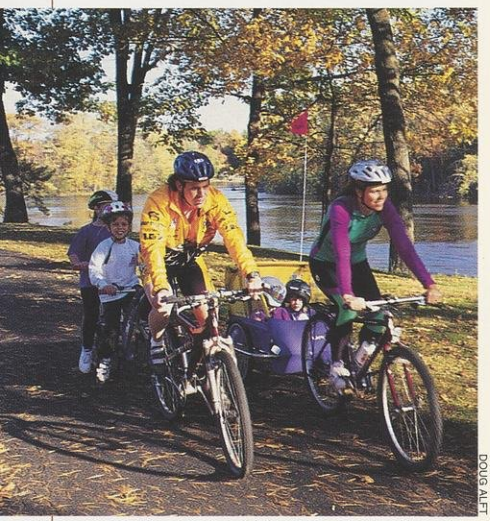
RJ & LINDA MILLER

Male Wood ducks – festooned in color.

39 Theresa Marsh Wildlife Area in Theresa
View more than 60,000 Canada geese. Theresa Marsh is also the seasonal home to several species of waterfowl and other birds, including Great Blue herons, marsh hawks and common egrets. (414/670-3400)

Get Up Close and Personal

Wisconsin's acclaimed "rails-to-trails" biking network offers smooth riding, while more challenging off-road paths lead straight into the thick of fall's glory.



DOUG ALFT

Fall biking along the Wisconsin River.

40 Gandy Dancer State Trail
A 47-mile converted rail-trail through northwestern woodlands and small towns. (800/788-3164; 800/222-7655; www.mwd.com/burnett/)

41 Bearskin-Hiawatha State Trails
A pair of converted rail-trails totaling 24 miles between Minocqua and Tomahawk. Enjoy scenic Northwoods lake country and plenty of wildlife. (715/385-2727)

42 Red Cedar & Chippewa River State Trails
Take-in the autumn glory of these two scenic river valleys between Eau Claire and Menomonie. 34 miles of converted rail-trails. (715/232-2631, 800/344-3866; www.eauclaire-info.com)

43 Mountain-Bay State Trail
Wind through Amish settlements, farmland, woodland and marshes for 83 miles from Green Bay to Wausau. (715/261-1550; www.co.marathon.wi.us/parks/)

44 Elroy-Sparta State Trail
A 32-mile ride through three century-old railway tunnels, small towns and wooded valleys, (608/463-7109; www.elroywi.com). At Onalaska, it connects to the 21-mile **La Crosse River Trail** (800/354-BIKE), and 24-mile **Great River Trail** (608/463-7109).

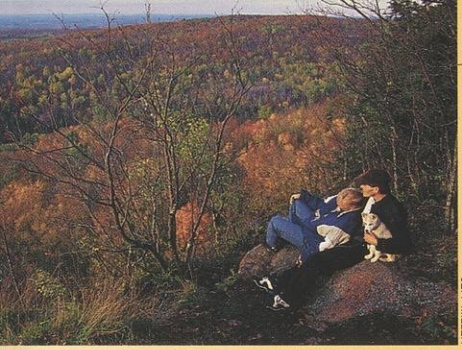
45 Lake Monona Loop
A 12-mile scenic route around the lake and through Olbrich Park. One of many cycling gems in Madison. (608/255-2537)

46 Sugar River State Trail
A delightful 23-mile roll along the Sugar River from New Glarus, Wisconsin's "Little Switzerland," to Broadhead. (608/527-2334)

47 Chequamegon Area Mountain Bike Assn. (CAMBA) Trail System
Six off-road trail clusters cover more than 300 miles in the Chequamegon National Forest of northwestern Wisconsin. (800/533-7454; www.cable4fun.com/camba)

48 Greenbush and New Fane Trails
A pair of challenging off-road trails in the colorful Northern Unit of the scenic Kettle Moraine State Forest. (414/626-2116)

For a free copy of the Wisconsin Biking Guide, call 800/432-8747.



JEFF MILLER

Chequamegon National Forest, near Mellen.

VIEWS FROM ABOVE

Some of the best places to take in the beauty of Wisconsin's brilliant fall landscape are on high ground.

49 Penokee Overlook
Amid the Chequamegon National Forest, this overlook about four miles west of Mellen provides a wonderful 20-mile view of the Penokee Mountain Range in northern Wisconsin. (715/264-2511)

50 Timm's Hill
In central Wisconsin, this hill near Ogema rises 1,952 feet above sea level – the highest point in the state. (715/339-4505)

51 Rib Mountain State Park
A 60-foot observation tower at this park near Wausau overlooks the Wisconsin River Valley. (715/842-2522; www.dnr.state.wi.us)

52 Highground Veterans Memorial Park
Near Neillsville, this park, atop a ridge overlooks a half-million acres of forested glacial terrain. (715/743-4224; www.thehighground.org)

53 Grandad Bluff
This bluff just outside La Crosse towers 540 feet above the Mississippi River and commands spectacular panoramas of the city, river and countryside below. (800/658-9424, 608/782-2366; www.couleeweb.com/laxparkrec)

54 Blue Mound State Park
Visible from miles around, the mound at this state park in south-central Wisconsin is an ideal spot for veiwing fall colors. (608/437-5711; www.dnr.state.wi.us)

55 Holy Hill
A longtime favorite, this religious shrine in Hubertus stands 1,335 feet above sea level, providing stunning views. (414/628-1838)

DONALD ABRAMS

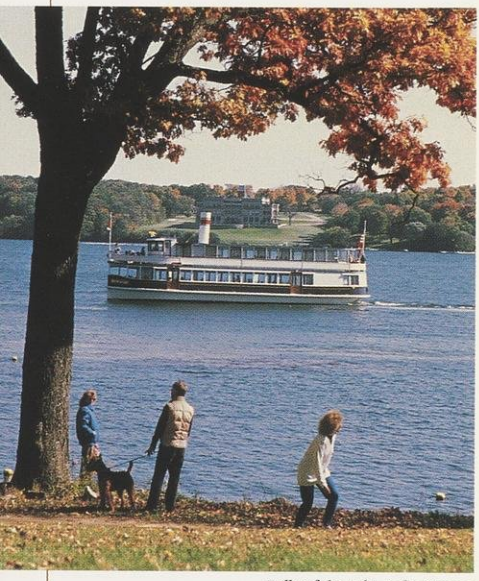
Holy Hill, near Hubertus.

56 Lapham Peak
This peak in Delafield is the highest point in Waukesha County at 1,233 feet. A 45-foot observation tower offers striking views. (414/646-3025)

57 EAA Air Adventure Museum
For an even higher vantage point, fall color seekers may opt to take an airplane ride. For a dose of nostalgia, this world-renown museum in Oshkosh offers rides aboard a 1929 Ford TriMotor plane. Call in advance for a flight schedule. (920/426-4886; www.eaa.org)

A Different Point of View

For a relaxing way to experience the full spectrum of Wisconsin's fall colors, climb aboard a boat or train.



JOAN COLLINS AGENCY

Belle of the Lake, Lake Geneva

CRUISES

58 Geneva Lake Cruise Line in Lake Geneva

The turn-of-the-century replica steamer *Belle of the Lake* offers narrated cruises with fascinating views of the grand estates that ring Geneva Lake. Or ride along on one of the few remaining U.S. Mail boat delivery routes in the United States. Late April through October. (1-800-558-5911; wwwgenevaonline.com/~glcl/)

59 Vista Fleet Cruises in Superior

A narrated 1-3/4-hour tour offers remarkable views of the Duluth-Superior harbor, a historic lighthouse and a waterfowl nesting habitat. Lunch, dinner and moonlight cruises are also available. Through mid-October. (715/394-6846, 218/722-6218; www.visitduluth.com/vista)

60 Apostle Island Cruise Service

Experience the memorable Apostle Islands through narrated tours. Sights include lighthouses, sea caves and shipwrecks. Mid-May through mid-October. (715/779-3925, 1-800-323-7619; www.apostleisland.com)

61 Chippewa Queen Tours in Hayward

The 25-mile narrated excursion unveils dramatic color and abundant wildlife on the Chippewa Flowage, which boasts 233 miles of undeveloped shoreline and 140 islands. Through Oct. 3. (715/462-3874; www.treelandresorts.com)

62 Upper and Lower Dells Boat Tours in Wisconsin Dells

Tours of the upper and lower dells reveal hidden canyons and towering sandstone cliffs complemented by brilliant fall foliage. Mid-April through October. (608/254-8555; www.dells.com/boattour.html)

TOURISM FILE PHOTO

Upper and Lower Dells Boat Tours, Wisconsin Dells

63 Original Wisconsin Ducks in Wisconsin Dells
Riders are treated to 8-1/2 miles of fun and adventure on land and water aboard the famous amphibious World War II "Ducks." Tours wind through colorful scenery on the Wisconsin River, Lake Delton and wilderness trails. Through Nov. 7. (608/254-8751; www.wisdells.com/ducks)

64 Wilderness Cruises in Hazelhurst
Passengers aboard the 76-foot *Wilderness Queen* can enjoy the breathtaking beauty of the Willow Flowage. Sightseeing, luncheon and dinners cruises available. Through Oct. 3. (1-800-472-1516 ext. 971, 715/453-3310 ext. 971)

65 The Boathouses of Vilas County in Eagle River
Elegant and unique 100-year-old boathouses dot the shorelines of Eagle River's chain of 28 lakes. Boat and pontoon rentals are available. Through mid-October. (715/479-8575, 1-800-359-6315)

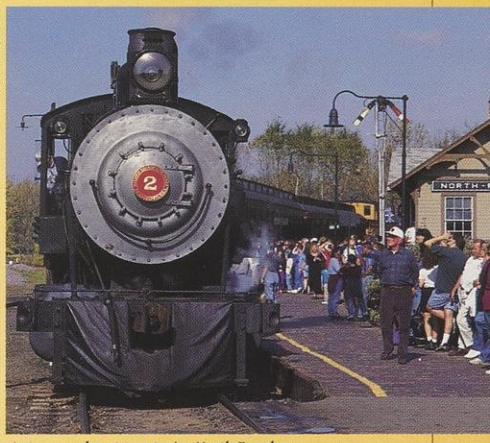
66 Chief Waupaca Steamwheeler in Waupaca
This steamwheeler floats guests along eight of 22 lakes that form the breathtaking Chain O' Lakes. Three 1-1/2 hour narrated tours are offered daily; private charters are available. Through mid-October. (715/258-2866; www.clearwaterharbor.com)

67 Julia Belle Swain Steamboat Tours in La Crosse
Recall the gracious style of a bygone era aboard this replica of a classic 1800s steam-operated stern paddle wheeler, one of only six of its kind on the Mississippi River. Through Oct. 24. (1-800-815-1005, 608/784-4882; www.juliabelle.com)

TRAIN EXCURSIONS

68 Mid-Continent Steam Train Autumn Color Tours in North Freedom
All aboard a turn-of-the-century steam train for a journey through the scenic Baraboo River Valley. Sights include La Rue, a former mining oasis and now a ghost town. Oct. 2 and 9. (608/522-4261; www.mcrwy.com)

ANDY KRAUSHAAR

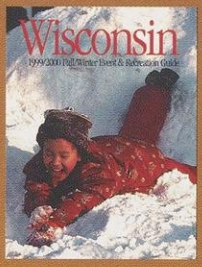


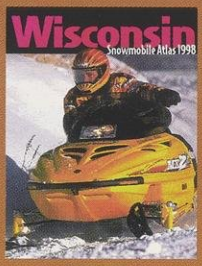
Autumn color steam train, North Freedom

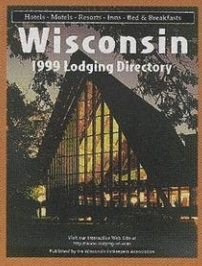
69 Kettle Moraine Steam Train in North Lake
A 50-minute nostalgic steam-powered round trip from North Lake to Merton provides a vibrant array of fall colors. Sundays in September, Labor Day, first four weekends in October. (414/782-8074)

70 Osceola & St. Croix Valley Railway in Osceola
Vintage steam and diesel passenger trains re-create the experience of rail passenger service of the 1940s and '50s. The ride along the stunning St. Croix River displays beautiful fall colors. Saturdays and Sundays through Oct. 24. (1-800-711-2591; www.mtmuseum.org)

More Free Wisconsin Travel Guides







Don't miss the snow!
For information about all the skiing, sledding, snowmobiling and events you can pack into a Wisconsin getaway, call for our free Winter Event & Recreation Guide.

Additional guides available cover:
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