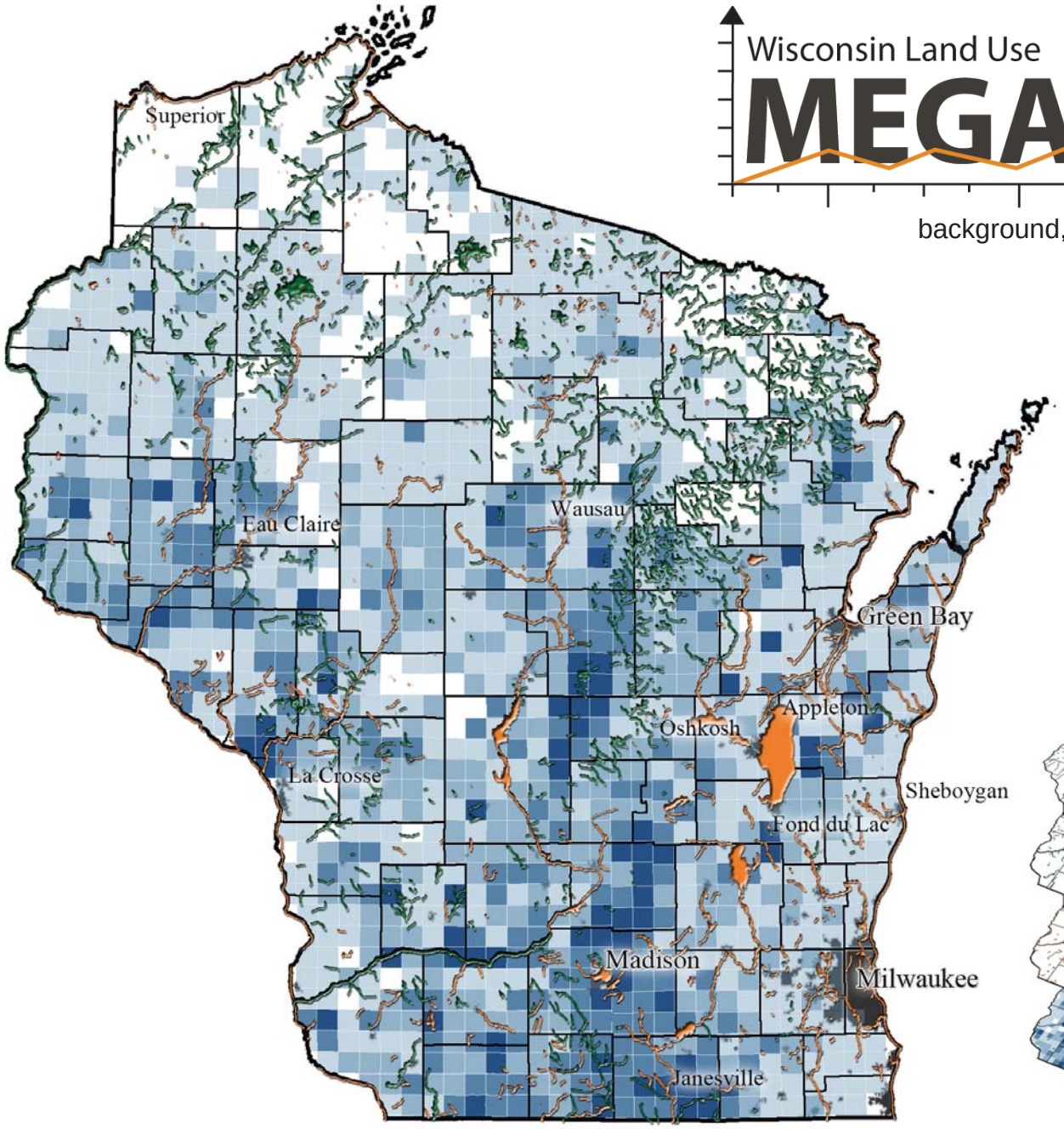
Summer 2014

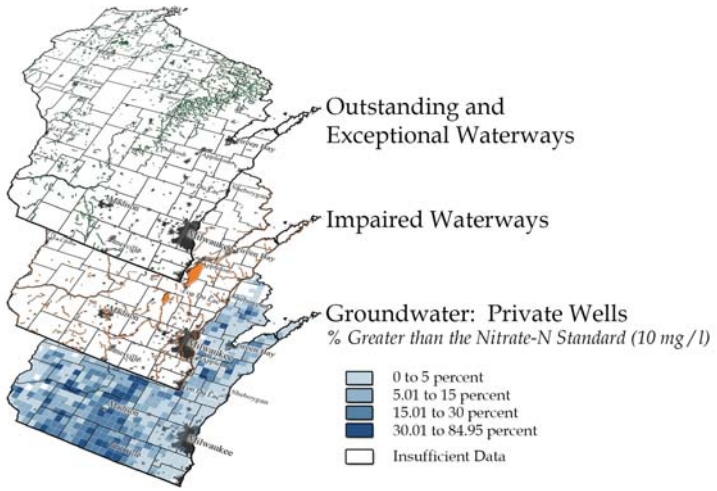
Wisconsin Land Use

MEGATRENDS

background, impacts, policy...information you need to know



How Healthy Is Your Water?



WATER

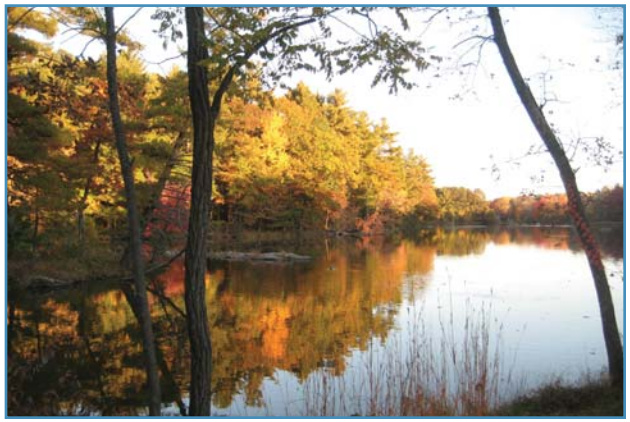
Introduction

This publication is intended for local government officials and others interested in investigating the connections between water and land use. We provide a timeline of Wisconsin's association with water, discuss a range of state and local policies that affect water use and the resource itself, and provide an understanding of Wisconsin's water resources. This includes the water cycle, water use, economics of water, and the role of the volunteers and organizations in managing specific water resources.

Water Weaved through History

For thousands of years, the seasonal rituals of native tribes marked the passage of time in Wisconsin water history. Thousands of effigy mounds built around the state's lakes and streams are testament to the importance of water to the region's tribes. In more recent years, European explorers began using the waterways to gain access to the region's bounty. Fur, then forests, drew people in and a new chapter in the state's history began. During this period, rivers were used for commerce and transportation, and many communities settled around rivers. As river transportation declined, points were identified on rivers where dams could generate power and create ponds and lakes.

Photo I1
Wisconsin River



Widespread drainage of wetlands for agricultural use began in the 1800s when wetlands were largely viewed as disease breeding lands and impediments to travel. By the early 20th century, the U.S. government was providing both technical services and cost-share for wetland drainage. In that era, tile and open ditch drainage were considered conservation practices.

In the late 1800s, more people came to Wisconsin lakes for vacations and relaxation. They took an interest in the quality of the water, and the plants and fish in the lakes. Cabin and resort owners banded together to protect lakes.

After World War II, the population swelled, and it became more obvious that our waters could not be both our dumping grounds and playgrounds. Something needed to change, and Wisconsin citizens pressed their lawmakers to enact rules to protect and restore clean water.

Beginning in the early 1970s, university researchers and state resource managers began working together to find new ways to improve and protect water health in Wisconsin. Today lakes, rivers and wetlands are widely recognized for their conservation value and the services they provide to humans. These include flood storage, water quality improvement, stream flow maintenance, fish and wildlife habitat, shoreland stabilization and more. Protecting and restoring our waters is now a priority in many Wisconsin communities. The timeline at right identifies key dates, policies, programs and facts in Wisconsin's water history.[1]

Wisconsin Water Timeline

1800s
Number of sawmills peaked at 1,100 and declined to 113 by 1930

1848
First paper mill (Milwaukee)

1860
First commercial cranberry production

1880s
Waukesha and Racine establish municipal water supply

1882
First hydroelectric dam (Appleton)

1887
First fish hatchery (Madison)

1898
First lake association (Lake Geneva)

1914
Diana Shooting Club v. Husting expands scope of Public Trust Doctrine to include protection of scenic beauty, water quality and wetlands

1919
First wastewater treatment facility (Milwaukee)

1945
Post-war shoreline development increases with highway improvements, automobile ownership and leisure time

1950-1969
Over 2 million pounds of sodium arsenite, a cancer-causing agent, are applied to 167 Wisconsin lakes to control aquatic plants

1959
Creation of Wis. Federation of Lakes

1965
Wis. Water Resources Act provides authority for shoreland and floodplain zoning

Water is the most critical resource issue of our lifetime and our children's lifetime. The health of our waters is the principal measure of how we live on the land.

Luna B. Leopold

Wisconsin's Waters Belong to Everyone: The Public Trust Doctrine

The Public Trust Doctrine provides the foundation for preserving our aquatic natural resources for future generations. Through all branches of government, the state of Wisconsin has an affirmative duty to protect and preserve our lakes, rivers, streams and wetlands in partnership with the citizenry and businesses of the state.[2]

The importance of the Public Trust Doctrine has increased as our aquatic resources face increased development and recreational pressures. The public interest, once primarily interpreted to protect public rights to transportation on navigable waters, has been broadened to include protecting public rights to healthy water quality and quantity, recreational activities and scenic beauty.

Photo I2
There was 35,000 pounds of wild rice harvested in Wisconsin in 2012. (Photo courtesy of Frank Koshere)

Cultural and Spiritual Aspects of Water

"Wisconsin" is the English spelling of a French version of a Miami Indian name for the river that runs 430 miles through the center of our state.

In Wisconsin, water is infused into the souls of its citizens and visitors. While this is not unique to Wisconsinites, the abundance of water in the state further embeds this relationship into our culture. Observations by archaeologists suggest that our attraction to water extends back to early civilizations. While water is a critical need, those who have experienced the deep yearning to be near water can tell you there is more to it than quenching their thirst.

Words like *sacred, magical, mystical* and *life blood* are frequently used to describe the connection between water and humans. Water as a sacred entity appears as the focus of traditions and symbolism in many of the religions practiced in Wisconsin.

Water plays an integral role in the spirit and philosophy of the Anishinaabe (Ojibwe and Chippewa) culture, which is central to the poem, *Nibi Speaks*.[3]

Anishinaabekwe, the Daughters, you are the keepers of the water. I am Nibi…water…the sacred source, the blood of Aki, Mother Earth, the force filling dry seeds to green bursting. I am the womb's cradle. I purify.

Nibi, the lifegiver…forever the Circle's charge. I have coursed through our Mother's veins. Now hear my sorrow and my pain in the rivers' rush, the rain… I am your grandchildren's drink. Listen, Daughters, always, you are the keepers of the water. Hear my cry, for the springs flow darkly now through the heart of Aki.

1968
Wis. Shoreland Management Program provides minimum shoreland zoning standards for counties (first in nation)

1972
Federal Clean Water Act supported by the Clean Water Act of Wis.

Just v. Marinette Co. upholds counties' rights to prohibit wetland fill through ordinance

1983
Wis. Groundwater Protection Act establishes groundwater quality standards

1985
Great Lakes Charter establishes principles for management of Great Lakes water resources

1990
Federal Stormwater Rules limit industrial discharge in medium and large cities

1991
State enacts water quality standards for wetlands (first in nation)

1994
First indoor water park in nation (Wisconsin Dells)

1999
Phase II Stormwater Rules expanded to include small communities and construction sites

2001
State enacts protections for isolated wetlands (first in nation)

2003
Wis. Groundwater Protection Act expanded to include groundwater quality

2008
Great Lakes Compact bans diversion of water from Great Lakes

2010
State Water Quality Standards limit phosphorus discharge to surface waters

See references for photo credits.

Water Resources

Wisconsin is a water rich state. As shown in Figure WR1, it has more than 12,600 rivers and streams meandering their way through 84,000 miles of varied terrain; 15,000 inland lakes spanning more than 1 million acres; two Great Lakes surrounded by 1,750 square miles of estuaries and bays; and more than 5 million wetland acres. Hidden beneath its surface the state has 1.2 quadrillion gallons of groundwater. This is enough to cover the state in nearly 100 feet of water. While this may sound like an inexhaustible supply, water demand exceeds supply in some parts of the state.

Figure WR2 shows the abundance of streams, lakes and wetlands by county in Wisconsin. More than 15 percent of the state is covered in water. Lakes account for 1 million acres, while wetlands account for 5 million acres. Since the state was first settled, one half of our wetlands have been destroyed, drained or filled to make way for agriculture, roads, urban development and other uses.

Figure WR1

Wisconsin's Water Resources[4]

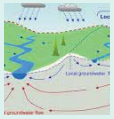
More than 15% of Wisconsin is covered in water

2 Great Lakes
6.4 million acres in Wis.
1,000 miles of coastline

15,000 inland lakes
1 million acres
6,000 named lakes

84,000 river & stream miles
13,500 navigable miles
2,700 trout streams

5 million wetland acres
10 million pre-settlement acres
75% privately owned

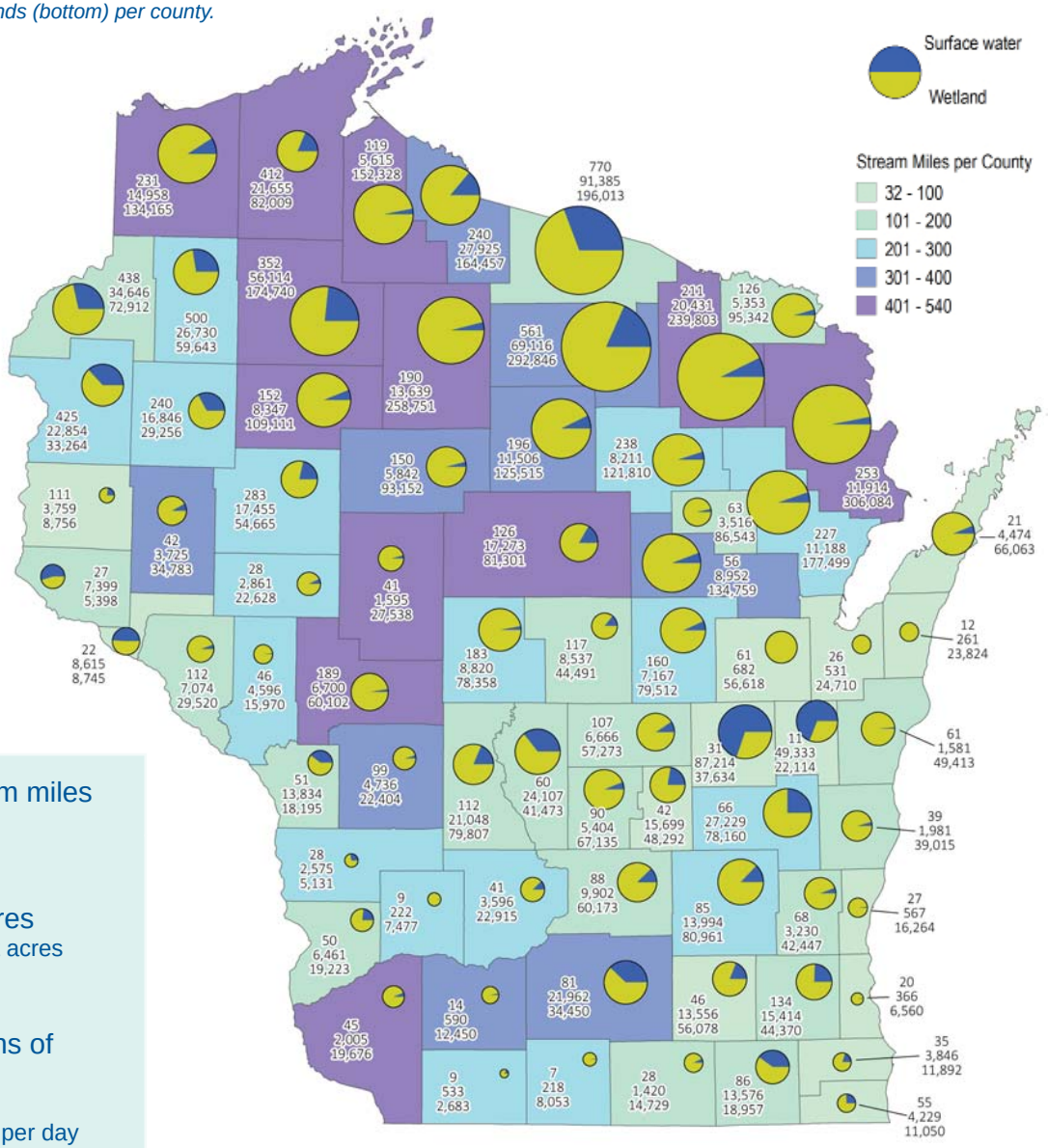


1.2 quadrillion gallons of groundwater
800,000 private wells
800 million gallons used per day

Figure WR2

Wisconsin's Surface Water and Wetlands by County[5]

The circles show the relative proportion of surface water (blue) and wetlands (yellow) per county. The background shading shows stream miles per county. Labels indicate the number of lakes (top), acres of lakes (middle), and acres of wetlands (bottom) per county.



The Water Cycle

Wisconsin receives an average of 30-32 inches of rainfall per year.[6] Roughly 6-10 inches soaks into the ground replenishing our groundwater supplies or runs off the land reaching lakes, streams and wetlands (see Figure WR3).[7] Most water eventually makes its way back to the atmosphere through the processes of evaporation and transpiration (see Figure WR4). Water in the atmosphere is replaced once every 8 days. In contrast, water may spend weeks, months, decades or more in rivers, lakes and groundwater.[8] Natural and human processes affect the quantity and quality of water moving through the system.

Figure WR3

Groundwater Recharge Varies Across the State

Average annual groundwater recharge based on streamflow data, 1970-1999 (Courtesy of the U.S. Geological Survey Wisconsin Water Science Center)

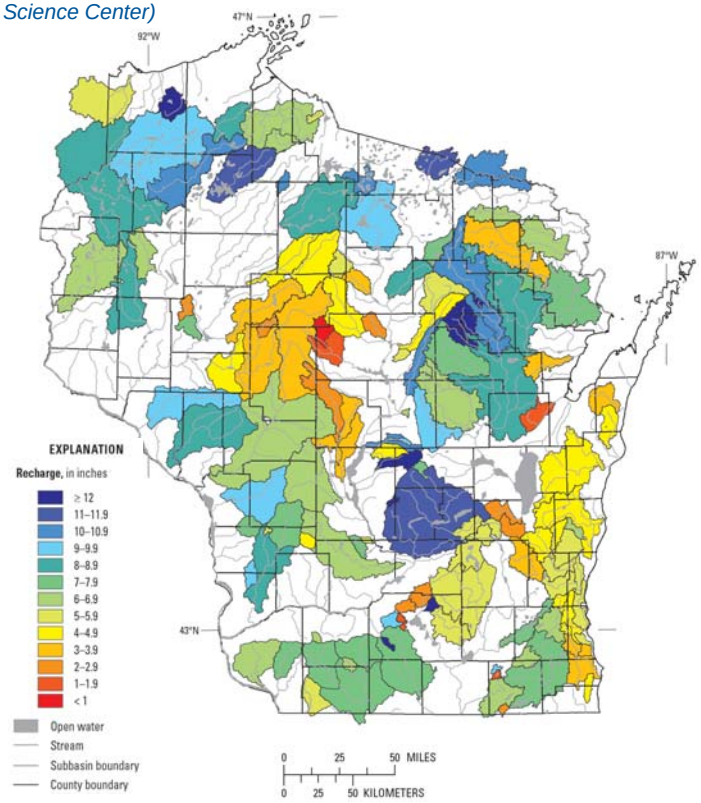


Figure WR4

Rain and Snow: Where Does It Go?

The water cycle shows how water continuously moves above, below and across the land surface. (Courtesy of Cooperative Institute for Meteorological Satellite Studies, University of Wisconsin-Madison)

Evaporation

Warmth from the sun causes water from lakes, streams, ice and soils to turn into water vapor.

Condensation

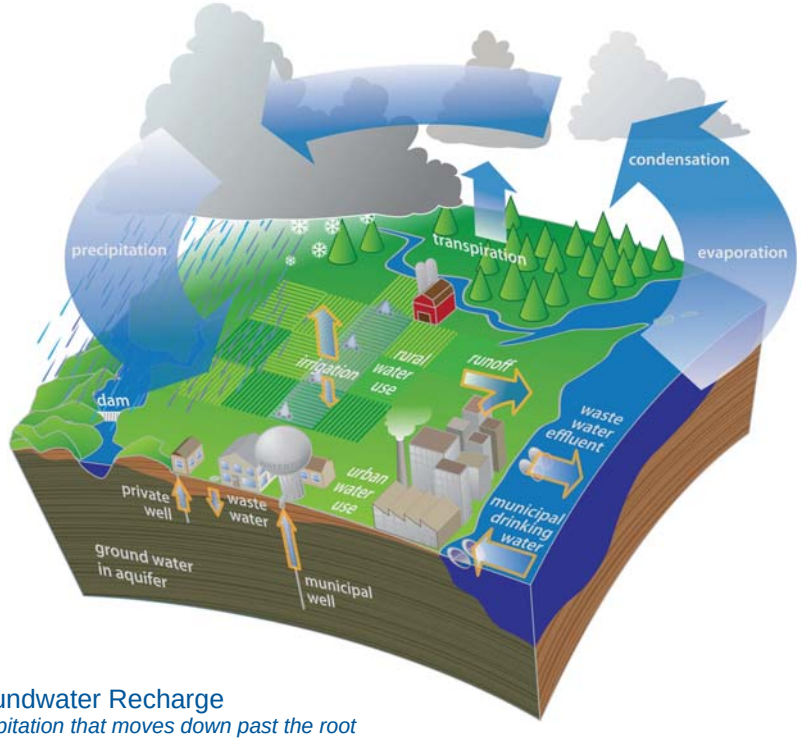
When water vapor rises into the cool air above earth, it turns into liquid water droplets. The droplets collect and form clouds.

Transpiration

Water that is removed from the soil by plant roots is released into the atmosphere from the leaves of trees, crops and other plants.

Precipitation

As clouds cool and become saturated, they release water in the form of snow, hail, mist and rain. A high percentage of precipitation is returned to the atmosphere through evaporation and transpiration.



Runoff

Water that does not soak into the ground runs over the land from areas of higher to lower elevations. Along the way water may pick up soil, chemicals and other pollutants, eventually dumping them into our lakes and streams.

Infiltration

Some precipitation moves downward through the pores and cracks in soil and rock. This water may be taken up by plants and released through transpiration, or filter down to replenish our groundwater supplies.

Groundwater Recharge

Precipitation that moves down past the root zone of plants reaches a point where all the empty spaces in the soil and rock are filled with water. This is known as the water table. Water under the ground is contained in aquifers, which are simply sand, clay and other materials that convey groundwater.

Groundwater Discharge

Groundwater moves slowly underground from areas of higher to lower elevation and through cracks and spaces in the soil. Where the water table meets the land surface, groundwater may be released into lakes, rivers, springs and wetlands.

Water Use

Ninety-seven percent of Wisconsin communities and 70 percent of residents (4 million people) rely on groundwater to meet their water supply needs. The rest (1.8 million people) rely on surface waters such as Lake Michigan and Lake Winnebago.

Water supply systems capable of withdrawing 100,000 gallons per day are required to report annual use to the Wisconsin Department of Natural Resources (DNR). In 2011, total statewide withdrawals exceeded 2.156 trillion gallons of water from more than 14,000 wells, ponds, streams, rivers and lakes. This is more than the annual flow of the Wisconsin River at the Wisconsin Dells and more than three times the volume of water contained in Lake Winnebago.

Figure WU1 shows total reported withdrawals for 2011. Power generation is responsible for the majority of withdrawals (1.6 trillion gallons), followed by municipal water supply systems (194 billion gallons), paper production (129 billion gallons), agricultural irrigation (86 billion gallons), and cranberry production (43 billion gallons).[9]

Figure WU1

2011 Withdrawals by Use

Total Withdrawals = 2.156 Trillion Gallons
Municipal water supply does not include other public water supplies. Public water supply is included in the "all other uses" category. (Courtesy of Wisconsin DNR)

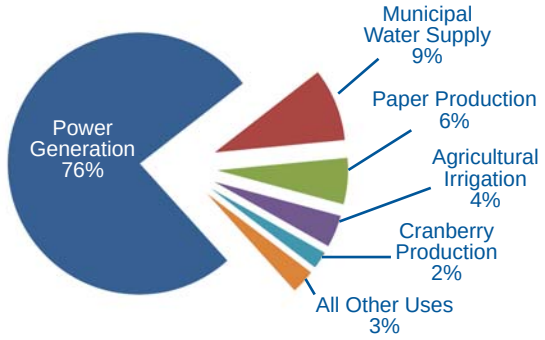


Figure WU2 shows withdrawals from surface and groundwater sources.[10] Note the heavy reliance on surface water for cranberry production in the central part of the state. Also note the heavy reliance on groundwater for agricultural irrigation in the central region. Figure WU3 on the next page shows our increasing use of water from 1950 to 2010.

Of all the water use categories reported in Figure WU1, agricultural irrigation represents the highest consumptive use of water, meaning water is lost to the atmosphere through evaporation and transpiration.

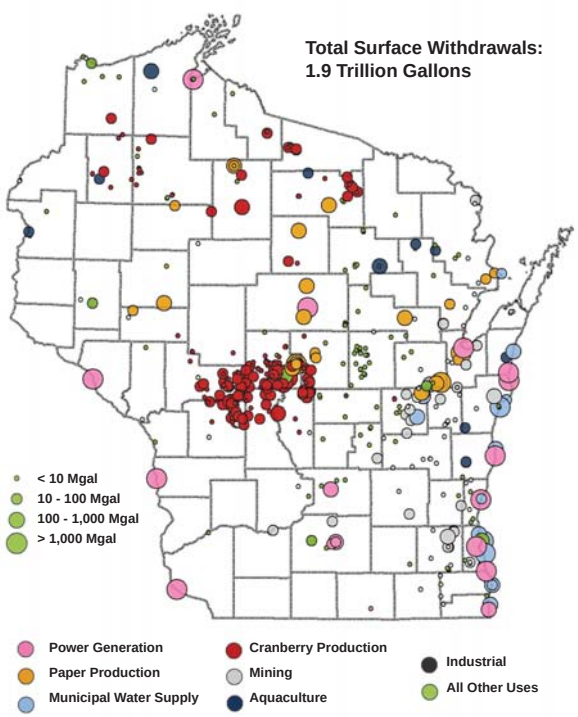
Figure WU4 shows the increasing use of high capacity wells, many of which are for irrigation. Water used for irrigation of crops or landscaping is generally considered 90 percent consumptive.[11]

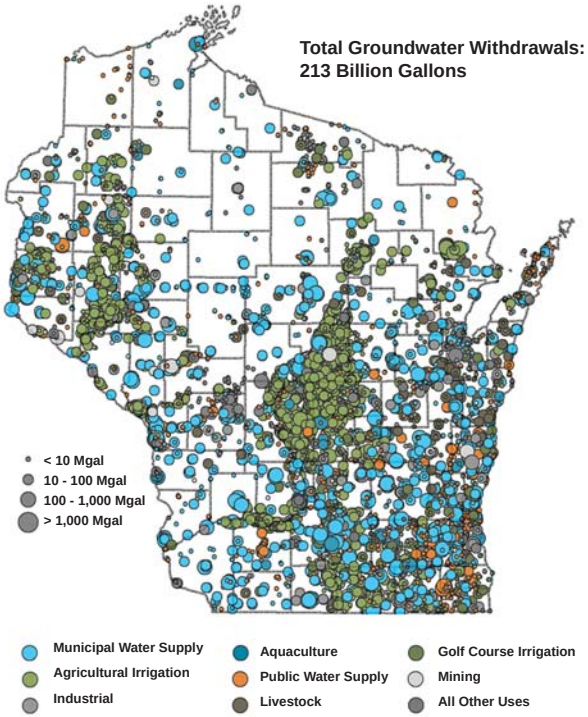
In contrast to irrigation, much of the water used for power generation is for cooling purposes and most water is returned to the original source. Other types of water, including residential water, also have little consumptive use. In many cases, water is simply used for some purpose (such as washing, toilet flushing, etc.) that transforms it from high quality water to lower grade water that requires treatment. The water is

Figure WU2

2011 Surface and Groundwater Withdrawals

Each circle represents a single 2011 point of withdrawal. The size of the circle varies according to the total 2011 volume of water withdrawn from that point. Public water supply includes mobile home parks, condos, resorts, etc. (Courtesy of Wisconsin DNR)





then sent to a wastewater treatment plant or on-site treatment system where it is cleaned and released back into the environment, either directly as surface water or as recharge to groundwater. Most water distributed by municipal water supply systems is recirculated in this manner. In many cases this occurs within the same watershed. In other situations water may be removed from one watershed and discharged into another. This is known as interbasin transfer.

While municipal water supply wells are dispersed across the state, irrigation withdrawals are largely concentrated in the Central Sands region of Wisconsin. In 2011, approximately one-quarter of high capacity well pumping occurred in Portage, Adams and Waushara counties. Other areas of concentrated irrigation include the Lower Wisconsin River Valley, parts of Northwest Wisconsin, Antigo and Rock County.

Concentrated groundwater pumping has become a concern in some parts of the state due to the drying of lakes, wetlands and streams. In particular, there have been dramatic declines in water levels in the deep aquifers of northeast and southeast Wisconsin. Maintaining groundwater levels depends on replacing the same amount of water that naturally flows to the surface and is withdrawn by wells. Water levels in northeast Wisconsin have begun to rebound as municipalities have switched from groundwater to surface water sources.

Water Conservation

Total water use in Wisconsin has increased over the years to meet the demands of our increasing population and expanded economy. However, we may be seeing signs of progress from recent water conservation efforts. Using five-year estimates from the USGS, total water use for 2010 was 1.4 billion gallons per day. This is down 13 percent from 2005 and represents the first significant decrease in total water use since 1950 when estimates were first recorded.

Recent declines are likely a result of increased conservation efforts by municipal water utilities, industries and commercial water users. Residential water use contributed only slightly to the recent decline. Using self-supplied domestic water use as an indicator, residential water use peaked at 61 gallons per person per day in 1990 and has declined slowly over the past two decades to 47 gallons per person per day.

As homes and businesses have implemented water saving practices and technologies, fewer opportunities exist to make large reductions in water use. Without the creation or adoption of additional water-saving measures, recent reductions will likely be absorbed through expansion of water intensive industries and population growth.

Figure WU3

Water Use Data from 1950-2010

This graphic does not include water used in the generation of power.[12]

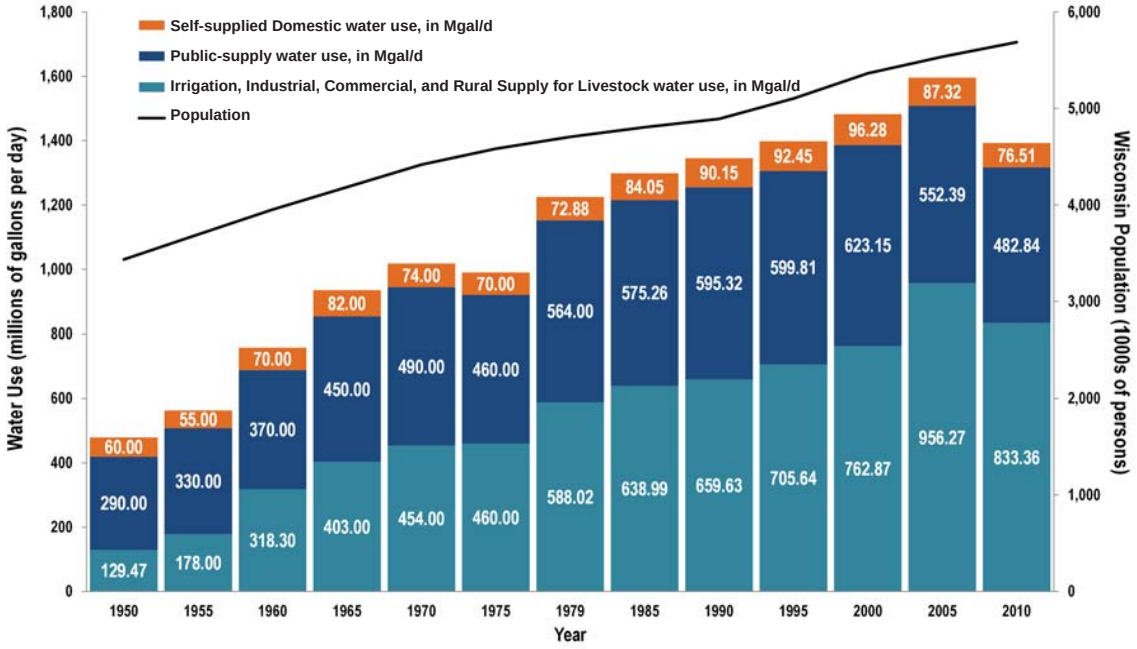
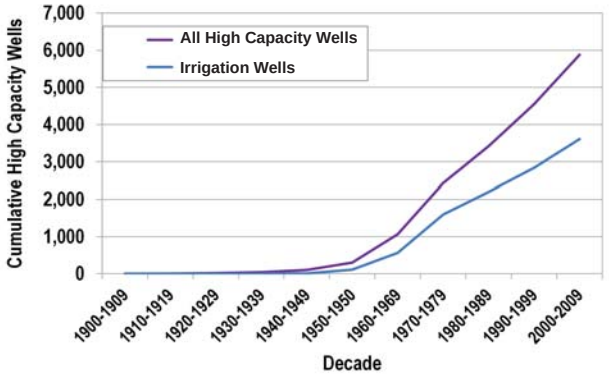


Figure WU4

Cumulative Well Data 1900-2009

Prior to 1950 most high capacity wells were municipal wells. Since 1950, nearly 60 percent of all high capacity wells installed have been for irrigation purposes.[13] This data does not include 554 irrigation wells and 611 high capacity wells with unknown installation dates.



Human and Environmental Health

The quality and quantity of our state's waters depend on actions that occur on the land, in the water, and in the air surrounding our waters. This section looks at some of the major factors influencing water quality in Wisconsin, including impervious surfaces, climate change, pesticides, road salts and mercury. Health effects on fish and people are also considered. Nitrate, phosphorus and sediments from agriculture are discussed in Wisconsin Land Use Megatrends: Agriculture.[14] Contaminants of emerging concern not discussed in this publication include pharmaceuticals, endocrine disruptors, coal-tar-based sealcoats for asphalt, and others.[15,16,17]

Impervious Surfaces

Many water contaminants originate on the land surface and are carried to surface and groundwater by rain and melting snow. As water flows over land, it picks up soil, chemicals and other pollutants. In urban areas, hard surfaces such as driveways, sidewalks, rooftops and roadways prevent water from soaking into the ground. As a result, water flushes quickly into storm drains carrying road salts, automobile fluids, heavy metals and other contaminants. In rural and agricultural areas, water picks up soil, pesticides and animal wastes, and washes them directly into our waterways.

Too many impervious surfaces surrounding lakes and streams can degrade water quality and impact the plants and animals that live there. One of the more visible examples of this is fish. Researchers in Wisconsin and Minnesota have found that brook trout and brown trout are eliminated from streams when impervious surfaces cover more than 11 percent of the watershed. Likewise, large mouth bass, northern pike and other species we enjoy catching are eliminated from rivers when impervious surfaces cover more than 12 percent of the watershed (see Figure H1).[18]

Water is Life...and the quality of water determines the quality of life.

Vision Statement of the Lake Superior Binational Forum

Climate Change

Impacts of impervious surfaces and pollutants on water quality are likely to be exacerbated by rising temperatures, shifting precipitation patterns, and heavy rainfalls associated with climate change. The Wisconsin Initiative on Climate Change Impacts (WICCI) has developed a worst-case scenario showing how different species will be impacted by these changes. While some species will benefit, others will be harmed. For example, warm water fish are likely to thrive, while coldwater and coolwater fish will likely lose habitat.[19]

Impacts of climate change are already evident in Wisconsin. During the summer drought of 2012, hundreds of northern pike died in central and southern Wisconsin due to surface water temperatures that had reached 90 degrees or more on some lakes.[20] When we experience protracted heat waves, there are likely to be more fish kills as was the case in 2012. Harmful algae blooms, which affect human, pet and wildlife health, are also predicted to increase significantly with increasing temperatures and longer growing seasons.[21]

Aquatic Pesticides

Aquatic plants form the foundation of healthy and flourishing lake ecosystems. They help to protect water quality, produce life-giving oxygen, and reduce shoreline erosion by reducing the effects of waves and currents. However, invasive species and excessive plant growth can degrade a lake or river. To control aquatic plants, homeowners, lake groups and agencies use a variety of techniques including harvesting, drawdowns, biological controls and herbicides. Herbicides, which are pesticides used to kill or control plants, are typically used to improve navigational access to lakes and rivers, to reduce the spread of invasive species to new water bodies, and to control nuisance plant and algae growth.

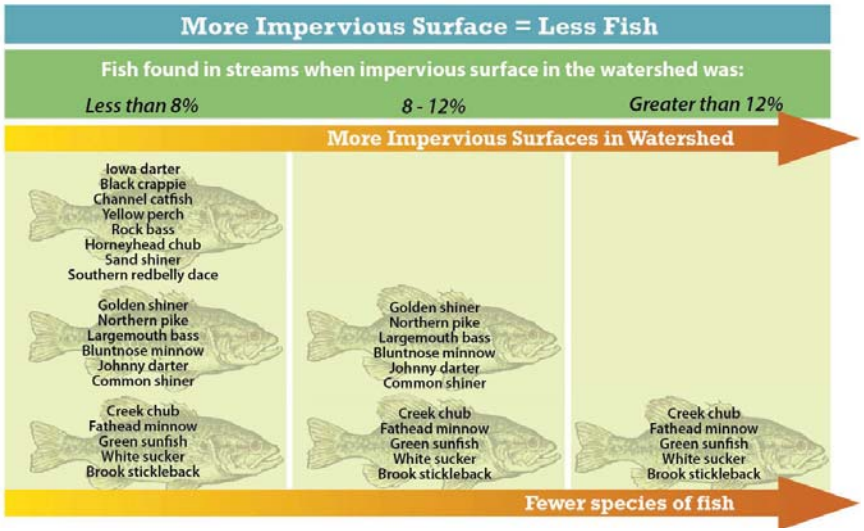
The World Health Organization defines environmental health as *"all the physical, chemical, and biological factors external to a person...that can potentially affect health."*

The most common herbicide applied directly to Wisconsin lakes is 2,4-D. According to the Wisconsin

Figure H1

Impact of Impervious Surfaces on Fish

The number of different stream species declines as the effects of impervious surfaces kill off more sensitive species. (Courtesy of Lynn Markham)

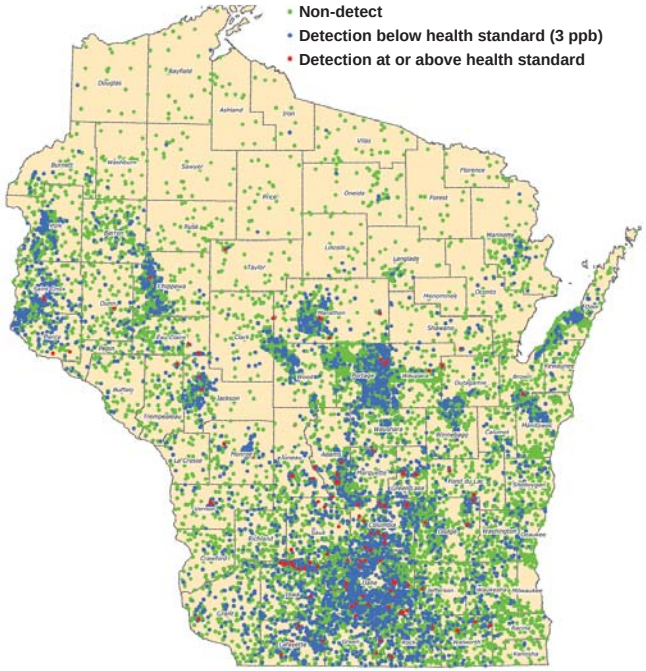


Department of Health Services, health effects include increased risk of lymphoma (a type of cancer affecting the immune system), increased risk of certain birth defects from high level exposure during pregnancy, and kidney and liver damage from long-term high level exposure.[22] Health effects of other aquatic herbicides applied to Wisconsin lakes and rivers are summarized by the Wisconsin Department of Natural Resources (DNR).[23] DNR regulates the application of aquatic herbicides through a statewide permitting program.

Figure H2

Wisconsin Private Wells Tested for Atrazine

The map includes sample results from 1988 to 2012.
(Courtesy of DATCP)



Agricultural Pesticides

Pesticides applied to land also enter lakes, streams and groundwater. A 2005 report indicates that approximately 13 million pounds of pesticides are applied to major agricultural crops in Wisconsin each year, including more than 90 different pesticides.[24] A 2007 survey of 398 private drinking water wells shows that one-third of Wisconsin wells contain a pesticide or pesticide metabolite. Areas of the state with higher intensities of agriculture generally have higher frequencies of pesticides and nitrate in wells.[25]

Atrazine, an herbicide used on corn, is one of the pesticides most often found in private drinking water wells in Wisconsin. Figure H2 shows testing results of private wells. Effects of atrazine observed in animals include liver, kidney and heart damage. Reproductive effects have also been noted among people exposed occupationally. Multiple studies show developmental and reproductive hormone effects in people.[26]

Road Salts

Another pollutant affecting water quality is salt. In the winter of 2011-2012 Wisconsin counties applied 10.47 tons of salt per lane mile of state highway. This is higher than Minnesota at 5.9 tons per lane mile and lower than Michigan at 12.6 tons per lane mile.[27] Road salt washes into rivers, streams and lakes along with melting snow and rain.

Increasing levels of chloride (mainly from salt) have been found in some Wisconsin wells, lakes and streams.[28] In Milwaukee, the Menomonee and Kinnickinnic Rivers have chloride levels in late winter and early spring that are 10 to 15 times higher than the federal level set to protect fish, amphibians and tiny crustaceans.

Mercury

Mercury is a persistent, bioaccumulative pollutant, which means it remains in the environment for a long time and tends to accumulate in organisms such as fish and people. In Wisconsin, power plants that produce electricity by burning coal are the largest source of mercury emissions. In fact, our state depends more heavily on coal to produce electricity than any other Midwestern state, although utilities are looking to capture mercury emissions.[29] Reducing electricity use or switching to electricity from wind, solar, biogas or natural gas can help to reduce mercury emissions.

Once mercury is released into the environment, it can convert to a toxic compound called methylmercury. As fish consume mercury it is retained in their flesh. The same thing happens to people who eat a lot of fish high in mercury. There are benefits to eating fish, including lowered risk of heart disease.[30] However, eating too much high-mercury fish harms our health, particularly the developing nervous systems of babies.[31] For this reason, the DNR has developed safe-eating guidelines for fish (see Figure H3).The DNR recognizes that additional caution is warranted where higher concentrations of mercury, PCBs and other contaminants have been found. A map showing 140 lakes and rivers with high concentrations of these substances is available on the DNR website.[32]

Figure H3

Safe Eating Guidelines for Fish Consumption

(Courtesy of Wisconsin DNR)

Economics

Despite Wisconsin's proximity to the largest source of freshwater in the world, we do not have an unlimited supply.[33] From an economic perspective the value of water, or our "willingness to pay" for its use or maintenance, is of particular interest to household consumers, industries and policy makers who are responsible for managing our limited water resources. Understanding the market value of water is important because it provides one frame for understanding how society values water.

The value we have placed on water is based mainly on the costs of extraction and delivery, not the value of the resource itself. Therefore, the price we pay does not include unpriced benefits such as recreational, aesthetic and ecological functions like flood control. Determining the market and nonmarket value of water presents a challenge because water is used and valued differently by different user groups. A brewery, for instance, uses and values water for industrial processing, while a birdwatcher or angler values water as a natural amenity. Unlike other goods in the marketplace (like corn or automobiles), water in Wisconsin is publicly owned and provided.[34]

When the well is dry we know the worth of water.

Benjamin Franklin

Water Intensive Industries

One way to understand the economic value of water is to analyze how water contributes to Wisconsin's establishments. "Water footprinting" has been developed as a tool for assessing the total volume of freshwater used by economic sectors, companies and regions. For most industries the production of raw materials like food crops and fibers makes up the largest portion of the water footprint. Other sectors, like electronics, rely on indirect water use to make products in their manufacturing supply chains.[35] While power generation and agriculture (for irrigation, livestock and aquaculture) account for about 90 percent of direct water withdrawals in the United States, the majority of industry sectors (96 percent) rely on indirect water uses. Indirect water use accounts for at least 60 percent of total water use.

Figure E1 displays the top 30 water users that rely heavily on water as an input.[36] Sectors such as wholesale trade, real estate establishments and telecommunications appear on this list due to their size. Others, such as cheese manufacturing, electric power generation and dairy cattle production demand significant amounts of water in their production processes.

Others have high wastewater discharges that require water treatment or disposal. Examples include apparel (particularly cotton); high-tech and electronics (semiconductor manufacturing); beverage, food and agriculture; biotechnology and pharmaceuticals; and forest products.

Many of these sectors play an important role in Wisconsin's economy. For example, in 2007 food services and drinking places employed almost 200,000 people in about 13,000 establishments bringing in sales of almost $6 billion. Additionally 244 paper manufacturers employed more than 32,000 people, with output valued at over $14 billion.[37]

Capitalizing on Wisconsin's Water Niche

Compared to other states in the nation, Wisconsin and other Midwestern states have a competitive advantage in terms of significant water resources and well-developed water infrastructure. Water technology clusters — geographic clusters of businesses that address water issues — have emerged over the past decade to support water technology research, development and business acceleration. Businesses that are part of these clusters hope to gain from collaboration, advocacy for consistent water technology policies, and research opportunities.[38]

Figure E1

Wisconsin Top 30 Water Users

Based on sector use of water, sewage treatment and other utility services as an input.

#	Sector
1	Private junior colleges, colleges, universities and professional schools
2	Other state and local government enterprises
3	Real estate establishments
4	Food services and drinking places
5	Private hospitals
6	Paper mills
7	Grain farming
8	Cheese manufacturing
9	Hotels and motels, including casino hotels
10	Nursing and residential care facilities
11	Telecommunications
12	Ferrous metal foundries
13	Waste management and remediation services
14	U.S. Postal Service
15	Wholesale trade businesses
16	All other crop farming
17	Electric power generation, transmission and distribution
18	Offices of physicians, dentists and other health practitioners
19	Civic, social, professional and similar organizations
20	Other basic organic chemical manufacturing
21	Vegetable and melon farming
22	Oilseed farming
23	Personal care services
24	Paint and coating manufacturing
25	Construction of other new nonresidential structures
26	Dairy cattle and milk production
27	Soap and cleaning compound manufacturing
28	Transit and ground passenger transportation
29	Poultry processing
30	Individual and family services

The Water Council based in Milwaukee is an example of a water industry cluster that has earned national recognition for its collaborative work. The Council acts as a hub for water research and industry for more than 130 water technology companies in the area. The Water Council supports the Great Lakes Water Institute, the largest freshwater institute on the Great Lakes; the University of Wisconsin-Milwaukee School of Freshwater Sciences; and the Global Freshwater Seed Accelerator that provides mentorship, funding and training for new water technology businesses. It also supports collaborative research initiatives among universities and industries.[39]

Tourism Impacts

Water is important to Wisconsin's tourism sector. Wisconsin's Statewide Comprehensive Outdoor Recreation Plan lists 71 outdoor recreation activities of which 20 (28 percent) are water-focused. All but two activities take place in natural settings (e.g., on lakes, rivers, wetlands, ponds and streams). Two activities, ice-skating and swimming in an outdoor pool, rely on human-made facilities. Many other activities rely on water for irrigation (e.g., grass playing fields, making snow for skiing and snowboarding).

Fishing is a popular outdoor activity that generates a significant economic impact for the state. More than 1 million resident and non-resident anglers spend almost 20,000 days fishing and generate more than $1.4 billion in trip and equipment expenditures annually.[40] Hunting is another popular sport. Waterfowl hunting adds about $19 million annually in trip and equipment expenditures to Wisconsin's economy.

The active outdoor recreation economy contributes more than $9.7 billion annually to the state economy, supporting 129,000 jobs, generating $570 million in state tax revenue and producing $7.5 billion in retail sales and services.[41] Together, outdoor recreational activities account for nearly 4 percent of gross state product. Unfortunately, there are no economic impact studies for specific water-related activities.

Figure E2 shows, in general, counties with more miles of shoreline have higher visitor spending per capita.[42] The notable exceptions are Adams and Sauk counties where the Wisconsin Dells and many water parks are located, and Walworth County, home to Lake Geneva. Lake Geneva is a tourist destination for Chicago and Milwaukee. Figure E3 mirrors this pattern.[43]

Land Value

Water is also an important factor in facilitating development and growth of primary and seasonal homes. Studies in the Northeast and Upper Midwest including Wisconsin have calculated the positive impact of water clarity on shoreland property value. For example, a five-year study of 900 lakefront properties in Maine showed that improved depth of water clarity resulted in millions of dollars of increased property values.[44] Similarly, a study in Vilas County, Wisconsin, showed that more restrictive shoreland zoning regulations generally have a positive influence on property values.[45]

Photo E1

Water Clarity

A Secchi disk is submerged in water to measure visibility depth. The photos show decreasing water quality from left to right. (Photos courtesy of the Minnesota Pollution Control Agency)

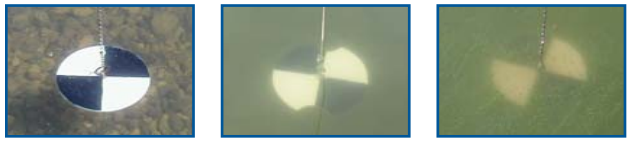


Figure E2

Direct Visitor Spending per Capita

The map illustrates direct visitor spending per capita by miles of shoreline.

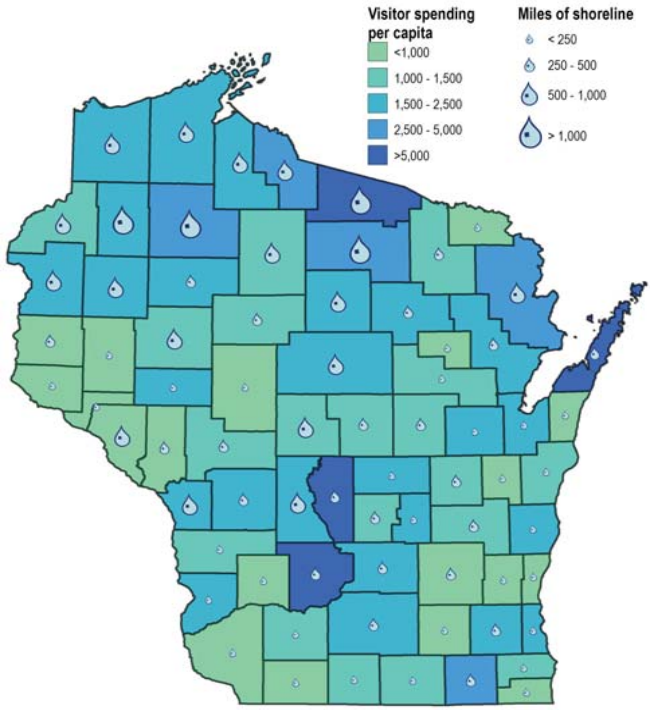
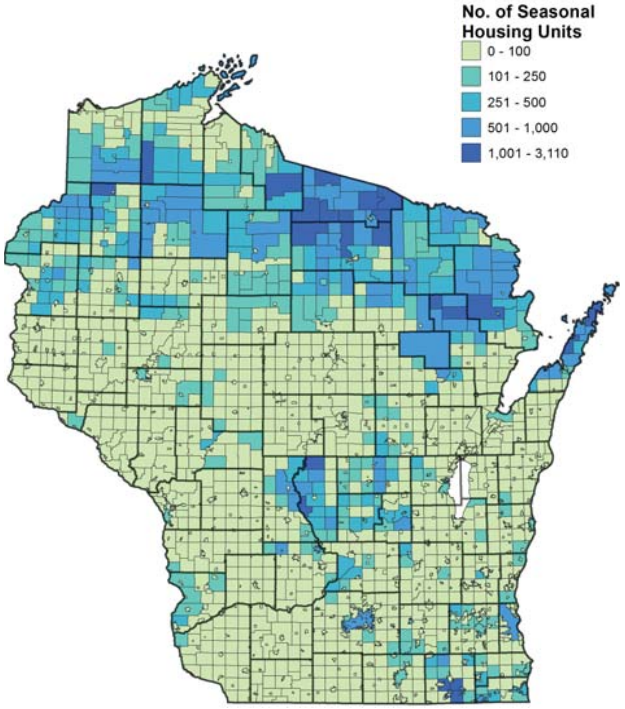


Figure E3

Second Home Ownership

The map shows seasonal housing units by municipality.



Recreation and Stewardship

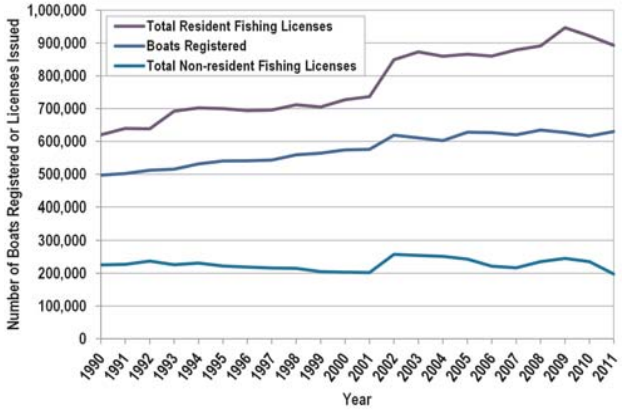
Recreational Uses of Water

Wisconsin residents and visitors connect with our abundant water resources through a variety of recreational pursuits. Each year, close to 2 million people participate in boating (2.1 million), visiting a beach (1.9 million), swimming (1.9 million), and freshwater fishing (1.7 million).[46] Over the past 25 years, boat registrations have increased by 27 percent with more than 100,000 more boats registered in 2011 than in 1990. Although the total number of non-resident fishing licenses has remained relatively unchanged since 1990, the number of resident fishing licenses has increased more than 40 percent (see Figure RS1).[47] The total number of people duck hunting is estimated at 48,000.[48] Water use for recreation is critical to Wisconsin's tourism industry and quality of life. The Economics section of this report underscores the importance of recreation to the state's economy.

Figure RS1

Recreational Licenses

Fishing licenses are reported for Wisconsin residents and non-residents from outside of Wisconsin.



Volunteers Improve Water Resources

Volunteer and partner organizations are important for protecting and celebrating Wisconsin's water resources. Currently, there are more than 1,000 lake and river groups confronting challenges as diverse as changing water levels and recreational use (see Figure RS2).[49] Stewardship efforts are regularly supported by multistakeholder groups that involve and leverage the support of citizens, business people, chambers of commerce, media outlets, elected officials, agency and tribal staff, and other water enthusiasts. The work of these groups is as diverse as it is important. They collect local water quality data, stimulate conversations about lake issues, provide a forum for residents and others to talk about and prioritize management actions, conduct educational outreach, and provide grassroots advocacy for lake management issues.

One example is the Citizen Lake Monitoring Network (CLMN). Each year about 900 citizen volunteers participate in monitoring the health of Wisconsin lakes. The work of these volunteers is valued at $1.9 million and participation has increased six-fold since the program started in 1986 (see Figure RS3).[50]

Case Study: Water Action Volunteers

The Water Action Volunteers Stream Monitoring Program engages citizens to monitor the health of their local streams and rivers. In 2013, volunteers monitored 565 unique sites (Figure RS4). The program offers three levels of participation for volunteers, meeting their varied interests and time availability. Volunteers in Level 1 monitor six aspects of stream health once a month May through October: streamflow, transparency, temperature, dissolved oxygen, habitat and macroinvertebrates. Volunteers in Level 2 monitor for status and trends of four aspects of stream health following methods used by DNR biologists. Level 3 projects are designed to address specific research

Figure RS2

Wisconsin's Water Groups

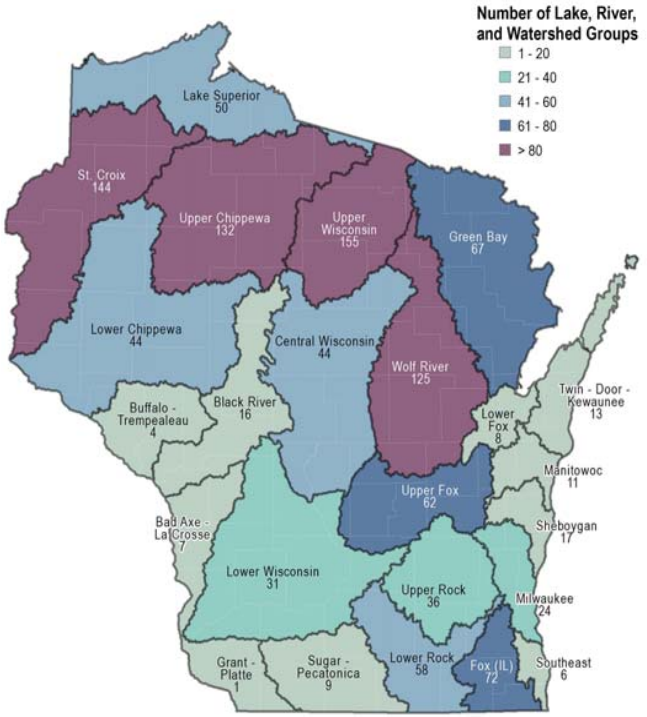
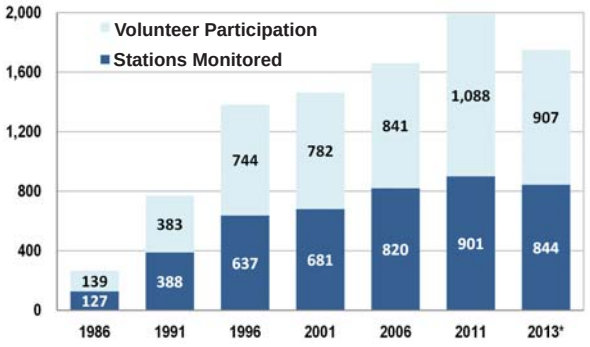


Figure RS3

Volunteer Participation

Participation is measured every 5 years, except for 2013 (*).

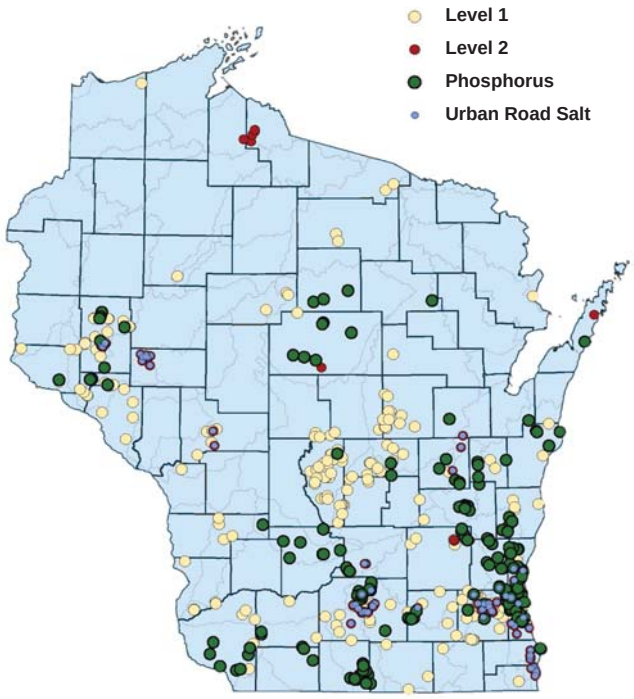


questions. In 2013, volunteers monitored 92 sites for total phosphorus, assisting DNR biologists with six projects in which these data were required to make management decisions. They also monitored numerous sites where no phosphorus data were on record. This data will help DNR managers determine if these streams should be listed as impaired with the EPA. In addition, volunteers are helping to assess impacts of road salting on wadeable streams at 99 sites in urban areas of the state. More information about the WAV program is available at watermonitoring.uwex.edu/wav.

Figure RS4

Water Action Volunteers 2013 Stream Monitoring Program Stations

(Courtesy of Water Action Volunteers)



Case Study: Wetlands

The Lake Koshkonong Wetlands Association (LKWA) is a nonprofit group with a diverse membership of naturalists, hunters, anglers, bird lovers and others dedicated to protecting the wetlands, natural communities and wildlife of Lake Koshkonong and the Rock River. LKWA members understand that the health of the lake depends on the extent and quality of wetlands adjacent to and upstream from their lake. In this respect they are both visionaries and leaders.

LKWA activities include but are not limited to wetland research, biological assessments and surveys, restoration of privately owned wetlands, and wetland educational programming. Many LKWA members own wetland property along the lake, and most have volunteered their time to support citizen-based monitoring, restoration and outreach.

In 2005, LKWA members collected data documenting that tens of thousands of ducks use the lake during spring migration, and that a number of other priority species breed in the adjacent wetlands and floodplain forests. As a result, the Wisconsin Bird Conservation Initiative designated the Greater Lake Koshkonong Area as an Important Bird Area a few months later.

In 2006, LKWA received the Wisconsin CLMN Program of the Year Award from the DNR for their research and nomination effort. The award recognizes outstanding projects, organizations or communities exhibiting innovation in the development or expansion of citizen-based monitoring programs that have had direct impact on DNR natural resource management. Visit the LKWA website for more information.[51]

Case Study: The Value of Lake Wausau

In 2013 more than 350 residents from the four communities surrounding Lake Wausau, an impoundment on the upper Wisconsin River, participated in a survey about their lake. The results show there are differences in how community members perceive the quality, safety and value of this water resource. The survey also reveals common values that residents share. For example, residents strongly believe in the power of Lake Wausau as a resource that "adds to the beauty of the community," while contributing directly to the "community's ability to attract new residents and employers." Residents support local efforts to address issues and strongly agree that "community members must take an active role in the future of Lake Wausau." They also agree that "local funding to revitalize Lake Wausau is a good investment in the future."

These results suggest that it may be possible to begin a community dialogue about managing water resources from areas of common agreement among stakeholders. As communities like those in Lake Wausau are faced with complex questions associated with water management, differing community attitudes over issues such as setting water quality goals, creating recreational amenities, and making financial investments in improving conditions in the lake need to be understood. Agreement that Lake Wausau is important to the greater community and that residents support efforts to improve lake conditions provides an opportunity for volunteerism and further engagement about the future of the lake.

Photo RS1

View Across Lake Wausau

(Photo courtesy of Jared Wehner)

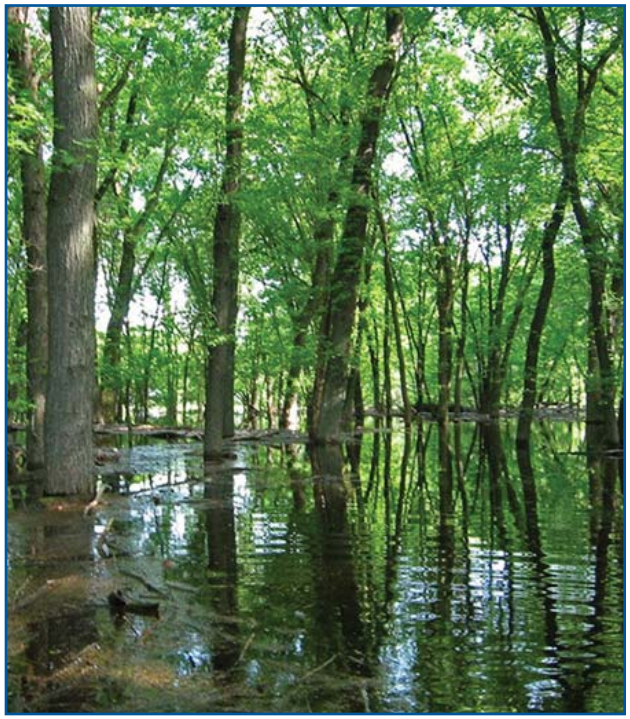
State and Local Policies

Wisconsin's water policies are rooted in the State Constitution and woven together through the Public Trust Doctrine. Over time, the state's laws and policies have evolved to meet changing needs for water and advances in our shared understanding of water pollution, groundwater protection, and effective methods for protecting and restoring waterways. The industrial era generated major new threats to Wisconsin's water as well as novel policy initiatives for managing those threats. A significant shift took place during the 1960s as state and local leaders began to see Wisconsin's water as a limited, valuable resource requiring proactive management and care.

Photo P1

Koshkonong Floodplain Forest

(Photo courtesy of Gary Shackelford)



Outdoor Recreation Action Program

The Outdoor Recreation Action Program (ORAP), signed into law by Governor Nelson in 1961, initiated statewide resource planning and land acquisition to protect important scenic and recreational resources. The vast majority of ORAP spending was directed to lands adjacent to lakes and rivers. Less than four years later, Governor Knowles signed the Water Resources Act into law in Wisconsin and in 1976 consolidated numerous state agencies and programs into a single new Department of Natural Resources (DNR). This was the first such environmental "superagency" that served as a model for other states.

Water Resources Act

The Water Resource Act created a new relationship between state and local governments with respect to water protection and management. The law called for zoning and other land use regulations in floodplains and areas surrounding lakes and rivers. However, it delegated most of the day-to-day implementation to local counties.

Wisconsin county governments and staff learned over time the strengths and limitations of statewide zoning standards as a tool for protecting water resources. Beginning in 1999, the DNR began providing grants to counties to enable them to classify their water bodies based on their vulnerability to development. Counties were also allowed to enact rules above and beyond the state minimum standards in order to better manage sensitive lakes and streams. More recently, the DNR revised the set of rules (NR 115) that shape county implementation of shoreland zoning to better reflect threats from polluted runoff and development near lakes and rivers.

Water Pollution Management Policy

State and local efforts to manage polluted runoff from agriculture and point-sources of water pollution have also evolved. DNR permits issued through the Wisconsin Pollutant Discharge Elimination System (WPDES) greatly reduce the amount of non-point-source pollutants allowed into rivers and lakes.

Most recently, the DNR has been taking a watershed approach for using WPDES permits to meet water quality standards. Adaptive management and nutrient trading enable point sources like wastewater treatment plants to collaborate with farmers and pay for best management practices on rural lands. This is less costly than making expensive sewage treatment plant upgrades.

Groundwater Policy

Over the last forty years, groundwater has also become a major topic of state and local policy. The threat of groundwater pollution and harm to human health motivated a 1983 state law strengthening water quality standards and clarifying the role of state agencies in enforcement.

In 2003, Wisconsin's groundwater law was changed to give the DNR authority to manage the quantity of groundwater pumped for private and public purposes.

Great Lakes Compact

The Great Lakes Compact of 2007 established a binding multi-state and international framework for ensuring that water is not excessively withdrawn from the Great Lakes Basin. Its purpose is to counteract the environmental impacts of interbasin transfer of water from the Great Lakes Basin.

Wetland Regulations

To protect the significant public benefits that wetlands provide, federal and state laws discourage development in wetlands. Projects must be designed to avoid and/or minimize wetlands, and permits for wetland fill can only be issued for unavoidable wetland impacts. Mitigation in the form of wetland restoration, enhancement or preservation, is required to compensate for unavoidable permitted impacts.

Wisconsin regulates construction activities in wetlands, regardless of wetland size or location.[52] Though local governments have the authority to exceed state minimum shoreland zoning standards, protection of wetlands that fall within the shoreland zone and appear on the Wisconsin Wetland Inventory (WWI) maps is required.[53] Counties and towns with comprehensive zoning authority have many opportunities to protect these wetland areas, including extending jurisdiction to protect inland wetlands.[54]

Federal and state laws have significantly reduced outright wetland destruction in the state, but are just a small part of what is needed to preserve and improve the protective services that wetlands provide.

Local and Regional Initiatives

There are many examples of Wisconsin communities and individuals developing local and regional initiatives to address their water challenges. For example, the Red Cedar Basin Monitoring Group in west-central Wisconsin is a partnership formed to deal with excess nutrient delivery to lakes, rivers and streams. Since 1989, the group has been engaged in large-scale planning and monitoring projects within their 212 square-mile watershed. They focus on monitoring water conditions and educating others in the watershed about issues in the basin. In Dane County, another partnership is emerging around the Madison area lakes known as the Clean Lakes Alliance. Both examples utilize watershed councils to develop monitoring plans and performance incentives to promote and evaluate new management practices aimed at improving water quality.

Photo P2

Red Cedar Basin

Runoff flows into a Dunn County ditch and then into Tainter Lake. (Photo courtesy of Dick Lamers)

Burnett County in northwestern Wisconsin provides an example of a community using DNR grants to develop a lake classification system and more finely tuned zoning and subdivision regulations. Located about two hours from the Twin Cities region in Minnesota, the county is endowed with more than 200 named lakes and 66 miles of trout streams. Based on a countywide analysis of lakes, streams and rivers, the county board approved a three-tier system of land regulation classifications. It calls for larger lot sizes and increased building setbacks for development on lakes that are more sensitive to polluted runoff and recreational pressure.

Many cities and villages protect their municipal wells using wellhead protection zoning ordinances. For example, the city of Waupaca in Central Wisconsin protects its groundwater using a wellhead protection plan and zoning. Certain industrial and commercial activities are limited in the area surrounding each of the city's seven shallow municipal wells, thereby minimizing the risk of pollutants entering their groundwater.

Calumet County Groundwater Guardians promotes groundwater protection through well testing and public education programs. The fractured carbonate rock in this area of Wisconsin makes the groundwater highly vulnerable to contamination. This local program provides testing kits for private well owners to discover which pollutants may be in their groundwater. Specialists then meet with the private well owners to discuss their test results and management options.

Photo P3

Des Moines Lake

Des Moines Lake is one of many Burnett County lakes. (Photo courtesy of John Haack)

Acknowledgments and References

On The Web

The Wisconsin Land Use Megatrends series is on the Web at www.uwsp.edu/cnr-ap/clue/Pages/publications-resources/LandUseMegatrends.aspx. Previous publications in this series have focused on forests, housing, recreation, energy, climate change and agriculture.

Acknowledgments

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Cover

The cover map was created by A. Thompson, using the following sources: Wisconsin DNR Hydro_24K Impaired Waterways, Outstanding / Exceptional Waterways, and UW-Extension Center for Watershed Science Groundwater Well Water View, available at www.uwsp.edu/cnr-ap/watershed/Pages/wellwaterviewer.aspx. For a definition of outstanding and exceptional resource waters, see http://dnr.wi.gov/topic/SurfaceWater/datasets/OERW/index.html. For impaired waterways, see http://dnr.wi.gov/topic/ImpairedWaters/. Infants or females that are or may become pregnant should not consume any water that is greater than the 10 mg/L Nitrate-N standard (either by drinking the water or by eating food prepared with the water such as soups, juices and coffee). The Wisconsin Dept. of Health Services recommends that all people avoid long-term consumption of water that has a nitrate level greater than 10 mg/L.

Introduction

[1]The Wisconsin Water Timeline includes several photos: Driving logs over Apple River Falls, WI (Minnesota Historical Society Press); Harvesting Cranberries cerca 1900 (Wisconsin Historical Society, WHS-24507); Dam across river, Appleton, Wis. (Library of Congress, LC-D4-4783); Big St. Germain Lake and Connors Lake Resort Landing (Wisconsin DNR, 2014, CC By-ND 2.0, available at www.flickr.com/photos/widnr/sets/72157631575825106); Great White Egret (Wisconsin Dept. of Tourism); Bottomland Forest Pond (Gary Shackelford); Milwaukee Harbor and Skyline and Lake Superior Shoreline (Wisconsis Dept. of Tourism); and Yellow Lake (John Haack).

[2]The Wisconsin DNR video series about the Public Trust Doctrine is available at http://dnr.wi.gov/topic/waterways/about_us/doctrine.htm.

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Water Resources

[4]Figure WR1 includes data from Wisconsin Water Library "Wisconsin Water Facts" and Wisconsin DNR "River Facts", and Wisconsin Wetlands Association. The images are maps from CLUE; Phizzy, CC-BY-SA-3.0-migrated; Geology.com; Historic Wetlands Map; and Central Wisconsin Groundwater Center.

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[49]Map created by D. McFarlane using data from the Wisconsin DNR (watershed), and UW-Extension Lakes and the River Alliance (water groups).

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