# Water rich and waterwise: progress in meeting Wisconsin's water quality challenges. Special section, [Vol. 12, No. 5] [September/October 1988]

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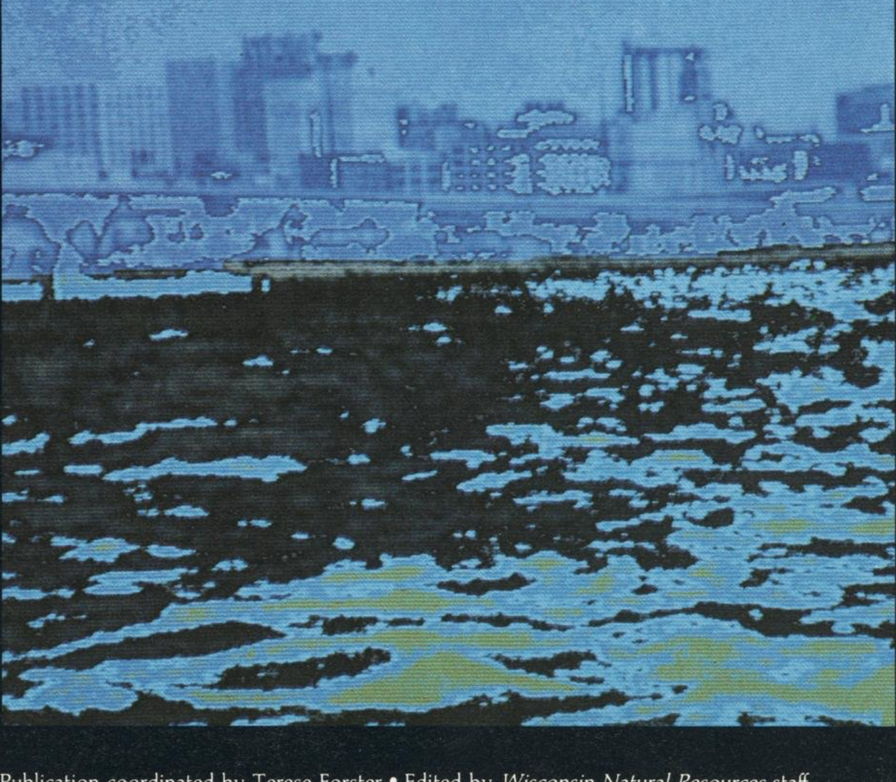
# Water rich -AND- waterwise

## Progress in meeting Wisconsin's water quality challenges.



Publication coordinated by Terese Forster • Edited by *Wisconsin Natural Resources* staff

# Praising and appraising water

*Bruce Baker*

Let us start with a simple truth: people are drawn to water. The liquid of life that sustains plant and animal communities also nurtures human societies. Water composes 65 percent of our bodies, and it is equally the economic lifeblood of our industry and commerce. No civilization has survived without plentiful water, and Wisconsin's industries — manufacturing, dairying, forestry, papermaking and brewing — all depend on water.

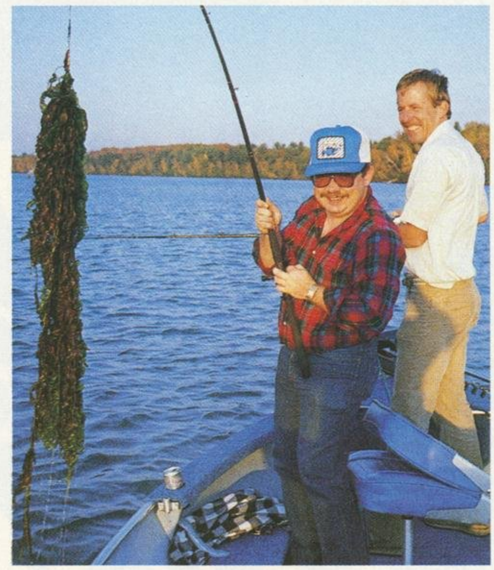
But our enjoyment of fresh, clean, cool water transcends our physical need for it. We know water as a gentle voice luring us to summer lakes, as bubbling brooks, as frothy rivers, as crashing Great Lakes coastlines and as emerald, soothing wetlands. We need water: body *and* soul.

We've written this publication to share some insights we've gained as students of Wisconsin's water quality. When people ask me to tell them about Wisconsin's water quality, these are the issues I discuss, the environmental threats I mention and the judgements we are making to protect quality water.

Wisconsin is blessed with such vast water resources that measuring and evaluating water quality takes considerable time and effort. The water systems we study today developed over millions of years, and our efforts over the last 100 years to understand these systems still pose significant challenges. Just as the earth did not come with a set of instructions, it did not come with diagrams and maps showing how surface waters and groundwater move and flow. As technology extends our senses to see and map changing water conditions, our judgements must also evolve.

Today, we are examining how synthetic poisons, "toxics," affect water. We are expanding efforts to analyze and predict how toxicants may affect our water. You'll read about them here.

This business of monitoring water quality contains paradoxes. Sampling for toxics demands skilled professionals who can use equipment and interpret results. You'll see the kinds of maps and charts they use to judge water quality. On the other hand, we are thoroughly convinced that interested citizens using very simple equipment can help monitor water quality too. You'll read about this partnership in our lakes program.



Author Baker (left) and Section Chief Mike Llewelyn enjoy an outing on the waters they help protect, even when "the big one" isn't a fish.
Photo by Tom Bainbridge

The drought of 1988 should teach us lessons about water and about land. We are lucky to live in a water-rich state that usually provides ample supplies of clean water, but we need to practice sound soil and land conservation to minimize water loss and pollution whether water is scarce or abundant. We have been painfully reminded how dependent we are upon water — for agriculture, business, industry and recreation. Protecting water quality and conserving water quantity are important goals for all of us. Wisconsin's abundant natural resources drew people here and still sustain us, but clean, abundant water is a privilege we must vigilantly protect. We cannot afford to take it for granted. ■

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*Bruce Baker directs DNR's Bureau of Water Resources Management.*

## *Wisconsin's water quality timeline*

*Terese Forster, F.H. Schraufnagel and Carl J. Blabaum*

*The Northwest Ordinance (1787) and the Wisconsin Constitution (1848) stated that all navigable waters were free and belonged to the public. During our settlement years, this concept of public ownership of waterways was rarely enforced to protect this valuable resource. Water use was strictly a private matter. Pipelines drew water to landowners and manufacturers alike for their own use and carried away untreated wastes. In the mid-19th century, concerns first surfaced that uncontrolled municipal and industrial uses of the state's waters could degrade public health. Despite widespread concerns, nationwide strategies to control waste discharges and protect public water supplies along interstate waters weren't established until the mid-1900s. Instead, the federal government promoted local control of water supplies, and state and local programs to manage wastes. Wisconsin policy makers have been debating and shaping public policies to protect water supplies since statehood.*

***FRONT COVER:***
(top) The meandering Wisconsin River. Photo by Thomas Watkins
(bottom) Computer-enhanced vision of Milwaukee Harbor. Photo by Jean B. Meyer

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# Liquid assets

## Raise a glass to Wisconsin's finest — pure water.

*Terese Forster*

Wisconsin's early settlers knew the value of water: they established their camps near it by places we now call Milwaukee, Sheboygan and Manitowoc on Lake Michigan; Menominee River, Peshtigo and Oconto on Green Bay; Fond du Lac, Calumet and Oshkosh on Lake Winnebago; and on the Wolf River, Lake Shawano and at the portage of the Fox and Wisconsin rivers.

These early settlers were, of course, Wisconsin's Native Americans. The rivers were their roads, and their settlements were ideal places for commerce and trade. Later, Europeans settled in the same places, a fact noted by Henry S. Baird, lawyer and early Green Bay settler, who recollected his first days in northern Wisconsin in February 1859:

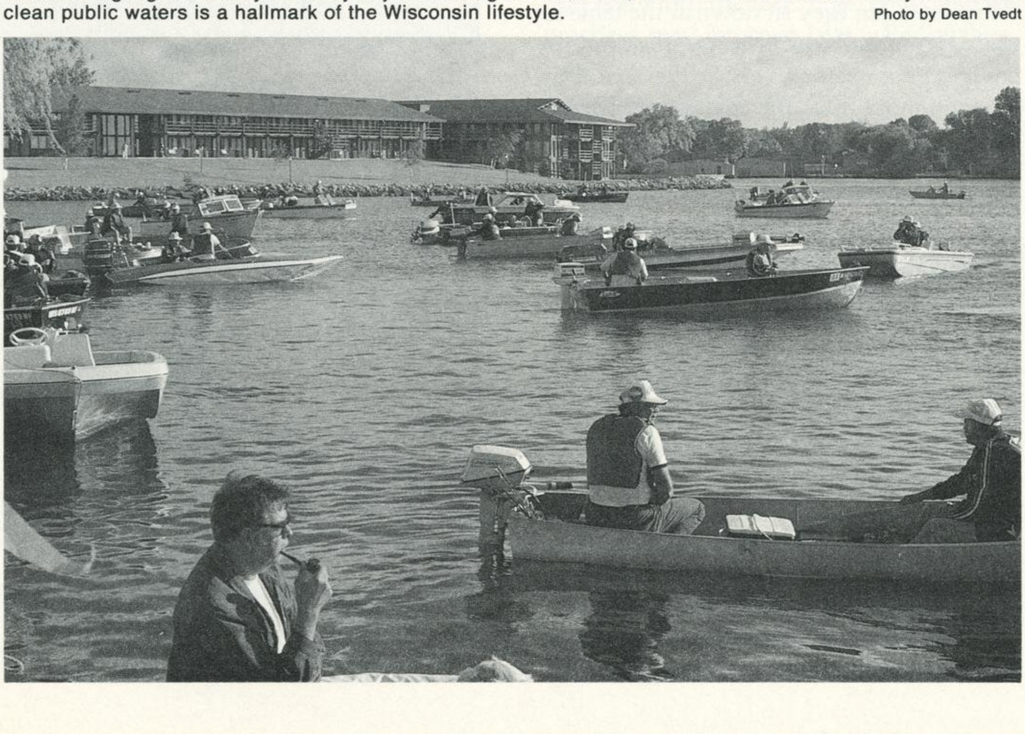
*It is a remarkable feature in the settlement of Wisconsin that all or nearly all of the principal cities, towns and villages, which now in all directions meet our view, were originally sites of Indian villages, showing (that we are indebted) to the sagacity and foresight of the Aborigines, rather than the judgment and discrimination of whites for the beautiful and eligible locations of (Wisconsin) towns.*

All of these communities were beautiful and important because they provided ready access to clean and usable water. Water quantity and quality are still vitally important to our municipalities and industries.

*Terese Forster is a staffer with DNR's water resources and technical services programs.*


From the tap or the bubbler, refreshing water is a clean drink in Wisconsin. Our well code is the nation's oldest and the standard for many other states. Photo by Robert Queen

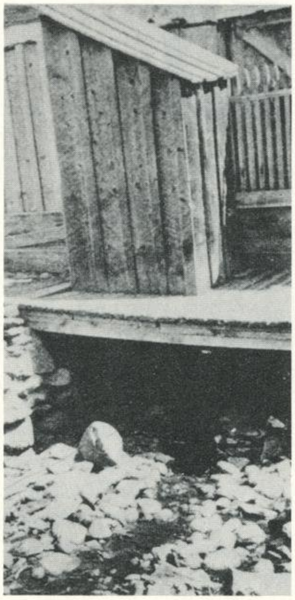
Whether angling in a walleye tourney or just cruising the shoreline, we flock to the waters. Easy access to clean public waters is a hallmark of the Wisconsin lifestyle. Photo by Dean Tvedt



## 1876

*The Wisconsin State Board of Health was created (primarily due to the efforts of Dr. C. Teal of Ironton) to investigate increases in typhoid fever, cholera outbreaks and continued evidence of smallpox. One of the board's first public statements warned the City of Milwaukee of dangers in dumping raw sewage into the Milwaukee River.*

*Water-borne diseases like typhoid and diarrhea were widespread community killers before the days of sewage collection and treatment.* DNR photo



*An old privy empties directly into a stream.* DNR files

## 1877

*The board's Committee on Water and Water Supply tested well water throughout the state. It concluded that not one Wisconsin locality provided a complete, functional water supply or an adequate public sewerage system. Sewage was collected in outhouses or directly emptied into the nearest river or creek. The board also stated that all waters tested were polluted. Under a storm of public and business criticism, the committee was dissolved and the board was told that the state would not tolerate "radical" reports from a state agency.*

## 1899

*The federal Rivers and Harbors Act sets the nation's first standards to minimize surface water pollution. The law stated no floating solids or visible foam could be present on navigable waterways.*

## Waterful Wisconsin

2,444 trout streams — end to end they would stretch 9,235 miles.
5,002 warmwater streams extend 17,532 miles — greater than the distance from Milwaukee to Perth, Australia.
860 miles of Great Lakes shoreline
14,949 inland lakes
Annual average precipitation is 30 inches — ranges as high as 41 inches and as low as 23 inches.
Groundwater recharge ranges between 6 and 10 inches per year.
2,000,000,000,000,000 gallons of groundwater

## Celebrate our collective rights to water.

In Wisconsin, all citizens "own" the water and have the right to clean water for their water needs. That's a distinct privilege, even from other parts of the United States.

Out West, water rights were established on a "first come, first served" basis, and new industries or municipalities had to buy the right to use water.

In other parts of the world, water is more precious than oil. Wars have been fought over rights and ownership of water. In the Middle East, officials from Egypt, Jordan, Iraq, Turkey and Israel have political differences, but they sit down at the table to discuss mutual concerns over water resources. The major rivers in the area flow through more than one country, and water diversions by an individual country could threaten the water supplies of a much larger area.

## Celebrate abundant groundwater.

Wisconsin also has ample groundwater resources, about two quadrillion gallons (that is 2,000,000,000,000,000!) at any one time. Overall, groundwater is very pure in Wisconsin and provides two-thirds of our citizens with good drinking water. Agriculture and industries rely on groundwater for most of their water needs. Our 5,331,392 wetland acres also depend on groundwater.

Water-based recreation is a major factor in Wisconsin's $4 billion tourist industry. Many communities celebrate their ties to water with lake and riverfront festivals, special days like Chippewa Falls' Pure Water Days and fishing tournaments like Fond du Lac's Walleye Weekend Festival or Shell Lake's Twenty-four Hour Fishing Contest. Tourists and natives alike enjoy taking part in water activities like canoe races, sailing regattas, bird watching hikes, old-time rendezvous days, water slides, water-ski shows, swim meets, ice fishing, ice boating, milk carton boat races, fishing, waterfowl hunting and trapping. We may not have the ocean pounding our shoreline, but Lake Superior and Lake Michigan are "Great" alternatives. No matter what your fancy, Wisconsin offers water enthusiasts a lot of choices.

Each generation needs to reaffirm the spirit our forbearers drew from Wisconsin's waters: acting as caretakers, preserving the quality and quantity not only for our own use, but also for the fish and wildlife that share the waters with us. ■

A new toy — bumper tubes.
Photo by Jean B. Meyer

## Waterful weekends

What did you do on your last vacation?

- Rent a cabin on a lake and go fishing, swimming, boating or water-skiing?
- Canoe the Lower Wisconsin River or run the rapids on the Wolf River?
- Visit historic sites along the Mississippi River and ride a riverboat?
- Go to Wisconsin Dells and watch the water shows, ride the Ducks or play on the water slides?
- Stroll along a shoreline beach on Lake Superior or Lake Michigan?
- Spend your winter weekends ice fishing or ice boating?
- Frog around a wetland?

What would a weekend vacation be without the refreshing feel and sounds of water?

# Our lakes' biweekly readers

## More than 200 volunteers help scientists track lake health.

*Carolyn Rumery*

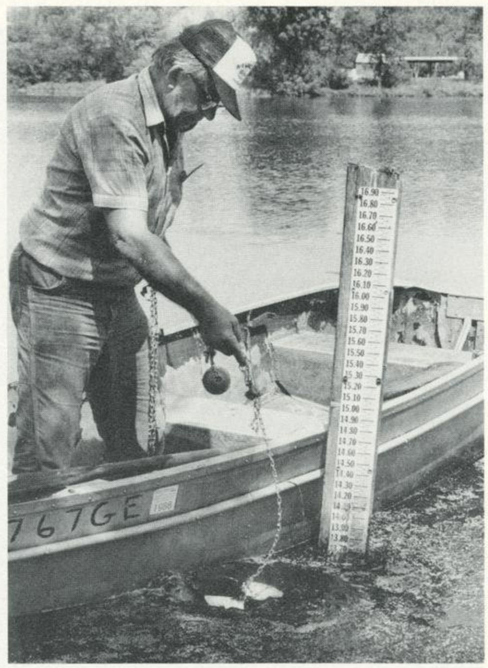
It's impossible to closely track the health of each of Wisconsin's nearly 15,000 lakes, but we have a big group of helpers. Volunteers who really care about their lakes are pitching in to track lake conditions spring, summer and fall on more than 200 Wisconsin waters.

In just two years, more than 200 people have agreed to take biweekly readings of lake water clarity. This kind of monitoring is an essential tool to measure how lake quality changes over time. While people who live on lakeshores or regularly visit lakes often sense that lake conditions are changing, we need to take scientific measurements to judge if these changes warrant corrective action.

Each volunteer in the Self-Help Lake Monitoring Program is trained by a DNR specialist. Volunteers receive a Secchi disc, a sampling notebook and pre-printed, postage-paid post cards to record their measurements.

The Secchi disc is a black and white plate that is lowered over the shady side of a boat until the disc disappears from view. Secchi disc readings roughly measure how much sediment and algae are suspended in the water. The average depth of two readings estimates water clarity. Volunteers collect these measurements every other week when lakes are ice-free. These recordings are tallied by the Department of Natural Resources, published and shared with lake organizations.

Water clarity in all lakes varies seasonally. Just after the ice melts, most lake water is quite clear. Algae blooms during the hot, summer days, lowering water clarity. When water cools off again in the fall, algae die and the lakes clear up again. Lake biologists interpret Secchi disc readings to monitor subtle changes in lake clarity that can indicate the water is overenriched by nutrients.




Volunteers check lake waters that otherwise wouldn't be monitored. LaVerne Anderson has measured water clarity on Crystal Lake since 1985.

Photo by Leo Van Beek courtesy of *The Arcadia News-Leader*

These nutrients usually come from land uses around the lake or many miles away that drain into the lake. Improving land use practices may improve lake water quality.

## Some lakes bear a closer look.

DNR staff use other tools to more intensively monitor about 50 lakes each year. Water chemistry and biological conditions are sampled five times a year in these lakes. Dissolved oxygen levels and water temperature — both critical to fish — are measured from the water surface down to the deepest point in the lake. By measuring the types and amounts of microscopic plants and animals, biologists can estimate if the lake provides quality food for fish, ducks and other aquatic organisms.

Through these volunteer and professional measures, environmentalists gain a clearer picture of the watery world below.

*Carolyn Rumery manages the Self-Help Lake Monitoring Program for DNR's Bureau of Water Resources Management.*

### 1878 - 1905

*University of Wisconsin Professor E.A. Birge and Superintendent of Fisheries Nevin conducted fish studies and reported that every body of water needs certain levels of oxygen to maintain varying types of fish life.*

### 1905

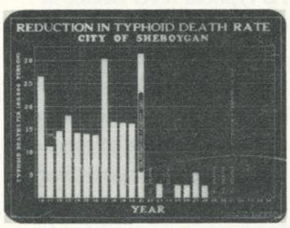
*As typhoid fever deaths increased, the Board of Health was given limited jurisdiction over proposed municipal water supply and sewerage systems. The board reminded the Legislature that "Sickness is costly; death still more so." No tax funds were appropriated to cover costs for lab analyses, so the University of Wisconsin gave the board free facilities to establish the State Lab of Hygiene. That lab is still housed on the UW campus.*

# Keeping the Great Lakes "GREAT"

## The United States and Canada are charting a course for Great Lakes recovery.

### 1919

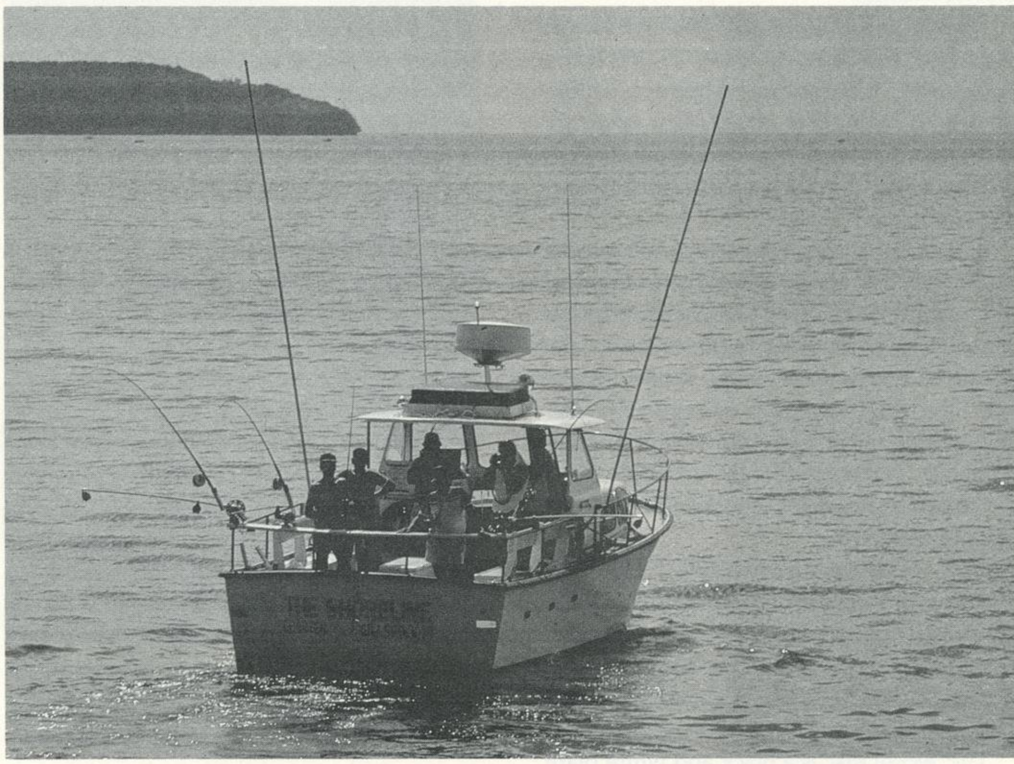
*The state's first comprehensive water pollution act, Chapter 144, was drafted. However, the State Board of Health received no money to enforce the new law, and pollution continued to increase in state waters.*




*Public health statistics show that many lives were saved when drinking water was disinfected and community sewage was treated.*
*DNR files*

### 1923

*Milwaukee and Minneapolis had the lowest typhoid death rates (one death for every 100,000 people) of medium-sized U.S. cities (300,000 to 500,000 population). This was attributed to cities' policies of chlorinating public drinking water supplies and providing general sewage treatment.*



Great Lakes fishing charters are big business. The salmon fishery in Lake Michigan spawned more than 500 new businesses that collect in excess of $3 million in charter fees annually. Controlling toxicants in Great Lakes fish is vital to sustaining this booming recreational economy. Photo by Larry Nielson

*Steve Skavroneck*

The Great Lakes are so vast that few believed pollution from cities and industries would ever affect these waters. Like the vast forest that covered Wisconsin when European settlers arrived, these inland seas were seen as an endless resource to harvest, use and abuse forever. Much of the original forests are history, and the water quality of the lakes have been badly scarred too.

Solving environmental problems in these waters is more difficult than just passing the right law or using the right pollution control equipment. Nearly 37 million people live in the Great Lakes Basin in the United States and Canada. These people are governed by two countries, eight states, two provinces, several tribal governments and hundreds of cities. Each government claims a piece of the lakes management "pie."

Human activities can profoundly affect the water quality of the lakes. Lakes Michigan and Superior are so large that water stays in each lake for a long time. The average parcel of water stays in Lake Michigan for 100 years and in Lake Superior for almost 200 years! Consequently, soil, debris and chemicals washed or discharged into these lakes may affect people and fish for many years.

So, what have we done and what do we intend to do to improve Great Lakes water quality?

The history of pollution controls in the Great Lakes parallels the history of water pollution control in our inland waters and

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*Steve Skavroneck leads the Policy and Planning Unit of DNR's Bureau of Water Resources Management.*

communities in Wisconsin. Canada and the United States joined forces in 1909 to form the International Joint Commission (IJC), which was charged with preventing and settling disputes among Great Lakes users.

Our water pollution control efforts have changed considerably in the last 20 years because the problems have changed.

In 1972, IJC members signed a Great Lakes Water Quality Agreement to reduce the most visible signs of water pollution: to reduce fish kills and green, scummy algae blooms; to reopen public beaches closed by bacterial contamination; and to eliminate severe odor problems.

The Great Lakes Water Quality Agreement of 1978 broadened goals from the first agreement to curb toxic substances in the lakes. The third agreement, signed in 1987, added programs aimed at stemming toxics in harbor and nearshore sediments and reducing the effects of air pollution on Great Lakes water quality. Great Lakes states and provinces agreed to prepare strategies for cleaning up "toxic hotspots" — the 42 worst polluted areas in the lakes.

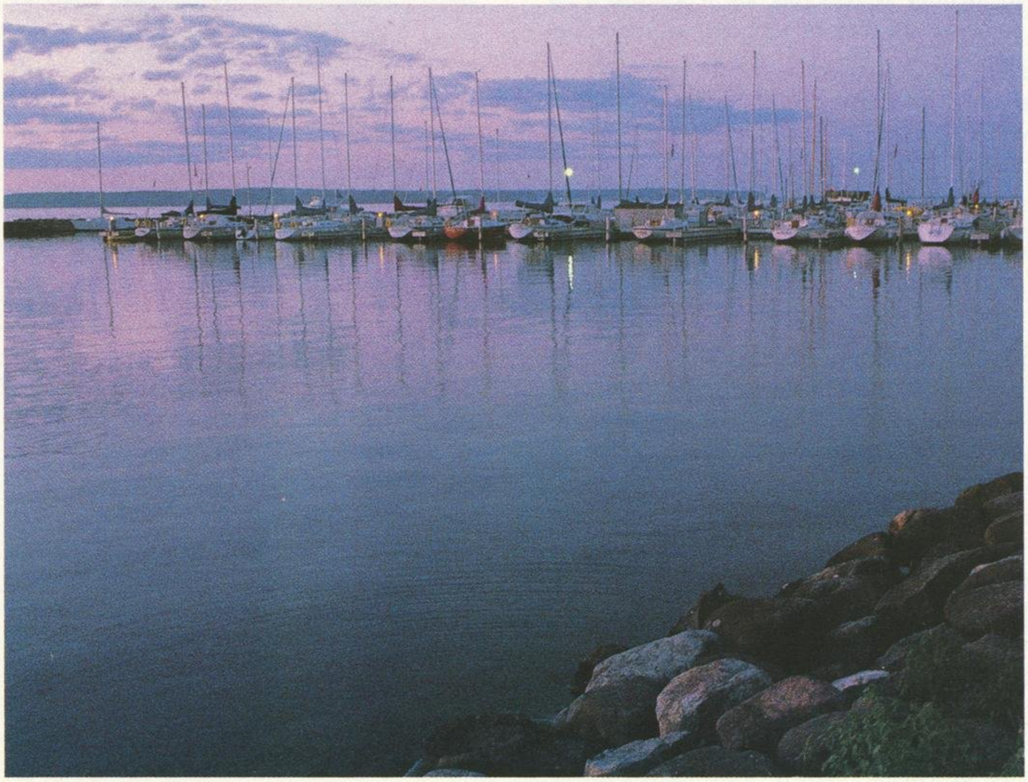
Controlling toxic contaminants will prove especially challenging. First, the subtler pollution issues posed by toxic substances were masked and overshadowed by suspended solids and organic wastes we controlled in the '60s and '70s. For example, water quality improvements in the lower Fox River brought back an excellent walleye fishery where there hadn't been fish for a long time. The problem is that the fish are contaminated with PCBs and should not be eaten.

Second, we now better understand how the levels of toxic pollutants in water relate to pollutant levels in fish, sediments and air. New programs to control Great Lakes pollutants also aim to reduce contaminated sediments and toxic air pollution.

Third, we have new tools that can measure extremely small quantities of toxic substances and predict how these substances affect fish and people who eat the fish. Many of the toxic substances in the Great Lakes that concern us today could not even be detected 10 years ago.

Addressing these challenges and stemming toxic substances in these majestic waters will require cooperation and perseverance among citizens, local governments, other states and provinces, and the governments of Canada and the United States. Together, we can keep the Great Lakes "GREAT." ■

Sunrise at Bayfield Harbor. This historic seaport is a gateway to Lake Superior sailing adventures.
Photo by Robert Queen



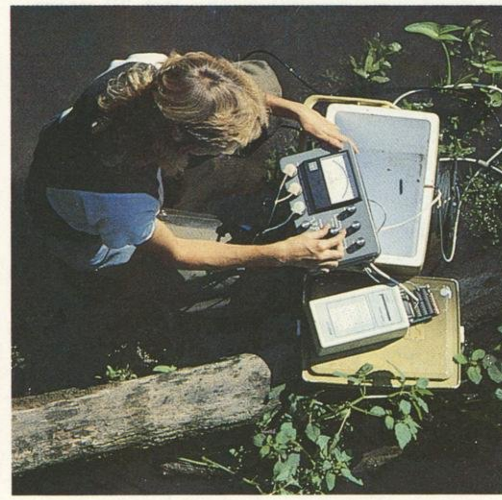
## 1925

*An estimated 10 to 20 tons of game fish died on the Flambeau River below the Park Falls pulp and paper mill. As a result, the Wisconsin Conservation Commission (a fish and game management agency) was urged by the Legislature to cooperate with the health board in pollution control. The State Committee on Water Pollution was created from several departments to provide a state agency with the authority to cope with industrial wastes. This milestone marks Wisconsin's transition from protecting water solely for health reasons to protecting water for its economic and social values.*

*Dramatic fish kills prompted early pollution controls.* DNR photo

# Monitoring water health

## Counting fish, insects, bacteria and chemical conditions are important measures of water quality.



(left) In healthy waters, we can trap a wide variety of water bugs and plants. (right) Electronic probes measure dissolved oxygen content and other chemical and physical conditions. Photos by Rick Wulk

*Joe Ball*

Healthy lakes, streams and rivers are full of life, teeming with millions of microscopic plants, animals, bacteria and a full host of insects and fish. We study the normal constituents of healthy waterways, and we use this information to prevent water pollution, to identify waters that are jeopardized by some action and to pinpoint water pollution causes.

The physical, chemical and biological characteristics of water, sediments and aquatic organisms are tools that biologists and engineers use to indicate stream health in the same way that doctors use thermometers, blood tests and physical exams to monitor human health. How are these tools used to evaluate surface water quality?

*Water chemistry:* Many lake or stream characteristics can be directly measured. We look for indicators — signs of chemicals that shouldn't be in water or chemical concentrations that are higher or lower than we find in healthy streams. Two important jobs are judging "normal" conditions for waterways and then regularly monitoring stream health. In setting water quality standards for all surface waters, DNR biologists determine what water chemistry conditions plants and animals need to survive and what conditions we need to maintain to protect public health.

*Joe Ball monitors surface water quality for DNR's Bureau of Water Resources Management.*

Less than day-old fathead minnows are sensitive to pollution. We use them as aquatic "canaries in the mine." Photo courtesy of The Institute of Paper Chemistry

*Aquatic life:* Just as we census human populations to learn about our changing numbers and habits, biologists take a head count of the relative species, numbers and health of aquatic organisms to evaluate water quality.

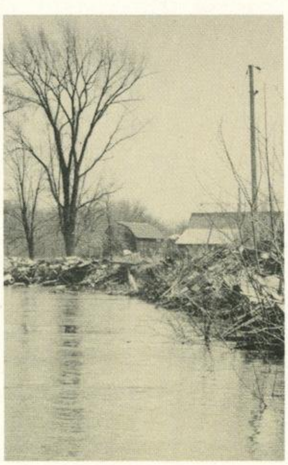
Clean water organisms normally need lots of oxygen and cool temperatures to survive. Polluted water often kills healthy organisms and harbors large populations of algae, aquatic insects and fish that thrive in poor quality water. For instance, greater than normal numbers of fecal coliform bac-

### 1925

*An estimated 10 to 20 tons of game fish died on the Flambeau River below the Park Falls pulp and paper mill. As a result, the Wisconsin Conservation Commission (a fish and game management agency) was urged by the Legislature to cooperate with the health board in pollution control. The State Committee on Water Pollution was created from several departments to provide a state agency with the authority to cope with industrial wastes. This milestone marks Wisconsin's transition from protecting water solely for health reasons to protecting water for its economic and social values.*

### 1926

*State Committee on Water Pollution tests showed that only the most (pollution-)resistant organisms could live in the Wisconsin River and none survived in the Fox River.*



*For decades, the Wisconsin River was viewed as a flowing wasteland and its banks were dumps and trash heaps.* DNR photo teria may indicate untreated human or animal wastes are entering the water.

Some waters may appear to be clean and can support a diverse population of fish and organisms, yet they are contaminated. Chemicals can seep into water in small amounts, which we can't readily detect. These chemicals can then accumulate in fish to levels that are unhealthy for animals and people that catch and eat them.

For several years the department has been monitoring fish from all over the state to determine if they are contaminated with chemicals such as PCBs and mercury and whether or not some fish from certain waters are less suitable or unfit to eat.

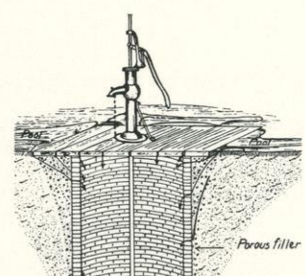
Sampling aquatic organisms, particularly identifying and counting organisms long buried in sediments, is an excellent tool for indicating past water quality problems. This contrasts with chemical sampling, which usually shows the quality of water at the time a sample was collected.

Like the young minnows, water fleas, *Ceriodaphnia dubia*, are toxic testers because they only survive in clean water.
Photo courtesy of The Institute of Paper Chemistry

Water resource managers almost always use a combination of chemical analyses, biological sampling, physical monitoring data and personal observations when judging water quality. ■

# 1936

*The Wisconsin Well Act, the first well code in the nation, was created. This act granted the supervisor of well drilling the authority to oversee water quality in private and public wells. The new well code aimed to prevent disease by requiring drillers to cover wells to prevent surface contamination and to drill wells set distances from septic systems and other potential contaminants. Previously, wells were commonly polluted by barnyard wastes, decomposing animals that fell into wells, runoff and septic wastes.*




*An illustration from Wisconsin's first well code set standards for protecting water supplies.*
*DNR Bureau of Water Supply*

# Modeling a river

## There's an art and a science in simulating how waters work.

*Dale Patterson*

Computers are great at storing large amounts of information, at analyzing statistics and displaying data in helpful ways. We're using them at the Department of Natural Resources to model how real rivers and lakes react to environmental stresses. It's a real challenge to predict how complex mixtures of flowing water, weather and wastes will interact to affect animals, plants and people who use waterways.

For instance, we're modeling water quality in the lower Fox River and Green Bay Harbor to predict reasonable pollution loadings for the many industries and cities that discharge wastes to this river.

Within seven river miles of the harbor, seven industries and cities empty industrial wastes and treated sewage into the Fox River. At different times of the year, these pollutants can cause poor water quality all along the river and into the bay. The mouth of the Fox River at Green Bay acts as an estuary. Sometimes the water flows out into the bay, and other times it reverses, flowing into the river.

We use computer models to simulate these fluctuating water movements that we can't readily see. The models convey what's going on in the river.

*Dale Patterson supervises the Water Resources Modeling Unit for the Department of Natural Resources.*

## Mapping water movement

First, we translate the physical layout of the waterbody into a series of geometric grids and mathematical formulas the computer can interpret. Actual water boundaries are interpreted as accurately as possible, but we have to simplify some of the complex areas. Once programmed, the computer model simultaneously calculates water speed and direction at all intersecting points on the grid map. We use data on natural forces like wind speed and direction and changing water levels in Green Bay and Lake Michigan to drive those calculations. Maps show water velocity at one

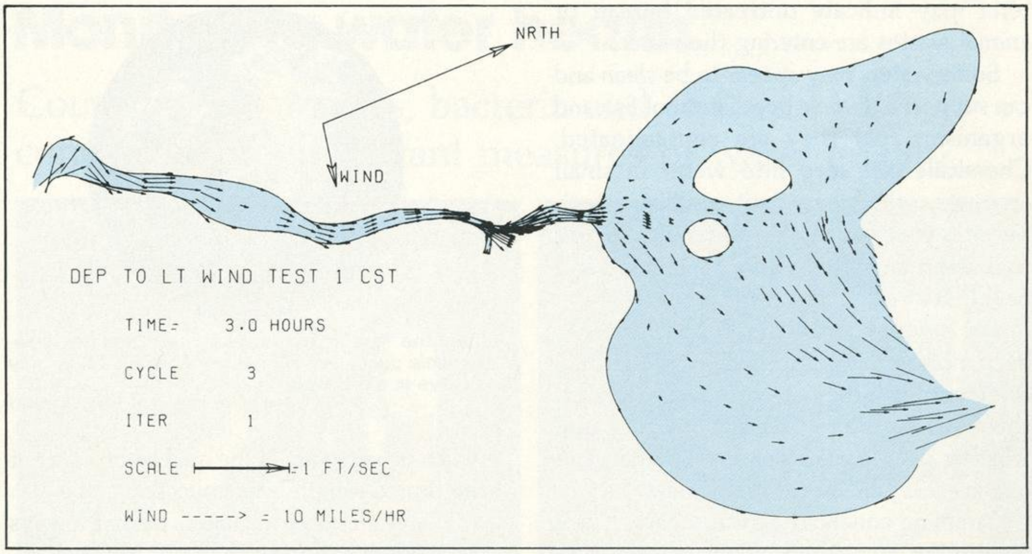
## 1936-39

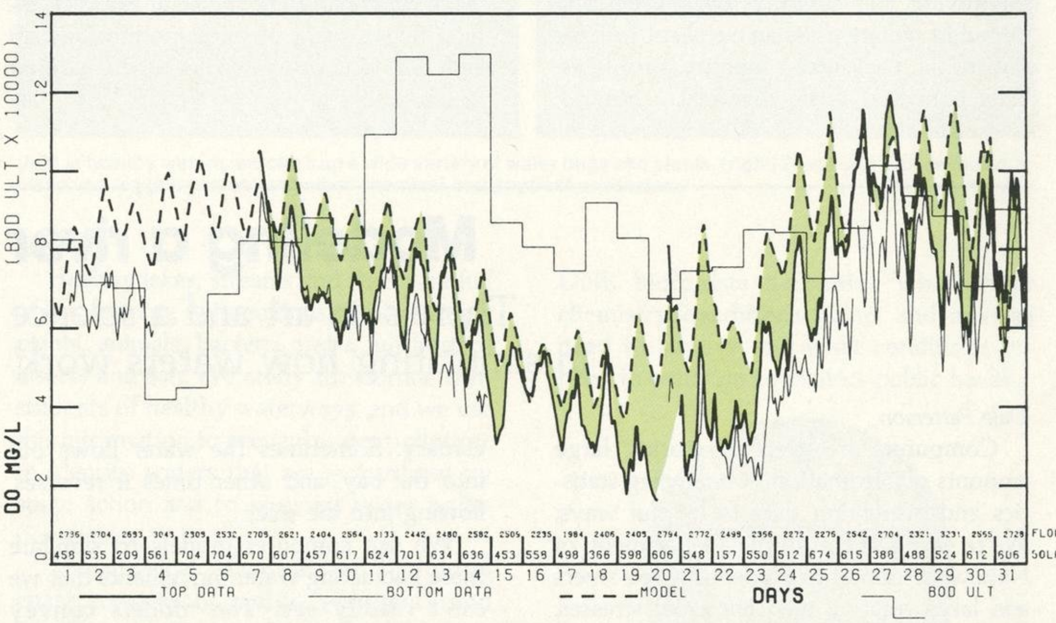
*President Franklin D. Roosevelt instituted several federal works projects. Wisconsin used the programs to build sewage plants. In 1925, the state had only 60 municipal wastewater treatment plants. By 1940, Wisconsin, having constructed 213 plants serving 238 municipalities, was further along than other states.*

*Field testing — measuring stream conditions like dissolved oxygen content by the streambank was a new idea.* DNR photo

## 1948

*Congress passed the Federal Water Pollution Control Act because states were unable to fully control pollution within their boundaries.*




(above) Computer interpretations of wind speed and water current help determine how wastes will be assimilated as the Fox River flows into Green Bay.
(below) Meeting the mark. The top dotted line plots a computer model prediction of dissolved oxygen fluctuations at a particular spot in Green Bay. The bottom shaded line shows actual measurements at the same place and time — a pretty tight fit.
Charts by Dale Patterson

point in time, but the model can predict changing water movements every hour.

# Matching water quality

Next, a water quality model combines information about the kinds and volumes of waste materials discharged to the river by industries and sewage treatment plants. When the computer adds this information to the water flow model, we can graph predicted dissolved oxygen concentrations.

To test the validity of these calculations, the Department of Natural Resources' model predicted dissolved oxygen levels once an hour for a specific location for a month. The Green Bay Metropolitan Sewerage District measured the real dissolved oxygen levels at the same spot in the river. As you can see in this figure, the predictions matched the actual readings very closely.

Once we have confidence that models reasonably reflect actual conditions, we use the model predictions to set limits that industries and municipalities should meet to protect water quality when the river would be most stressed — when water levels are dropping, flow is slow and water temperatures are high.

# Protecting the water down under

## For drinking water and key businesses, clean groundwater is a must.

*Al Lulloff*

We take groundwater seriously in Wisconsin because we are so dependent upon it. Groundwater supplies drinking water to all rural residents and 94 percent of our cities and villages. Wisconsin businesses — agriculture, commerce and industry — all depend on high quality groundwater.

Groundwater in most of Wisconsin provides pure drinking water, but in some areas the well water may be naturally hard, have an off color or taste from excessive iron, manganese or sulfate. The main natural contaminant we consider unhealthy is radioactivity. A few public water supplies in eastern Wisconsin drawing groundwater from deep, sandstone layers are naturally high in radioactive minerals. Standard water softeners or special filters can safely reduce radioactivity levels at a reasonable cost.

We've passed laws to protect groundwater quality because we're discovering that contaminated groundwater can't be cleaned at a reasonable cost.

The law protects groundwater by setting water quality standards for human devices that potentially pollute water like septic tanks, gasoline stations, landfills and storage piles for road salt. When people deposit materials containing these chemicals on the land surface, pollutants can move through the soil and contaminate groundwater.

The way that groundwater moves varies greatly depending on the soils and rocks through which it flows. Groundwater monitoring determines the types, amounts, flow and locations of contaminants in groundwater.

The groundwater law also requires:

- the state to set health and welfare standards for known and suspected groundwater contaminants. To date, groundwater standards have been established for 60 chemicals that have been detected in groundwater;
- a program to ensure that private laboratories analyzing groundwater samples can meet quality control standards;
- an extensive groundwater monitoring program and groundwater protection requirements in existing regulations on landfill sites, wastewater discharges, pesticide storage sites, septic tanks and road salt storage piles.

*Al Lulloff plans groundwater management strategies for DNR's Bureau of Water Resources Management.*

## Protecting drinking water

Three types of contaminants have been most frequently found in Wisconsin groundwater.

*Nitrate* contamination threatens infants under the age of six months. When babies drink high-nitrate water, their bodies convert the chemical to nitrite, which inhibits its normal blood oxygen flow causing the "blue baby syndrome" (methemoglobinemia). This suffocating condition can be readily remedied. Babies don't drink great quantities of water, and parents can inexpensively use bottled water or another source of water during the infant's first six months.

Nitrate enters groundwater from many sources including fertilizers, animal wastes, wastewater from cities and industries, refuse disposal and seepage from malfunctioning septic systems.

Recent well samplings indicate more than 10 percent of Wisconsin's 700,000 drinking water wells exceed the nitrate standard. You can test your well for signs of nitrate inexpensively with a kit from the State Lab of Hygiene or a state-certified laboratory.

*Volatile Organic Chemicals (VOCs)* are also commonly detected in groundwater. VOCs are the solvents, cleaners and fuels we use that evaporate rapidly and have an odor. For example, gas-

*Water testing in the State Lab of Hygiene in the early 1950s.*
*Photo courtesy of State Lab of Hygiene files*

### 1949-50

*The Izaak Walton League led the fight to reform state water pollution control policies. Politicians were reluctant to approve stricter water pollution controls that were opposed by industry and labor unions that feared job losses. Public demand for "reasonable or realistic" regulation increased. Health concerns were the driving force. Many state waters stank and were visibly polluted. Finally, in 1950, the Committee on Water Pollution was granted a budget by the Legislature. It hired staff and named Theodore F. Wisniewski as its first director.*

## 1919-59

*State pollution control efforts concentrated on three major sources: domestic sewage, food products processors and forest products processors. Though it was clear that poorly managed domestic wastes could spread disease, cities resisted installing water purification equipment, sewerage systems and wastewater treatment systems because construction and maintenance costs were high and the state did not help fund these projects. Wisconsin businesses needed to curb industrial wastes that badly polluted public waters. Through persuasion and threats of enforcement, several pollution control firsts occurred here: Sulfite liquor wastes from papermaking were productively used as road binder, the first full-scale magnesium-based sulfite pulping mill was built, and vegetable and fruit cannery wastes were treated by coagulation then by fill-and-draw lagoon filtration followed by spray irrigation. Wisconsin's Committee on Water Pollution initiated the concept of water drainage basins as units of control and administration.*

oline, industrial cleaners, spot/stain removers, paints, thinners and drain cleaners commonly contain VOCs.

VOCs can cause nausea, dizziness and tremors. Some VOCs are suspected carcinogens.

VOC contaminants can leak from underground fuel tanks, landfills, chemical spills and places that handle hazardous chemicals.

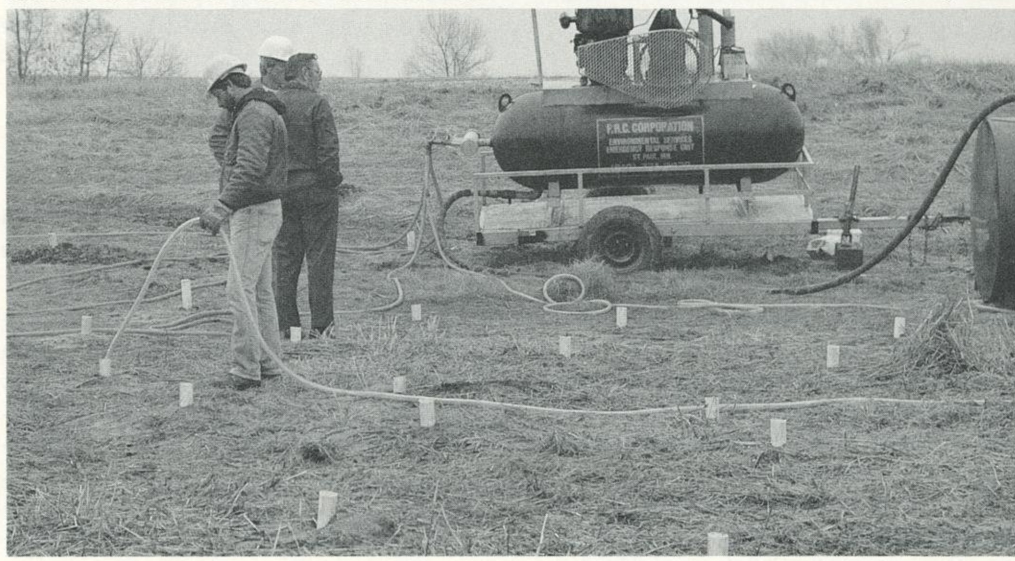
Since 1980, the Department of Natural Resources has sampled more than 5,300 wells for these chemicals. We've detected 28 different compounds in 906 wells.

*Pesticides* have contaminated drinking water supplies in agricultural regions and in communities where chemicals are manufactured, stored and formulated.

Since 1983, the Department of Natural Resources has sampled more than 3,050 wells for signs of pesticides finding 24 compounds in 686 wells.

The most common pesticide contaminant is aldicarb, used to control insects on potato crops. Other common farm pesticides used to control weeds in agricultural crops have also been detected in groundwater. To date, most problems from these other chemicals have been linked to spills or improper disposal of pesticide residues. ■

Which way did it go? DNR investigators sunk all these wells to track and trap a spill. Gasoline and some chemicals float on groundwater. Some of the floating pollution can be sucked back to the surface. Other contaminants adhere to soil, rocks or dissolve in water. Photo by Greg Matthews



# Managing earth and water

## Wise land use is a key to protecting water.

*Michael T. Llewelyn*

"Ecosystem" and "biosphere" are terms to describe how everything on our planet — humans, other animals, plants, water, air and land — is interdependent. How people use land dramatically affects water.

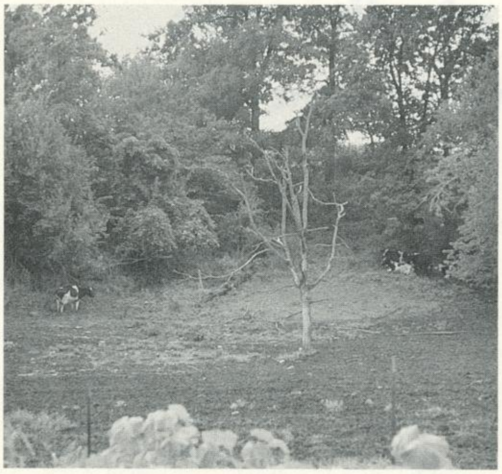
Land choices are central to human existence. We build homes on it, we cultivate it for food and we develop it for our pleasure. Yet, we often fail to consider the limitations of the land that sustains us.

Whenever land is disturbed — for agriculture, subdivisions and new homes, highways or industrial parks — soil is exposed to wind and water erosion.

I doubt modern history can provide a bleaker land abuse example than the "Dust Bowl" days of the 1930s when we destroyed the fertile croplands of mid-America. Yet, we still abuse land even as we did 50 years ago.

To minimize soil loss to our lakes and streams, many communities now are enact-

*Michael T. Llewelyn leads the Nonpoint Source and Land Management Section in DNR's Bureau of Water Resources Management.*



After a storm, soil and sediment would run off the heavily grazed woodlot on the left. By fencing out cows and replanting cover crops, woodlots heal; rainwater gently soaks in and soil stays put.

Photos by Susan E. Bergquist

ing erosion control ordinances that require sound land management at all construction sites. Farmers can use "best management practices" such as minimum tilling and contour stripping across sloping fields to reduce soil erosion.

## Unbridled development

Where we choose to develop land also matters.

Consider wetlands. For years, valuable wetlands have been filled to provide more land for development. These wetlands that once filtered sediment and nutrients from runoff and provided excellent habitat for fish and other wildlife were filled or drained. As wetlands disappeared, sediment and nutrients flowed directly into lakes. That destroyed fish habitat and caused excessive weed growth.

Consider building sites. Homes built too close to lakes on soils that can't adequately treat septic tank wastes can destroy the soil's filtering capacity and contaminate water with bacteria and nutrients.

Our counties and communities can protect these valuable water resources through shoreland and wetland zoning ordinances, which minimize development in buffer areas.

Consider how urbanization changes drainage patterns. Before development, rain and melting snow "percolate" into soil to "recharge" our groundwater supplies. Paving streets, constructing parking lots, downtowns, homes and malls decreases the places storm water can filter. The water, which does not percolate into the soil quickly, runs off into streams or lakes. Litter, lawn fertilizers, pesticides and pollutants from city streets, industrial areas and rooftops are carried into waterways. Torrential rains can also rapidly flood low-lying areas.

## What can people do?

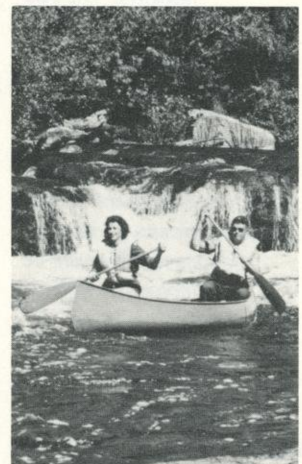
We know ways to minimize or prevent water pollution from developed areas. Communities can protect urban wetlands that handle floods and filter nutrients. Leaving undeveloped green belts by streambanks and lakeshores can buffer runoff while providing space for trails, bike paths and wildlife areas. Detention ponds can trap sediments and hold storm water so it slowly seeps into streams after the storm. Well planned developments can minimize the effects these activities have on our lakes, streams and groundwater.

We can help. The Bureau of Water Resources Management can assist your community in developing ordinances to curb construction site erosion and manage storm water. Other nonpoint source programs help farmers choose best management practices to slow down soil loss and nutrient runoff on their property.

Each generation molds the landscape to reflect its way of life, but we don't have to change the basic fabric and character of the land entrusted to us. Well planned development can celebrate our appreciation of the interdependence of land and water instead of our independence from natural cycles.

## 1960s

*New environmental groups were formed as Wisconsin's citizens felt that the state was not controlling pollution fast enough. The Department of Natural Resources was formed in 1968 by merging the Wisconsin Conservation Department and the Department of Resource Development. The state began providing financial aid to build publicly owned treatment works. Wisconsin adopted water quality standards to parallel the new Federal Water Pollution Control Act of 1965. However, the state was not granted authority to use clean stream standards as a means of controlling waste discharges.*



*Making all surface waters "fishable and swimmable" for recreation was the primary goal of nationwide water quality laws.* DNR photo

## 1970s

*In the 1970s, the federal government finally became more involved with pollution control and prevention. The Water Pollution Control Act was passed by Congress over a presidential veto. In 1972, the Clean Water Act Amendments set specific national water quality goals for the first time and established the first workable nationwide system for regulating wastes discharged to public waters.*

# Looking forward to challenges

## In protecting quality water, we face some exciting opportunities.

*As early as 1970, we tested fish for signs of chemical contaminants. Here, John Konrad prepares fish for mercury testing. He still researches water quality issues for the Department of Natural Resources.* DNR photo

### 1973

*Since state law Chapter 147 met federal requirements, Wisconsin was authorized to enforce both state and federal discharge permits. Permit violations would finally be enforceable by law.*

### 1978

*The Legislature created the Wisconsin Fund to supplement and later replace federal financial aid for communities building new wastewater treatment plants or upgrading inadequate plants.*

*Bruce Baker*

You don't have to be a great swami to forecast the major water quality issues we face heading into the next century: monitoring and maintaining clean water; stemming the flow of toxicants into waters, waterfowl, fish and, ultimately, people; curbing nonpoint pollutants in rural and urban areas; maintaining successful pollution control programs and cleaning up contaminated sediments. We take these issues seriously, and we will continue working with legislators, communities and individuals to resolve them.

We also face some less obvious water quality challenges, and let me make a few observations about these:

1. **Viewing technology as an aid, not an answer** — People are naturally fascinated by probes and gizmos that measure environmental changes we cannot directly sense for ourselves. No doubt, technology will become even more fantastic as remote satellite sensors and underwater probes automatically monitor environmental conditions several times a day. These measurements are important tools and gauges, but they will not resolve our difficult environmental problems. We should never forget that technology aids our decisions, it does not answer them. We shouldn't let our fascination with machinery replace the need for sound judgement. For instance, knowing that rivers may contain 0.25 parts per trillion of a substance doesn't tell us if that chemical is risky for people, fish or plants. It doesn't tell us if natural ecosystems can break down that chemical. It doesn't tell us how long we have already been exposed to that chemical. It doesn't describe long-term threats from exposure to that compound.

Ultimately, the judgements, the educated guesses, we make are made by comparing the qualities of these unknown threats to similar threats we have faced elsewhere. If we cannot make meaningful comparisons, our judgements don't get easier, they get much more difficult. This is one compelling reason to continue research that can help us better assess how small amounts of chemical compounds affect environmental health. It's also an argument for preventing problems whenever possible.

2. **Environmental progress with less federal funding** — Historically, we responded to serious water quality problems that caused health problems in our communities — epidemics of water-borne diseases, horrendous odor problems, bacterial infections that closed beaches, etc. Then, we developed statewide and national programs to eliminate these threats. We funded public waterworks, improved sanitation and health care and built sewage treatment plants.

Now, the pendulum is swinging back, away from an era of federal spending back to an era of increased community responsibility for environmental management. The wells are installed, and the sewerage systems are built. The challenge now is to keep pollution controls working and to carefully handle the sludges and residues trapped in pollution controls.

Recent harsh lessons show what happens when we don't meet that challenge. How foolhardy to spend millions of dollars separating sewage sludges and medical wastes only to dump them back into water and wait for them to drift ashore.

Increasing the efficiency of sewage plants, segregating toxic wastes from other waste streams, handling sludges in a healthy, economical manner and carefully monitoring effluents in waterways will challenge Wisconsin communities in the 1990s.

3. **Runoff and saving soil** — We resolved sewage pollution by piping wastes from homes and businesses to treatment plants. Unfortunately, we can't use that strategy to trap other pollutants. We need to make more sustained commitments to

*Bruce Baker directs the DNR Bureau of Water Resources Management* trap and stabilize manure, fertilizers and pesticides from farming; trash, sand and oils from city streets and soil from construction sites.

We know how to install effective, natural filters like grassed waterways, berms, settlement basins and contour strips. We are adapting farming techniques like no-till, low-till and sustainable agriculture, which could significantly cut soil losses and farming costs. We can require that builders and developers hold back soil when sites are ripped up and exposed during construction. We can restrict building or development in wetlands, shorelands and streambanks.

These relatively simple, low-cost pollution controls have been slowly adapted. Why has it taken so long? Because we act quickly when we can build a gadget to cure our problems, but we react very slowly when we're asked to change our habits.

4. **Storm water** — One significant nonpoint source pollutant could be more readily collected and treated — storm water. In most communities, rain and snowmelt carry salt, soil, fertilizers, trace metals, pesticides, oily street grime, grit and trash directly from roads and parking lots into our lakes and streams. It's a good bet that states will develop plans to treat storm water as seriously as we treat sewage during the next decade.

5. **Toxics management** — We are in our infancy in understanding the complex interactions of toxic materials in aquatic environments. Among the intriguing questions we need to consider are:

- How do we trap potential poisons, and what do we do with the materials once we've isolated them?
- What organisms or tests best predict how toxicants affect aquatic life?
- How do we limit exposure to toxicants to protect people from the combinations of chemicals frequently found in waste by-products?
- How do we put the risks of toxicant exposure into perspective with other unhealthy risks that people readily accept?
- How do we manage large quantities of contaminated sediments already deposited in some Wisconsin waters?

Without doubt, concerns about environmental toxicants will be argued in the courts and in the court of public opinion into the next century. Those who take part in these discussions — environmentalists, policy makers, regulators, business representatives and the general public — will each interpret the risks of toxicant exposure and recommend what price society is prepared to pay to protect ourselves from toxicants.

6. **Drought and water quantity** — It's hard to imagine Wisconsin running out of water, but recent weather has given all of us a taste of what it's like when the well runs dry. Future population increases and growing demands for places to swim, boat and fish may conflict with industrial and agricultural water uses. Wisconsin water laws guarantee that public waters are held in trust for everyone, but that doesn't guarantee an equal share for everyone at the same time.

The Legislature recognized that fact in 1985 in passing the Water Resources Conservation and Management Act. The Department of Natural Resources was directed to examine water use conflicts, assess existing water quantity regulations and propose a comprehensive water policy for allocating water should rationing ever become necessary.

Diverting water from the Great Lakes to western states will intrigue politicians, but it's unlikely that such a massive engineering project will be economical in the immediate future, if ever. Besides, to consider water diversions, current charter agreements require federal legislation and consultation with all states and provinces surrounding the Great Lakes.

7. **Team building to solve complex water problems** — Ecosystems have so many parts that our early environmental programs separated the complex pieces to better manage the whole. We developed separate programs to manage air, water, wastes, wildlife, fish and other resources. Now, like the Japanese concept of "quality circles," we are encouraging teams from each DNR function to collectively develop better solutions for complex environmental problems. One example is our Remedial Action Planning teams, and to date we've used them to plan ways of cutting toxicant flow in the lower Fox River and Green Bay, start plans for safely managing contaminated

## 1979

*The nation's first nonpoint source program was created in Wisconsin to control urban and rural runoff pollution. The program has expanded so that the natural resource agency works cooperatively with state transportation and agricultural agencies to develop plans for controlling nonpoint source problems on farmland, highways and construction sites.*

## 1980s

*Federal laws were tightened to better control toxic substances. States were directed to develop water quality standards to curb toxics in surface water and groundwater.*

## 1988

*As we learn more about toxics, our attention still focuses on long-term health concerns of both human and animal exposure to these substances. Our knowledge of methods for removing and preventing toxic contamination is still in its infancy. History teaches us that a key strategy is preventing toxic contamination at the same time we develop strategies to control these substances.*

Our mutual stake in clean water is worth protecting. DNR photo

sediments from harbors, and assess how and where nonpoint pollution sources need to be controlled.

8. **Changing attitudes and expectations** — We need to recognize natural conditions when we see them. For example, our attitudes about lake weeds and lake dredging are worth examining.

We can't and shouldn't strive to eradicate all lake weeds. Some lakes are not, never have been and never will be crystal clear, weed free, azure ponds. Lakes should not look like swimming pools. Healthy lakes have a full complement of weeds, aquatic animals and fish. Neither should we dredge lakes to form deep pools where nature never intended them. Some lakes are shallow bogs that are on their way to becoming real estate — they are naturally filling in, their shores are becoming brushy, and they will shortly become solid land. Our energies to improve and monitor water quality should be directed at curbing pollution people caused rather than fighting natural forces.

9. **Recognizing and encouraging volunteers** — Our self-help lake monitoring program is teaching us a lot about the power of volunteers.

By actively searching for people who are committed to preserve lakes and by investing a little time to train these volunteers, we are keeping close tabs on many lakes at minimal expense to taxpayers.

It's exciting to realize that people are our greatest under-tapped resource in our goal to protect water.

I can even sense this near Madison. Groups like Trout Unlimited are stabilizing miles of streambank and revamping heavily used streams; graduate students in the UW-Madison Water Resources program developed a curriculum to teach Madisonians about the four lakes that surround them; the Lake Mendota Fishing Association is raising and stocking quality walleye fingerlings in public waterways; and people like Ken Plenke, who sold fishing bait, dug deep into their own pockets to build a pond where Reedsburg kids could learn to fish. I know this kind of enthusiasm is repeated in all regions of Wisconsin.

Clean water advocates, we're looking for you. We need people power to start other programs like widespread groundwater monitoring, wetland protection and lakeshore improvements.

## It's worth it

Making a laundry list of concerns like this leads some people to wring their hands in despair — not me. When I think about the challenges that face us, I see opportunities — a chance to correct long-term problems, a chance to stem new pollutants before they get out of hand, a chance to change attitudes and a chance to prevent environmental contamination.

Collectively, as a society, and professionally, as committed DNR staff, we are up to the challenge, and abundant clean water is worth the work. ■

*Terese Forster works with DNR's water resources management and technical services programs. F.H. Schraufnagel is chief of Analytical Services for DNR's Office of Technical Services. Carl J. Blabaum directs the Bureau of Wastewater Management.*