Groundwater Series #3

Dodge County Groundwater

A Community Resource

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Center for Watershed Science and Education

UW Extension

Dodge County Groundwater:
A community resource

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A community resource

A clean and dependable supply of water is necessary to ensure a high quality of life and strong economy. Groundwater is of particular importance since this resource serves as the primary source of water for Dodge County residents and industries. Because we cannot see groundwater it is important that we pay extra attention to this resource if we are to ensure the quantity and quality of groundwater is maintained for our current and future needs.

The luxury of quality drinking water is something that many of us commonly take for granted. Municipal water supplies are subject to strict guidelines and water quality testing to ensure that the water is safe to drink. However, there are thousands of private residential wells which serve as the primary water supply for rural residents in Dodge County. Private residential wells and are not required to be tested or treated and homeowners are often unaware of the safety of their drinking water.

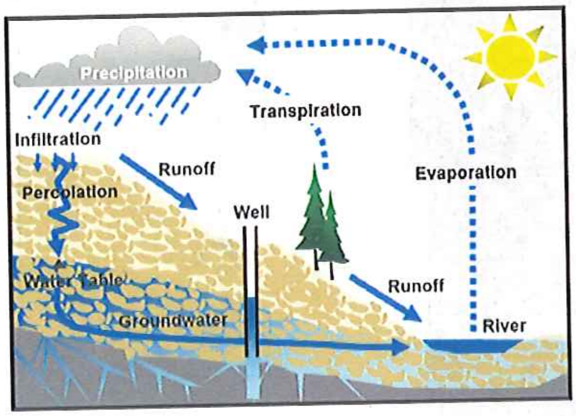
Groundwater is vulnerable and if it is not carefully monitored, managed, and protected has the potential to be depleted or degraded. While much has been done to protect our groundwater supply we increasingly face the question of how to manage groundwater quality and quantity. Wide-spread land-use activities have resulted in elevated concentrations of pollutants such as nitrate and pesticides in groundwater. Cleaning up groundwater after it is contaminated is difficult and expensive; therefore it is beneficial to prevent groundwater from becoming contaminated in the first place.

As a way to address the groundwater and drinking water concerns, the Dodge County UW-Extension office in cooperation with local town governments and the Center for Watershed Science and Education at UW-Stevens Point conducted a number of drinking water testing programs. These programs offered community members an opportunity to test their water and learn about their community's groundwater and drinking water quality.

The results from over 2,100 voluntarily submitted well tests have been used to generate this report. While the results are not representative of a random sample and cannot be considered part of a scientific study, the results do give insight into the overall groundwater quality in Dodge County. The information collected not only helps to highlight groundwater concerns in various parts of the county but has also helped residents to become better informed on local groundwater issues. This report is intended to summarize what was learned, to further educate residents and local leaders on important groundwater issues, and assist in managing groundwater resources for the future. The residents of Dodge County who participated in the well water testing program deserve special thanks; without them this report would not have been possible.

What is Groundwater?

Groundwater is water contained in the empty spaces between soil particles and rock materials below the surface of the earth. If you dig a hole and find the **saturated zone**, the point at which all of the empty spaces between the soil and rock are filled with water, you have hit the **water table**. The saturated areas below the water table make up our groundwater resources.



The hydrologic cycle.

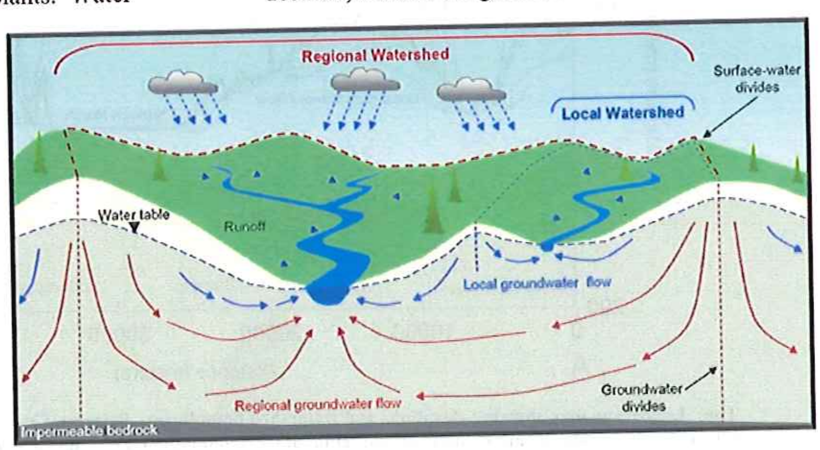
Groundwater is not the mysterious subject that some people believe it to be. Wisconsin's groundwater is related to all other water on earth through a process called the **hydrologic cycle**, or the water cycle. In the water cycle, water is transported from the earth by the processes of **evaporation** and **transpiration** to form clouds. The water in the atmosphere eventually falls back to the earth as precipitation. Some precipitation runs off into surface water. Some soaks into the ground to be used by plants. Water that soaks past the roots of plants to the saturation zone becomes groundwater. Some of this water will be pumped out by wells and used in our everyday activities.

Groundwater that supplies Wisconsin's **wells** does not flow in underground rivers. Rather, the **aquifers**, water bearing geological formations that transmit and store water, are more appropriately thought of as underground "sponges". Major aquifers in Dodge County include unconsolidated deposits (mostly glacial deposits) and dolomite and sandstone bedrock.

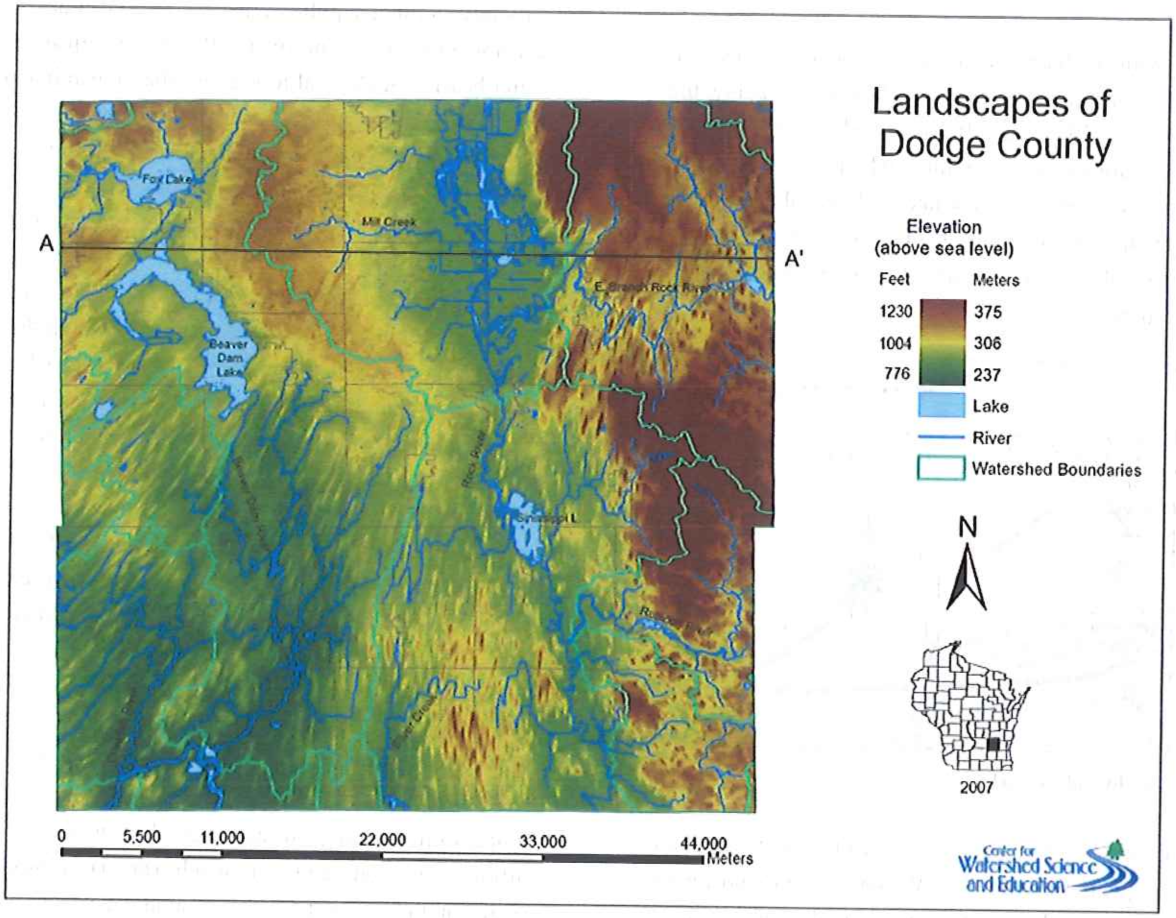
What many people do not realize is that groundwater is always moving. It moves very slowly through the small pores or cracks found in the soil and bedrock. Two factors that affect the rate at which groundwater moves are: 1) the size of the pore spaces and 2) how well the pores or cracks within an aquifer are connected. The larger the spaces and the better connected those spaces are, the faster water will move. Typically groundwater may only move a few inches to a few feet per day, although in areas where there is fractured bedrock, groundwater may move much quicker.

In Wisconsin's shallow aquifers, groundwater flows only short distances, a few thousand feet to a few miles, from **recharge areas,** areas where water infiltrates into the ground, to **discharge areas** lower points on the landscape where groundwater intersects the land surface and water exits the ground. Examples of discharge areas include streams, rivers, lakes and wetlands.

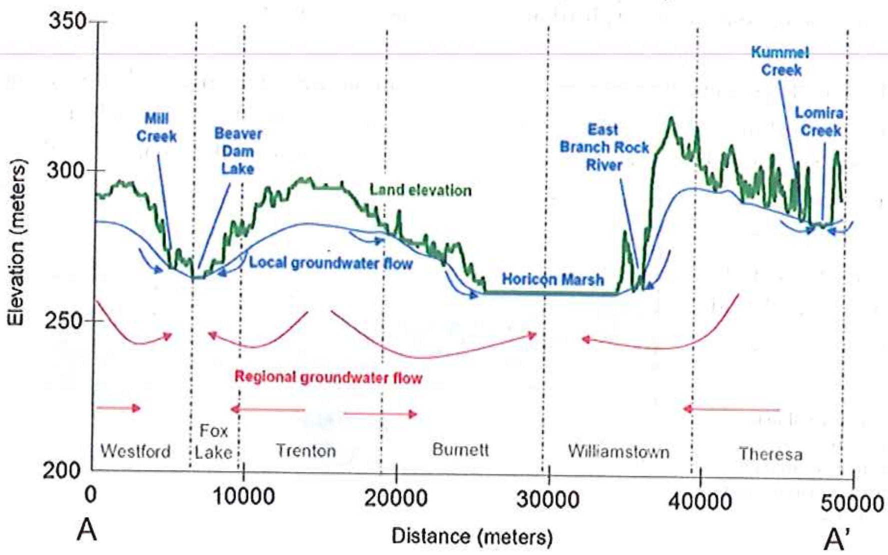
Groundwater traveling in shallow flowpaths has been in the groundwater system only a few years or decades; most of the groundwater that we use is



Local groundwater flows shorter distances to nearby streams. Deeper in the aquifer groundwater generally flows longer distances to major discharge areas.



Generalized Groundwater Flow Paths in the Cambrian-Ordivician Aquifer Systems of Dodge County



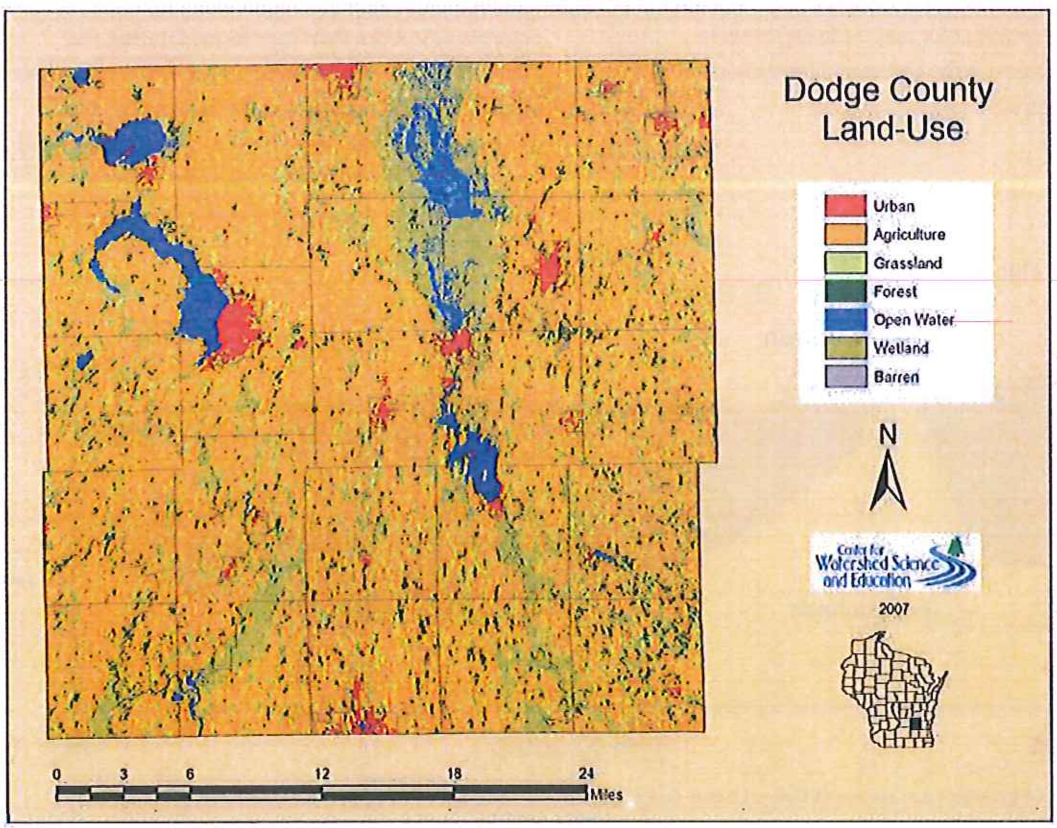
Top: Landscape map showing elevations and watershed boundaries. Bottom: Generalized cross section showing inferred water table elevation and likely direction of local and regional groundwater flow.

supplied by these shallow flowpaths. Deeper in the aquifer where the groundwater flowpaths are much longer, water may be in the groundwater system decades or maybe even hundreds of years. Even though water may be very old, it is important to understand that our groundwater does not come from Canada, and few very deep wells tap water that has been underground since glacial times.

Since groundwater generally discharges to the landscape at surface water bodies, we use the concept of a **watershed** to determine the area of recharge for lakes and rivers. A watershed is the land area where water originates for lakes, streams or groundwater aquifers. Any water that ends up in a lake or river originated or fell somewhere within that lake or river's watershed. Most precipitation that isn't taken up by plants or doesn't evaporate will eventually find its way to a lake or river within the watershed, some through direct runoff over the land surface and much of it through infiltration and groundwater flow. Large rivers, such as the Rock River, will have a large watershed that can be divided up into many smaller watersheds to represent the contributing area of smaller tributary streams.

Water is often referred to as the universal solvent because it can dissolve many different materials, some which may be harmful, and may be found in groundwater. Because the groundwater used by most Dodge County residents is locally recharged, it is greatly affected by local geological conditions and local land use. People may be surprised that groundwater quality problems do exist in Dodge County. Some of the problems occur naturally from the contact of water with soil and rock; others are introduced by human activity.

It is important to keep in mind that what we do on top of the land and how carefully we do it often determines whether or not groundwater becomes polluted. Many everyday activities have the potential to impact our groundwater below.



General land-use map of Dodge County.

Geology of Dodge County

In order to understand some of the key factors affecting groundwater, it is important to know about the **geology** and soils of Dodge County. Geologic materials and soils both influence groundwater. Different geological formations have different chemical and physical properties that greatly affect groundwater chemistry as well as the storage and transport of groundwater.

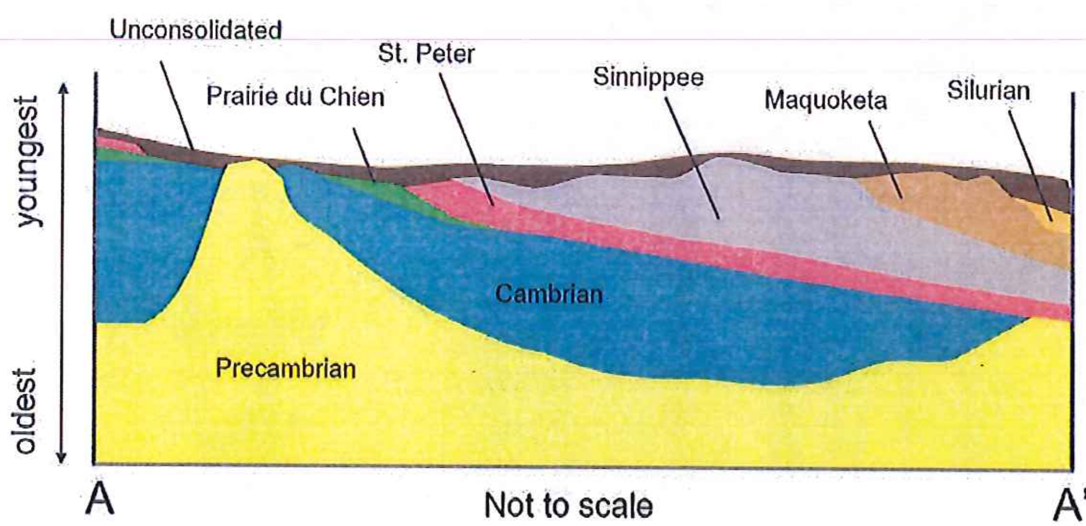
The geology of Dodge County is very similar to a layered cake, with each layer of the cake representing a different geological material and different geologic period. Some rocks are metamorphic, formed billions of years ago, when Wisconsin was experiencing volcanic activity. Most of the bedrock layers however are sedimentary in nature, these layers were deposited when ancient seas rose and fell over Wisconsin hundreds of millions of years ago. The most recent layers are the result of glacial activity in the region. In order to learn more about the different aquifers, let's work our way forward through time in the order that these layers were formed starting with the oldest and lowermost geologic material.

Precambrian Rocks

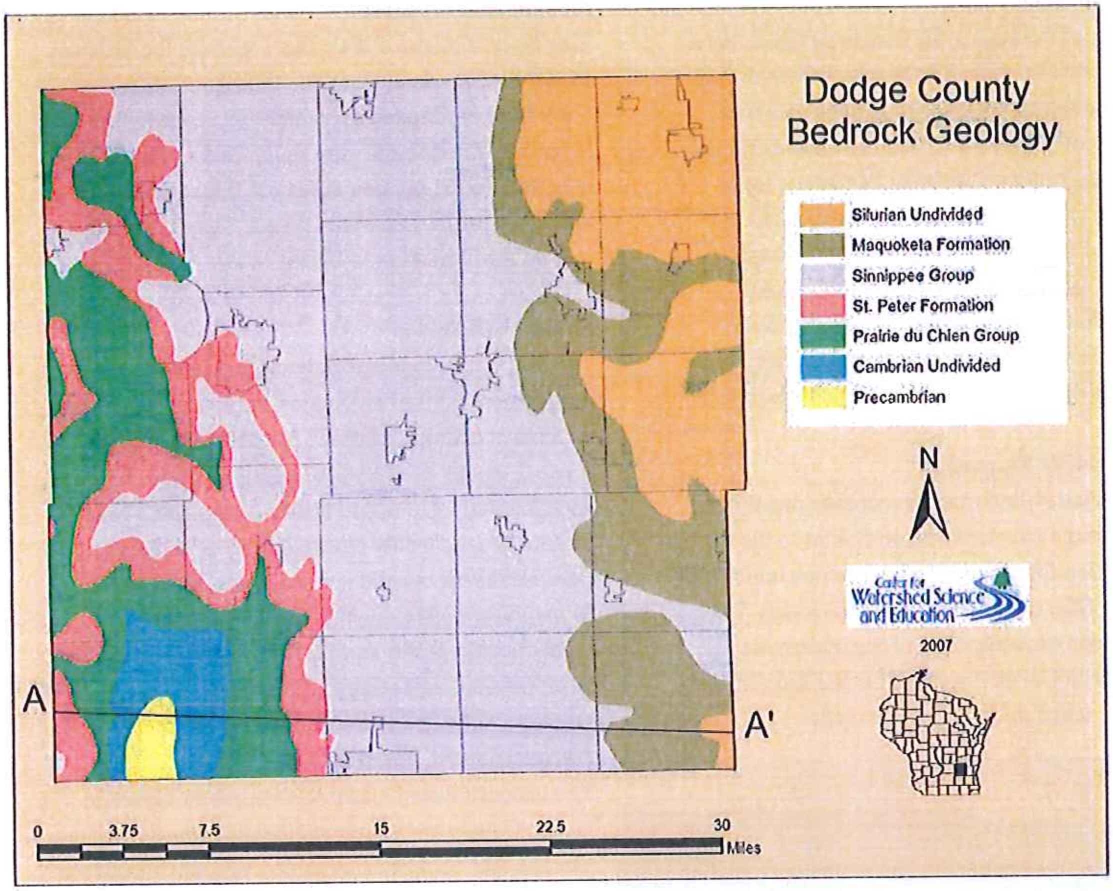
The Precambrian layer is the bottommost layer of bedrock. While this layer underlies the entire county, it is the uppermost bedrock layer in only 1% of Dodge County. Precambrian rocks consist of some very old sedimentary rocks, as well as igneous and metamorphic rock types such as basalts, ryolites, and granites formed from volcanic activity and igneous intrusions. These are some of the oldest rocks in the world and were formed approximately 2.8 billion years ago. In general most Precambrian rock types store very little water and do not transmit water readily, making for a very poor aquifer; as a result it is not practical for most wells in Dodge County to extend into this geologic formation to obtain their water. Because this formation is found close to the surface in a small portion of the southwestern portion of the county, some wells do extend into this formation.

Cambrian Undivided

Located on top of the Precambrian rocks are the Cambrian sandstones. Cambrian sandstones are sedimentary rocks that were formed during the Cambrian period from about 550 to 490 million years ago. As upland areas eroded, weathered materials were deposited onto a nearly flat landscape by wind and rivers. This landscape was later submerged as sea levels rose. The ocean waves and currents



Generalized geologic cross section of Dodge County (see map on p. 6 for location of cross section represented by A to A').



Surficial bedrock geology map of Dodge County.

redeposited the sand over the ocean floor, and over time this layer of sand was loosely cemented together to form sandstone rock.

Sandstone is quite porous and allows a substantial amount of water to be stored and transmitted through the small interconnected pore spaces between the cemented sand grains. Pouring water into sandstone is much like pouring water into a very rigid sponge. While this layer can be located at some depth below most of the county, it is the uppermost bedrock layer in only 3% of the county. This material when pumped can generally produce between 100 and 1,000 gallons per minute, which makes sandstone an excellent aquifer for obtaining water. It is generally the principal source of water for municipal and industrial wells in the county. Where this formation is close to the surface, wells may extend down into this layer to obtain their water.

Prairie du Chien Group

Overlying the Cambrian sandstone layer we find a formation of the Prairie du Chien dolomite which is the uppermost bedrock layer in 11% of the county. Dolomite is another sedimentary rock formed when ancient seas deposited limestone on the ocean floor. Over time the magnesium enriched sea water helped convert the limestone into dolomite rock. Dolomite is a dense rock that does not hold much water. Rather, groundwater is carried in the many cracks and fissures present in this formation. These are the same cracks and fissures that make this formation a good source of stone for buildings. Dolomite is also soluble in slightly acidic water, and over time solution fractures will continue to develop as water travels through the cracks in the dolomite. (see also karst topography)

St. Peter Sandstone

In some parts of the county the Prairie du Chien layer is overlain by the St. Peter Sandstone; formed during a period when sea levels lowered and the area was exposed to weathering. Rivers and streams exhumed some of the underlying Cambrian Sandstone from upland areas, while wind and water redeposited the sand on top of the more recently formed dolomite layers. St. Peter sandstone is very finely sorted quartz sand that has been cemented together over time. This formation is the uppermost bedrock layer in about 20% of the county and is largely unsaturated.

Galena-Platteville Formation

The Galena-Platteville formation consists mostly of dolomite and its characteristics are similar to the Prairie du Chien formation. This formation underlies nearly 75% of the eastern portion of the county and constitutes approximately 50% of the uppermost bedrock layer in Dodge County. It is the aquifer most heavily relied upon for private wells.

Area of Silurian dolomite in the Town of Lomira. Areas such as this where the soil layer is thin to absent and overlies fractured bedrock are very prone to groundwater contamination.

Maquoketa Formation

This layer consists of shale that separates the Galena-Platteville Formation from the Silurian Formation. Shale has very limited permeability; as a result this layer does not transmit very much water. This layer is often referred to as an **aquitard**, because of its ability to restrict water movement. Very few wells rely on this formation to obtain water.

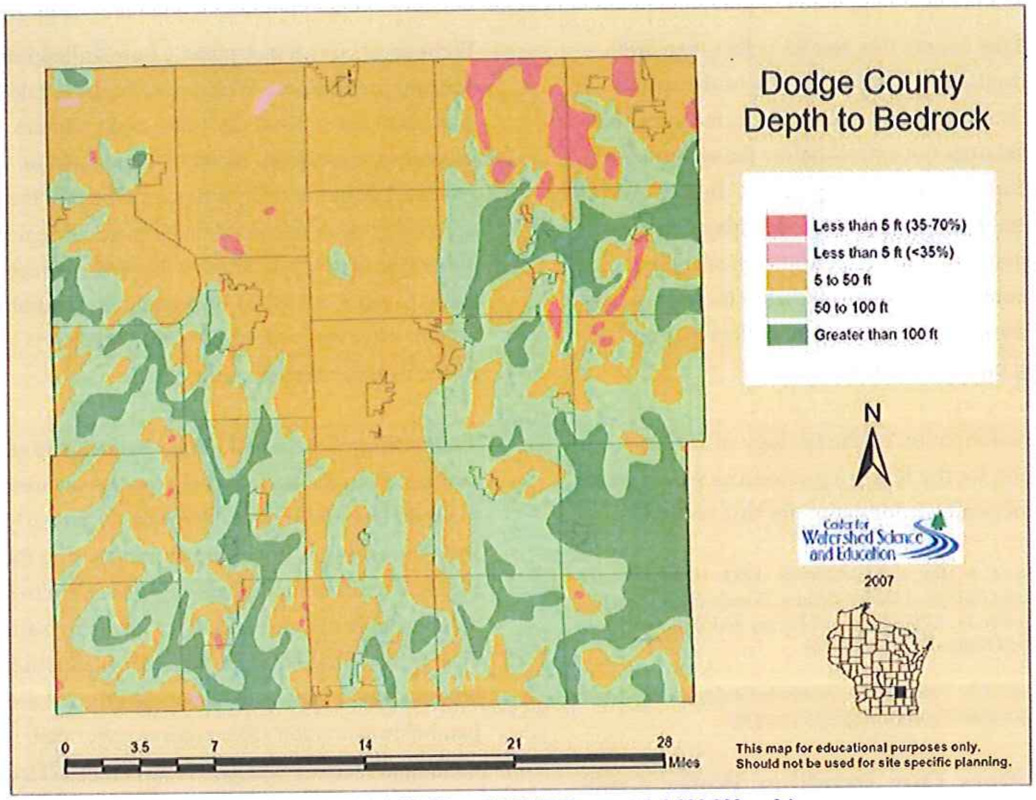
Silurian Undivided

The Silurian Dolomite is only present in the northeastern portion of Dodge County and is the uppermost bedrock layer in 13% of the county. It consists mainly of dolomite deposits formed approximately 430 to 415 million years ago when Silurian seas probably covered all of Wisconsin. Because the unconsolidated materials overlying this formation are often thin and the bedrock can be highly fractured; this aquifer is relatively susceptible to contamination (See karst topography).

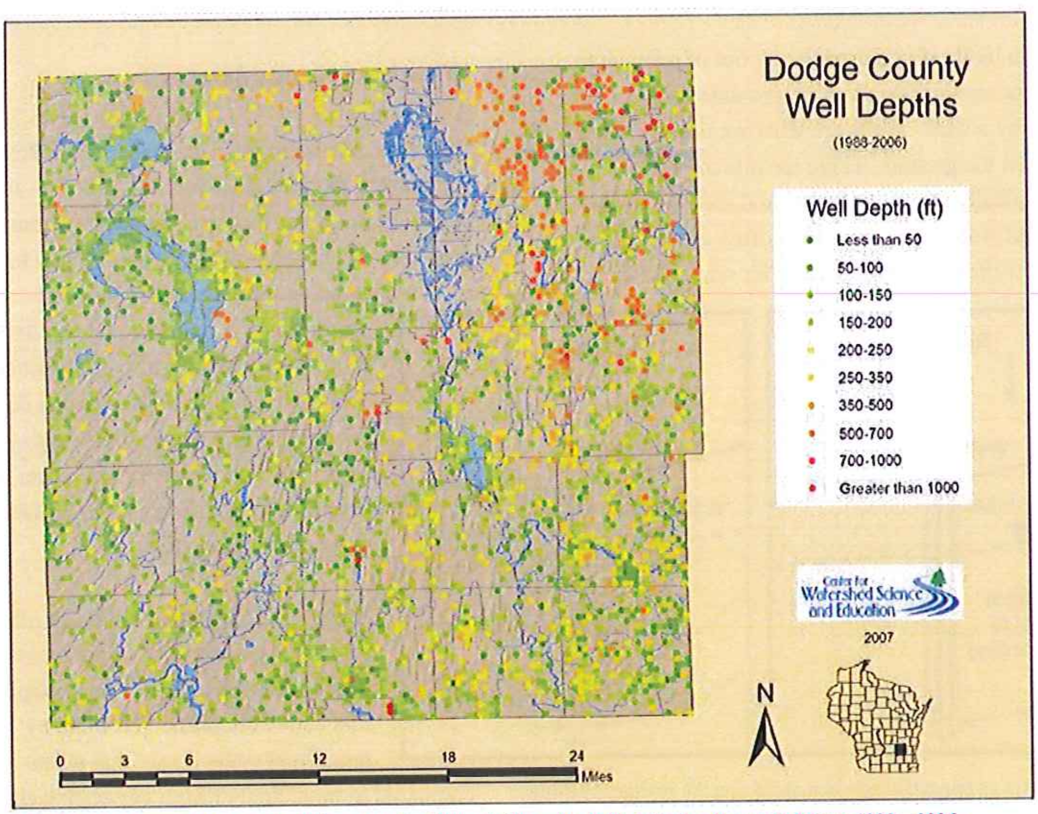
Unconsolidated Materials

The unconsolidated materials overlying bedrock in Dodge County are largely sediments deposited by the glaciers that occupied this part of Wisconsin between 26,000 and 10,000 years ago, but also include some alluvium and marsh deposits. These materials can range in size from clay to boulders. Many of Dodge County's unique landscape features were formed by the advance and retreat of glaciers. If you look at the landscape map (p. 3) you can see the direction of ice movement based on the alignment of drumlins or elongated hills found throughout the county.

Karst Topography - The enlarging of fractures by the weathering of dolomitic rock has created the potential for what is known as **karst topography** in areas of Dodge County where dolomite is the uppermost layer of bedrock. Karst topography is generally located in areas characterized by thin soils or shallow unconsolidated deposits overlying fractured dolomite or limestone bedrock. Areas where karst topography is found may also have sinkholes, sinking streams and springs found nearby. Dolomite accounts for 73% of the uppermost bedrock layer in Dodge County. This bedrock layer is often a very productive aquifer and many residential wells tap into this bedrock layer for their water supply. Because water moves through fractured bedrock very quickly, the potential for pollutants to move quickly to groundwater and sometimes into our wells can represent a significant problem in areas of the county where karst topography occurs.



Map shows depth to bedrock (Source: 1973 USGS and WGNHS map at 1:1,000,000 scale)



Wells depths reported from Well Construction Reports for wells drilled during the period from 1988 – 2006.

In 95% of the county this aquifer is less than 50 ft thick (Devaul et. al., 1983). In 46% of the county this layer is not considered an aquifer, meaning that the material does not extend below the water table and therefore does not provide water. In areas where a substantial amount of the unconsolidated materials are saturated, such as the southeastern section of Dodge County, obtaining water from these materials is highly variable, from 10 – 500 gallons per minute, depending on the type of material.

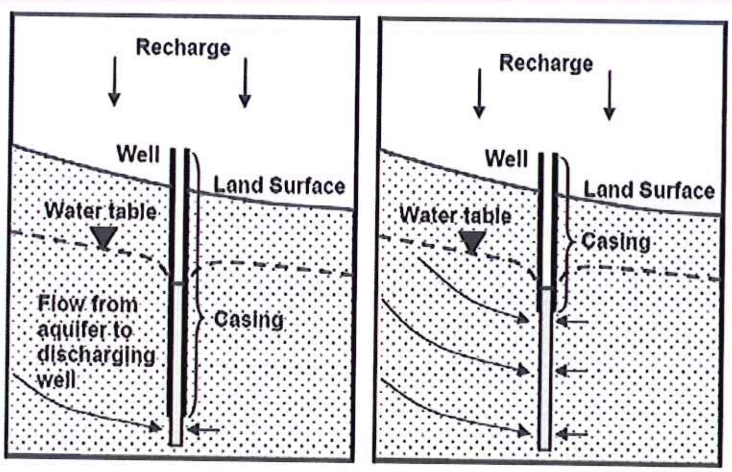
For more information on the geology of Dodge County look for the following resources which were useful in obtaining information for this section:

Devaul, R.W., C.A. Harr, and J.J. Schiller. 1983. Ground-Water Resources and Geology of Dodge County, Wisconsin. Information Circular Number 44. U.S. Geological Survey and Wisconsin Geological and Natural History Survey.

Dott, R.H., and J.W. Attig. 2004. Roadside Geology of Wisconsin. Missoula: Mountain Press Publishing Company.

Where Does Our Drinking Water Come From?

More than likely if you drink water out of a faucet in Dodge County you are drinking groundwater supplied by a well. Wells are what we use to extract water from the ground. There are private wells which typically serve one home, and there are large **municipal water systems** which often consist of multiple wells that provide water for whole cities.



Casing plays an important role in maintaining the sanitary conditions of a well and determining which area of an aquifer a well draws water from.

Wells aren't much more than a hole drilled into the soil and rock below. Wells must be drilled deep enough to extend past the water table into the groundwater aquifer. As water is pumped or removed from the well, water contained in the adjacent rock or unconsolidated material replaces the water that was removed from the well. A recent study found that typical Wisconsin residential wells obtain water that recharged within about a ¼ - ½ mile of the well (Gotkowitz, 2007).

Well casing is the metal lining that helps to seal the well off from the surface and prevents unconsolidated material from falling into the well. A properly installed casing is important in maintaining the physical and sanitary conditions necessary to provide a dependable and safe supply of drinking water. Casing also plays an important role in determining where a well receives its water. Wells that are cased just below the water table receive water that recharged recently and generally can be affected by local land-use activities more quickly than are wells cased further below the water table.

What's in Groundwater?

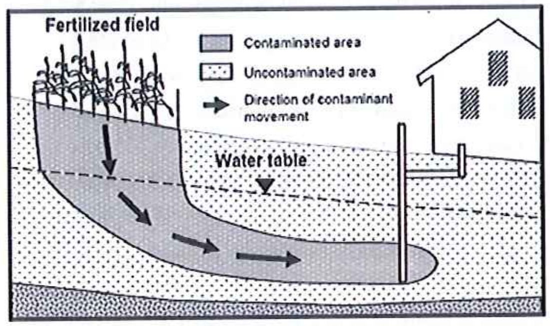
Generally, the deeper the water is found below the water table, the older the water tends to be. In areas where groundwater has been affected by human activities, older groundwater tends to show less signs of being impacted. However, all groundwater originates as precipitation infiltrating into the ground. Eventually even very deep groundwater that does not show signs of being impacted today may show signs of degradation in water quality over time as the newer water replaces older water within the aquifer.

A well that pumps continuously often will lower the water table surrounding the well. This is referred to as a **cone of depression.** The cone of depression created by residential wells is minimal when compared to municipal or **high capacity wells.** Depending on how much water is being pumped and the well location, under certain circumstances wells have the potential to impact surface water bodies. A high capacity well located in close proximity to the headwaters of a small stream, for example, could reduce the amount of groundwater discharge to the stream. If the reduction in streamflow is significant, there can be damaging effects to the stream's aquatic ecosystem. It is important when siting new high capacity wells to understand what effect they will have on nearby surface waters.

Water under natural conditions is never just H_2O or pure hydrogen and oxygen atoms. Water is often referred to as the universal solvent because it has the ability to dissolve many different types of materials. Just because water is not pure water does not necessarily mean that it is contaminated or unsafe to drink. Groundwater will naturally contain certain solutes depending on the type of soils and minerals the water has contacted along its way. Minerals or elements such as calcium and magnesium, which are readily found in groundwater, are necessary for good health. On the other hand, naturally occurring arsenic in groundwater is considered to be a contaminant since drinking water that contains arsenic can negatively impact people's health.

Drinking Water and Health

Humans also have a significant impact on what is in our groundwater. While many people know that a leaking landfill or a chemical spill are sources of contamination, everyday activities such as fertilizing your lawn or salting roads can also contaminate groundwater supplies. Depending on what land-uses are allowed to take place and how careful we are about carrying out these activities, many chemicals will eventually find their way into our groundwater. Because groundwater travels very slowly, we may not realize that we have contaminated it until it is too late. Once groundwater becomes contaminated, it is very difficult to clean up. Since the water being withdrawn from wells is often years or even decades old, eliminating the contamination source today may not improve quality for years to come.



Example of how land-use activities can sometimes contaminate a nearby well.

While the majority of wells in Wisconsin provide a clean and dependable supply of drinking water, there are a number of contaminants found in private and municipal wells that can negatively impact health. Contaminants in drinking water are always a cause for concern. Health effects related to contaminants in drinking water can be divided into two categories; those that cause acute effects and those that cause chronic effects.

Acute effects are usually seen within a short time after exposure to a substance. Bacterial contamination is an example of a contaminant that causes acute effects. People who consume water contaminated with harmful bacteria or other pathogens usually develop symptoms within a relatively short period of time after ingesting the water. Copper is another example of a contaminant that can cause acute health effects. While some copper is necessary, too much in drinking water can cause abdominal pains.

Chronic effects result from exposure to a substance over a long period of time; this could be months or many years. Drinking water that contains even very small amounts of contaminants like pesticides, arsenic or lead for a prolonged period of time increases the likelihood of developing certain types of cancer or other long-term health effects.

Public vs. Private Water Systems

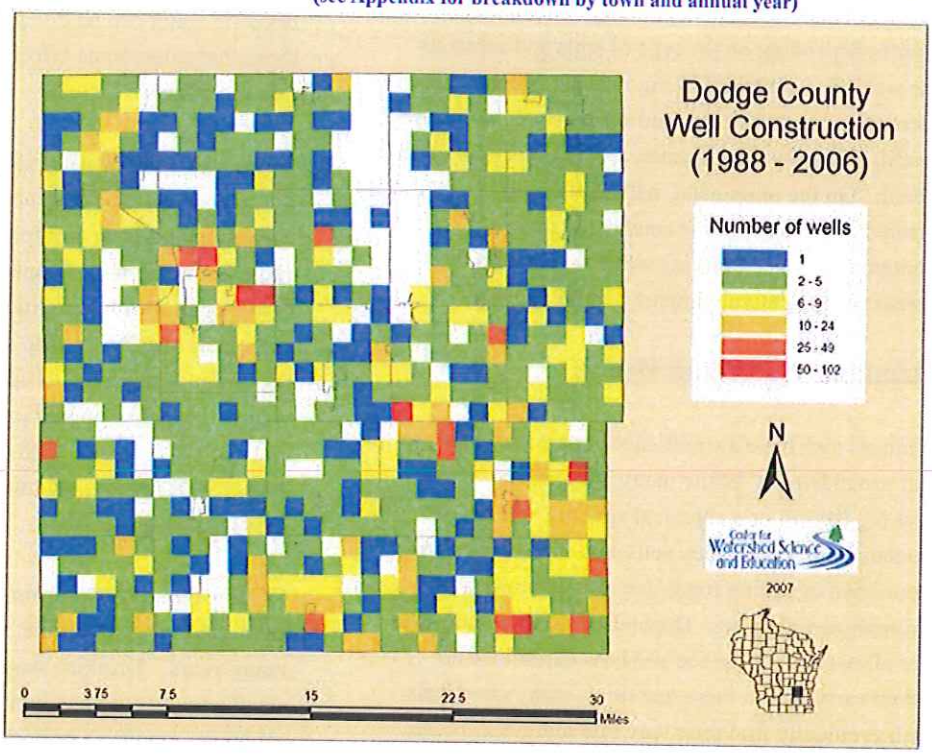
Any water supply system that provides drinking water to the public and has at least 15 service connections or regularly serves an average of at least

25 individuals daily at least 60 days out of the year is considered a "public water system". As of 2005 there were 229 public water systems in Dodge County, 18 of which are municipal systems and provide water to whole cities or villages. Public water systems are regulated by the WI Department of Natural Resources, meaning that they are regularly tested and must notify the public if water exceeds certain drinking water standards. In the case of municipal wells, if water does exceed drinking water standards additional steps must eventually be taken to ensure that the standards are met before the water is distributed to the individual homes in the community. Municipal systems provide reasonable assurance that drinking the water will not result in any acute or chronic health effects. If you would like to find out more about the water quality from your municipal water supply contact your local water utility.

Private water supply systems, which include most rural residential wells, are not required to be regularly tested. The majority of the county's nearly 12,000 wells fall under the category of private water supply. It is up to the individual homeowner to determine what tests to perform and how often. If water quality problems are detected, the homeowner is not required to treat the water; it is the individual's responsibility to determine what the risks are and whether those risks are great enough to correct the problem or find an alternative source of drinking water. The following information will help individuals on private wells to understand what water quality tests are important and how to interpret the test results.

Interpreting water quality information can often be difficult. While water testing by residential well owners is encouraged, individuals are often unable to understand what water test results mean in terms of drinking water safety, aesthetics and effects on household plumbing. In order to truly understand results people must be informed on what they are testing for and why. In addition, people must have standards to compare their water test results to. The following information was collected from over 2,100 private well samples collected from 1994 to 2006 and is summarized for educational purposes (See Appendix A for summary of all results). Interpretation information has also been included to help people determine if their water is safe to drink and identify other potential problems.

Newly constructed wells (by section) for the period from 1988 – 2006. (see Appendix for breakdown by town and annual year)



Developing safe drinking water standards

When dealing with substances that cause chronic health effects, it can be difficult to determine how much of a substance is too much. For those contaminants that cause chronic health effects such as cancer, it is assumed that at any dose some adverse health effects may be possible. Standards are developed to provide a reasonably low risk of developing any adverse health effects; risk levels usually range from one additional case of cancer in ten thousand people to one in a million. As with other health related issues, certain individuals may be more at risk than others. While standards exist for some of the more common chemicals found in groundwater, there are many others for which standards have not yet been developed. To complicate matters further, little is known regarding multiple contaminants in water and the combined effect that they may have on people's health.

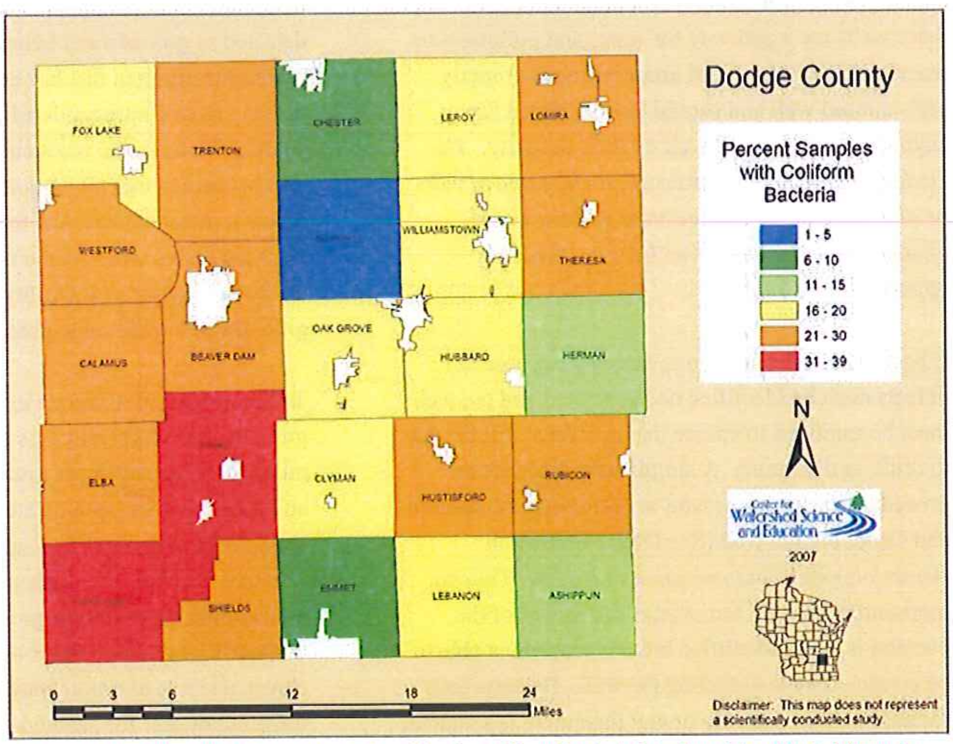
Private Well Data from Dodge County

Tests Important to Health

Coliform Bacteria

A coliform bacteria test is the most important test to have performed regularly on your well. Testing for coliform bacteria helps to determine if a private well is bacterialogically safe. There are many different types of bacteria. Coliform bacteria are very common microorganisms found in surface water, soil and also in human and animal waste. Coliform bacteria is used as an indicator of the sanitary condition of the well, as a result all wells that supply drinking water should not contain any coliform bacteria. Coliform bacteria do not usually cause disease themselves, however; their presence indicates a potential pathway for fecal coliform and other pathogenic (waterborne disease-causing) organisms such as *E. coli* to enter the well. The presence of coliform bacteria should be taken seriously and steps should be taken to correct the problem. The presence of E.coli bacteria is confirmation that human or animal wastes are contaminating the water supply and is a much more serious concern. Contamination from human or animal wastes can cause gastrointestinal diseases, hepatitis, or other serious waterborne diseases.

In most cases a properly constructed well (well construction is regulated by NR 812) will prevent bacteria and other disease causing organisms from entering a well. Soils are usually able to filter bacteria out of water before it reaches the saturated zone. Unfortunately in areas with karst topography, bacteria can more easily contaminate the groundwater aquifer. Under these conditions even a properly constructed well may become contaminated with bacteria. Installing wells according to required distances from septic systems, animal feedlots and manure pits should help in avoiding contamination from fecal bacteria and other disease causing organisms.



Percent of samples (by town) that tested positive for coliform bacteria based on data collected through the well testing programs. (1994 – 2006 data)

Also, ensuring that pets are not allowed in the area directly surrounding the well is a good precaution.

Bacteria can also enter wells through sanitary defects. One of the most common sanitary defects is related to the well cap. Wells should have a vermin proof cap which covers the top of the well. If the well cap is loose or absent, insects or small animals can enter and can contaminate the well with bacteria. Bad or loose connections to the well may also allow bacteria an opportunity to enter the water supply.

Other sanitary defects may have to do with the well casing. Over time the casing may corrode or crack, allowing water to enter into the well close to the surface before bacteria can be filtered out. Grouting is also a component of a properly constructed well, and should fill any gaps between the casing and the surrounding soil or material. A poorly grouted casing may allow water to carry bacteria from the surface down into the groundwater. Similarly, wells that are no longer in use and have not been properly sealed may also represent a source of bacteria contamination. Improperly abandoned wells represent a direct conduit to the groundwater resource. Left open, these wells are a pathway for water and pollutants to reach groundwater. **Well abandonment** properly seals unused well and should be considered for anyone with an unused well on their property. *The Dodge County Land Conservation Department will be able to help answer questions related to well abandonment and may even have cost sharing opportunities available.*

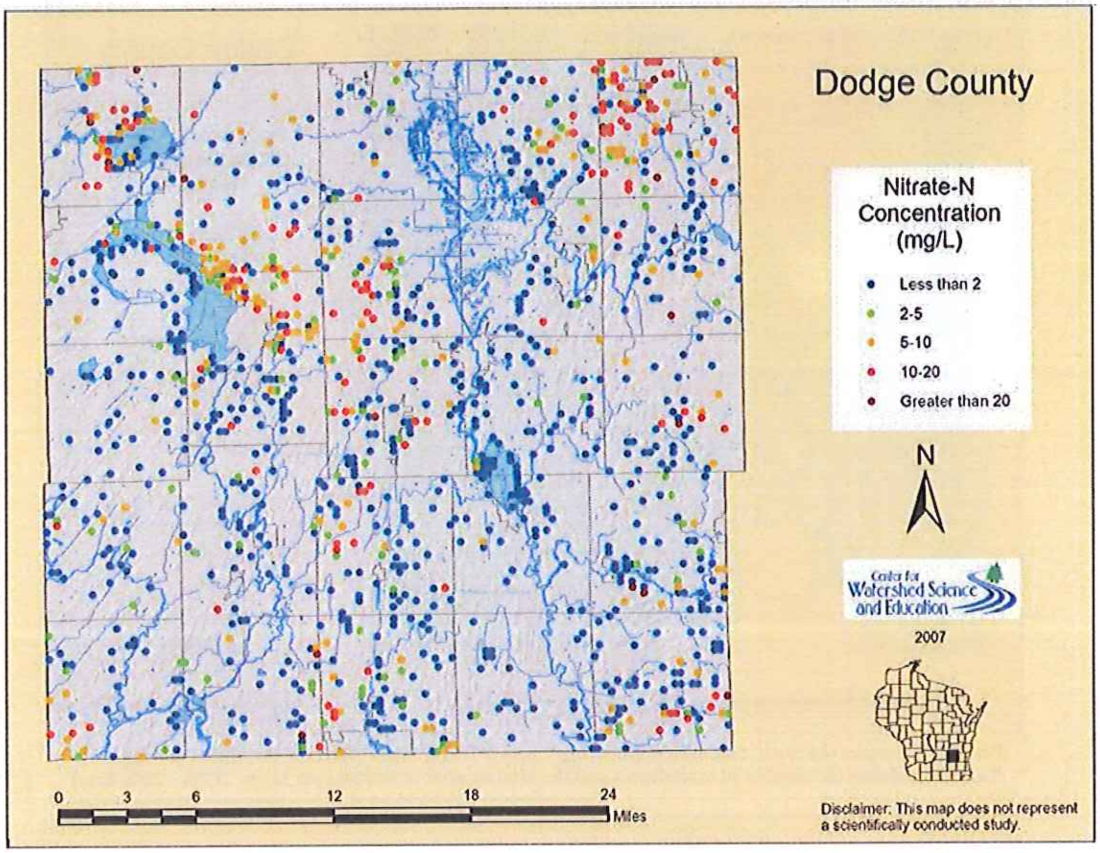
If bacterial contamination is detected any sanitary defects must be identified and corrected and the well must be sanitized to ensure that the water will be safe to drink in the future. A simple well disinfection procedure can be successful at destroying the bacteria and sanitizing the well (See DNR Publication *Bacteriological Contamination of Private Wells* for more information). Sometimes the source of the bacteria is never identified but the problem is able to be corrected by disinfecting the well. Bacteria tests should be done annually or any time there is a sudden change in the taste or odor of the water.

Nitrate-Nitrogen

Nitrate-nitrogen in groundwater commonly results from the use of agricultural and lawn fertilizers, animal waste or septic systems. It is a widespread groundwater contaminant in Wisconsin especially in agricultural regions where applying more nitrogen fertilizer than a plant needs often leads to nutrient leaching into groundwater as nitrate. Even when applying just the right amount, nitrate often leaches to groundwater under wet conditions when water carries nitrate past the root zone of plants quicker than the plants are able to take it up. Nitrate in groundwater can also be a problem in areas of high-density housing where homes rely on septic systems to treat wastewater. If designed properly most septic systems are effective at preventing bacteria from entering groundwater but do not effectively remove nitrate.

While nitrate is a groundwater pollutant, it also represents an economic loss for those farmers who continue to apply fertilizer in excess of what crops can take up in any given year. This is especially true for farmers who don't properly apply nitrogen credits from manure applications. Any nitrate that is detected in groundwater below an agricultural field represents nitrogen that has not been utilized by crops. As the price of nitrogen fertilizers and energy continue to increase, practicing nutrient management will become extremely important. Tailoring nutrient inputs to meet the needs of the crop and reduce leaching losses will become increasingly important as a way to improve profitability and protect groundwater at the same time.

The natural level of nitrate in Wisconsin's groundwater is typically less than 2.0 mg/L (parts per million). Concentrations greater than 2.0 mg/L are an indication that groundwater is likely being impacted by surrounding land-use activities. Because nitrate is very mobile in groundwater, it is considered a good indication that the groundwater is susceptible to other forms of pollutants as well. Areas that have elevated levels of nitrate may also consider testing the groundwater for pesticides if there is agriculture nearby.

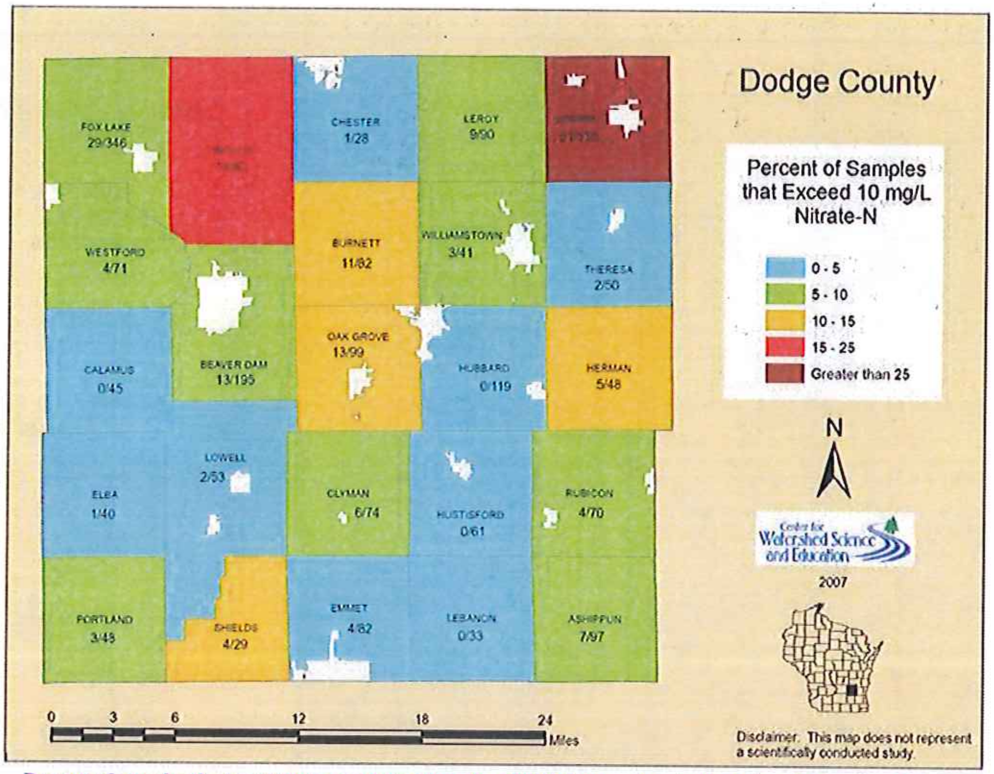


Nitrate-nitrogen concentrations from private well testing programs. (1994-2006 data)

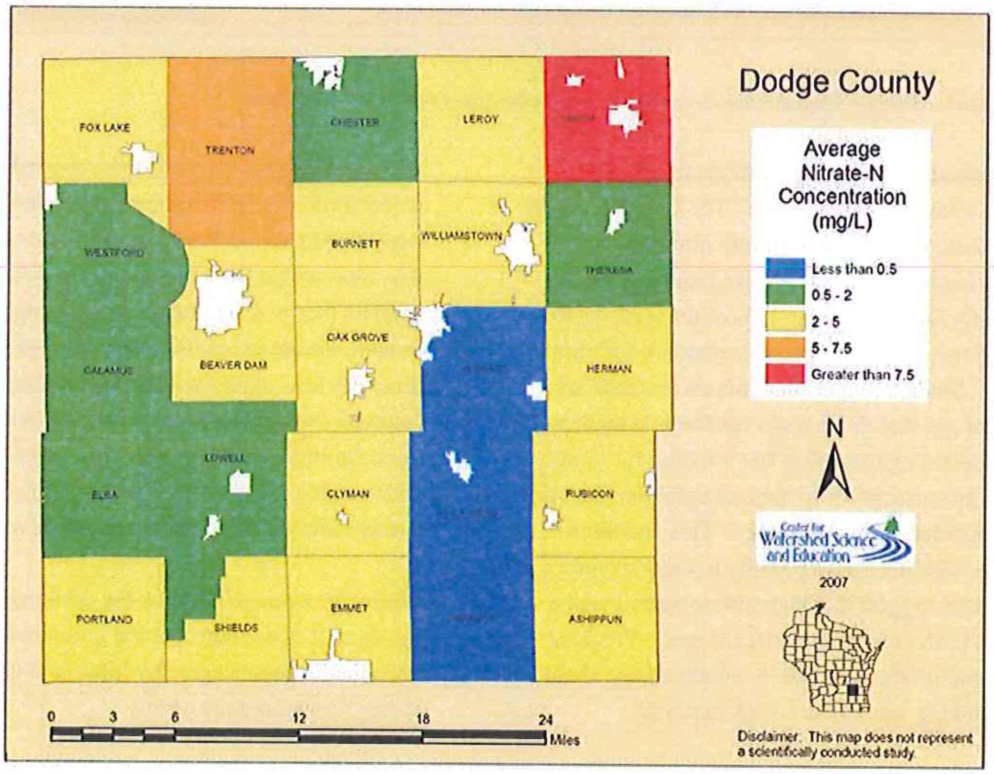
There are certain health implications related to drinking water with high nitrate. The US EPA set the safe drinking water limit of nitrate-nitrogen in drinking water at 10 mg/L. According to the water test data for Dodge County, 10% of the wells tested exceeded the safe drinking water standard for nitrate-nitrogen. Studies suggest that infants less than six months of age that drink water (or formula made with water) containing more than the standard for nitrate-nitrogen are susceptible to methemoglobinemia, also known as "blue baby syndrome". This condition interferes with the blood's ability to carry oxygen. Studies also suggest that high nitrate water may be linked to birth defects and miscarriages. Pregnant women and infants less than 6 months of age should avoid drinking water that is high in nitrate.

In Dodge County, the wells that reported the highest concentrations of nitrate-nitrogen tended to be located primarily in the town of Lomira; these are also areas where karst topography can exacerbate the problem (see p. 6 for details on karst topography). Overall, nitrate concentrations in Dodge County are generally low. Areas with soils less than 5 ft depth to dolomitic bedrock appear to be of the most concern. Concentrations of nitrate-nitrogen ranged from undetectable levels to 53.4 mg/L. The county-wide average nitrate-nitrogen concentration was 4.4 mg/L.

While this average is below the drinking water standard, it does show that the groundwater is being impacted to some degree by local land uses in many places throughout the county.



Percent of samples (by town) that exceed the 10 mg/L safe drinking water standard for nitrate-nitrogen. Numbers indicate the number of exceedences and the total number of samples per town. (1994 – 2006 data)



Average concentration of nitrate-nitrogen (by town) for results from private well testing programs. (1994-2006 data)

Pesticides

A pesticide is any substance used to control or repel a pest or prevent the damage that pests may cause. The term pesticide includes insecticides, herbicides, fungicides and other substances used to control pests. When pesticides are spilled, disposed of, or applied on the soil, some amount can be carried into the surrounding surface water or groundwater. These products move with water and can eventually enter groundwater and nearby drinking water wells. The occurrence of pesticides in groundwater is more common in agricultural regions, although it can occur anywhere where pesticides are used.

While the long-term or chronic health effects of drinking water that contain pesticides are not completely understood, certain pesticides may cause an increased risk of developing certain diseases, including cancer. Because of the large number of pesticides on the market, health standards for safe amounts in drinking water have not been established for all pesticides. This is further complicated by the fact that pesticides can break down into many other chemicals which may also adversely impact health. Little is known about the health effects of drinking water containing a combination of smaller amounts of multiple pesticides and pesticide breakdown products. As a result, limiting the amount of pesticides that end up in groundwater is the best way to ensure safe drinking water for the future.

Based on Department of Agriculture, Trade and Consumer Protection survey, the most frequently detected pesticides in Wisconsin groundwater are alachlor, metolachlor, and atrazine (DATCP, 2002). While these are the most commonly detected, there are often others depending on the types of pesticides that have been applied in the area. The safe drinking water standard for alachlor is 2 ppb (parts per billion) while atrazine is 3 ppb. There are currently no drinking water standards for metolachlor.

Results from a limited number of triazine samples from Dodge County revealed that 21% of the wells that were tested contained measurable amounts of this pesticide in the groundwater. These results are based on the triazine screen tests performed during the water testing programs. While none of the tests were over the 3 ppb standard for total atrazine, this test is only a screening tool and often underestimates the amount of atrazine and its breakdown components. However, this is only one of many pesticides that are used in Dodge County and does show that groundwater in Dodge County is susceptible to contamination from localized pesticide use and is being affected by it. Care should be taken by individuals when deciding on the types and application rates of pesticides, and strategies should be developed to minimize the potential adverse health effects and environmental impacts that result from pesticide use.

Arsenic

Arsenic is often naturally occurring at low levels in the soil and bedrock, but has been found at levels above the drinking water standard in some Wisconsin wells. Studies show that prolonged exposure to low levels of arsenic can increase the chances of developing cancer of the skin, liver, kidney or bladder.

The drinking water standard for arsenic is 0.010 mg/L (may also be reported as 10 parts per billion). While the chance of finding elevated levels of arsenic appear to be greatest in northeastern Wisconsin, arsenic has been detected in at least some wells in every county in the state. Wells with high concentrations of iron may be more likely to contain arsenic bearing minerals. Because little is known about the extent of arsenic in groundwater throughout Dodge County, all residents are encouraged to test for arsenic at least once.

Lead

Lead is a toxic metal which until 1985 was commonly used in the construction of most copper plumbing systems in Wisconsin. Under natural conditions groundwater has little to no measurable lead. However, water that sits in lead pipes or pipes containing lead solder has the potential to dissolve lead and increase the concentration of lead in drinking water to unsafe levels. Brass fixtures also contain lead and may increase levels in drinking water. Corrosive water increases the likelihood of experiencing elevated lead levels.

The safe drinking water standard for lead is 0.015 mg/L (or 15 parts per billion) of lead. Lead can be especially harmful to young children. Drinking water that contains elevated lead levels has been shown to cause brain and nerve damage as well as kidney damage. One way to reduce lead levels in drinking water is to run the faucet for a couple of minutes to flush out water that has sat in pipes for extended periods of time. Treatment systems can also be purchased which reduce the amount of lead in the water or reduce corrosivity and the ability of the water to dissolve lead.

Dangerously high levels of lead have been found in water that sits in garden hoses for an extended period of time. Many hoses contain polyvinyl chloride which uses lead as a stabilizer. Overtime lead can leach from the hose into the water, increasing the concentration of lead significantly. As a result, garden hoses should never be used to obtain water for consumption; this is especially true for young children.

Copper

Copper is a reddish metal that occurs naturally in rock, soil, water, and air; however the source of copper in drinking water is most often due to plumbing. Copper pipes are commonly used in household plumbing. Much like lead, when water sits in copper pipes for extended periods of time it has the potential to dissolve copper pipes and increase copper levels in water. Corrosive water increases the likelihood that you will experience elevated copper levels in drinking water. Blue-green staining in sinks and bathtubs is a good indicator that copper corrosion is taking place.

Small amounts of copper should not cause problems; however too much copper in our diets can be potentially harmful. The safe drinking water standard for copper is 1.3 mg/L of copper. Immediate effects from drinking water with high levels of copper may include vomiting, diarrhea, stomach cramps, and nausea. Long-term exposure of high levels of copper may cause kidney and liver damage. To reduce copper levels in drinking water run the faucet to flush out water that has sat in pipes for extended periods of time. Treatment systems are also available that will reduce the amount of copper in drinking water or reduce the corrosivity and the ability of the water to dissolve copper.

Volatile Organic Compounds (VOCs)

VOCs are a group of common industrial and household chemicals that evaporate, or volatilize, when exposed to the air. Sources of VOCs include a variety of everyday products such as gasoline, fuel oil, solvents, degreasers, polishes, cosmetics, and dry cleaning solutions. VOCs are most commonly used at airports, automobile service stations, machine and paint shops, electronics and chemical plants, dry cleaning establishments, and most residential homes. When chemicals containing VOCs are spilled or disposed of on or below the land surface some of the chemicals can be carried down into the groundwater where they may pose a threat to nearby wells. Some VOCs are quite toxic while others pose little risk. Health risks vary depending on the type of VOC, but effects of long-term exposure can include cancer, liver damage, spasms, and impaired speech, hearing and vision.

VOCs are generally not widespread contaminants in groundwater. If there has been a chemical spill or you have other reasons to suspect contamination you may want to consider a VOC test.

Emerging Contaminants

The increase in prescription drug medications over the years has let to increased concerns of their fate in the environment. Little is known about the extent of pharmaceuticals in our groundwater, but as you can imagine anything that we send down our drains and to our septic system could potentially end up in our groundwater. It is important that we do what we can to minimize these contaminants showing up in our groundwater and surface waters.

Viruses are also another contaminant that we know little about. Viruses are pathogens that can sometimes cause acute illnesses when ingested. How persistent they are in groundwater is still not well understood, but recent studies do suggest that, depending on the geology, viruses can reach groundwater if there is a source of fecal waste.

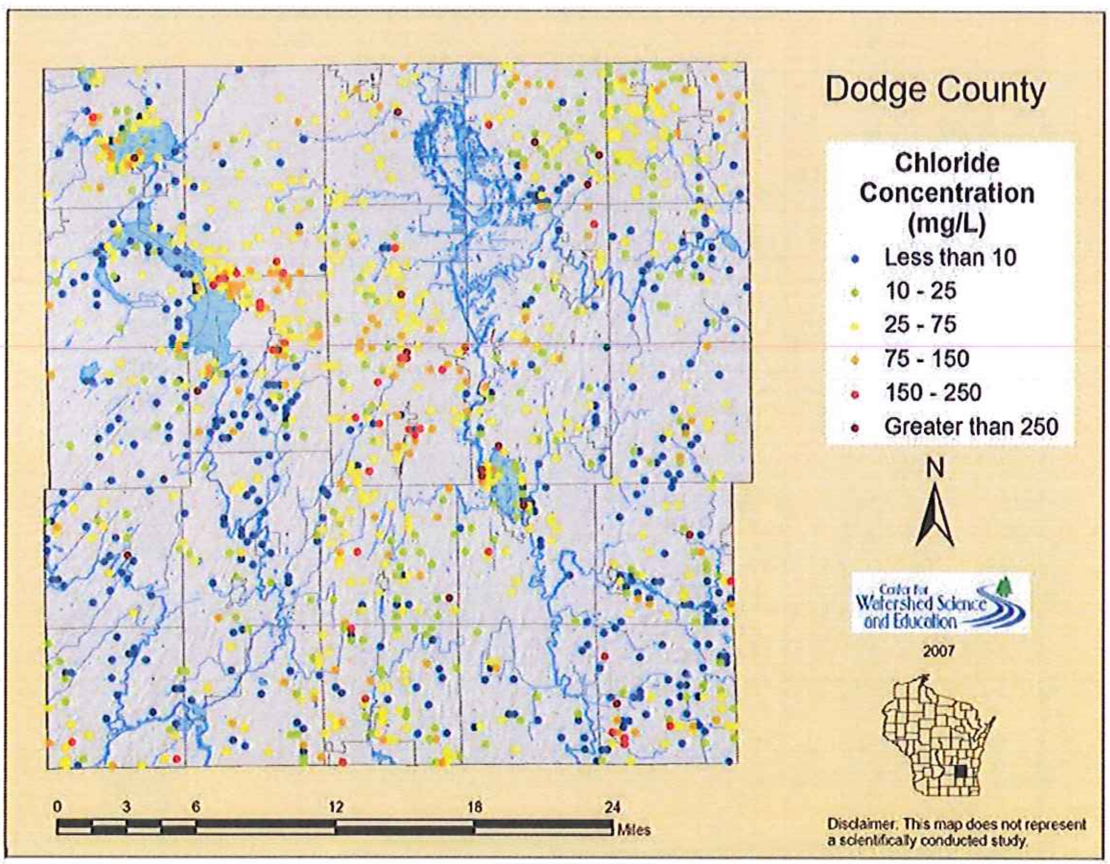
Other Water Quality Indicator Tests

Chloride

In most areas of Wisconsin, chloride in groundwater is naturally less than 10 mg/L. Higher concentrations usually indicate contamination by septic systems, road salt, fertilizers, animal waste or other wastes. Chloride is not toxic in concentrations typically found in groundwater, but some people can detect a salty taste at 250 mg/L. High chloride may also speed up corrosion in plumbing (just as road salt does to your car).

Because of its mobility in groundwater, chloride is also considered an indicator of other potential surface related contaminants. Levels of chloride that are above what is typical under natural conditions indicate that groundwater is being affected, and extra care should be taken to ensure that land-use activities do not further degrade water quality.

In Dodge County 26% of the well tests showed low levels of chloride in groundwater while 22% were only slightly elevated. The remaining 42% of wells which tested above 25 mg/L of chloride may indicate human influence.



Chloride concentrations reported from private well testing programs. (1994-2006 data)

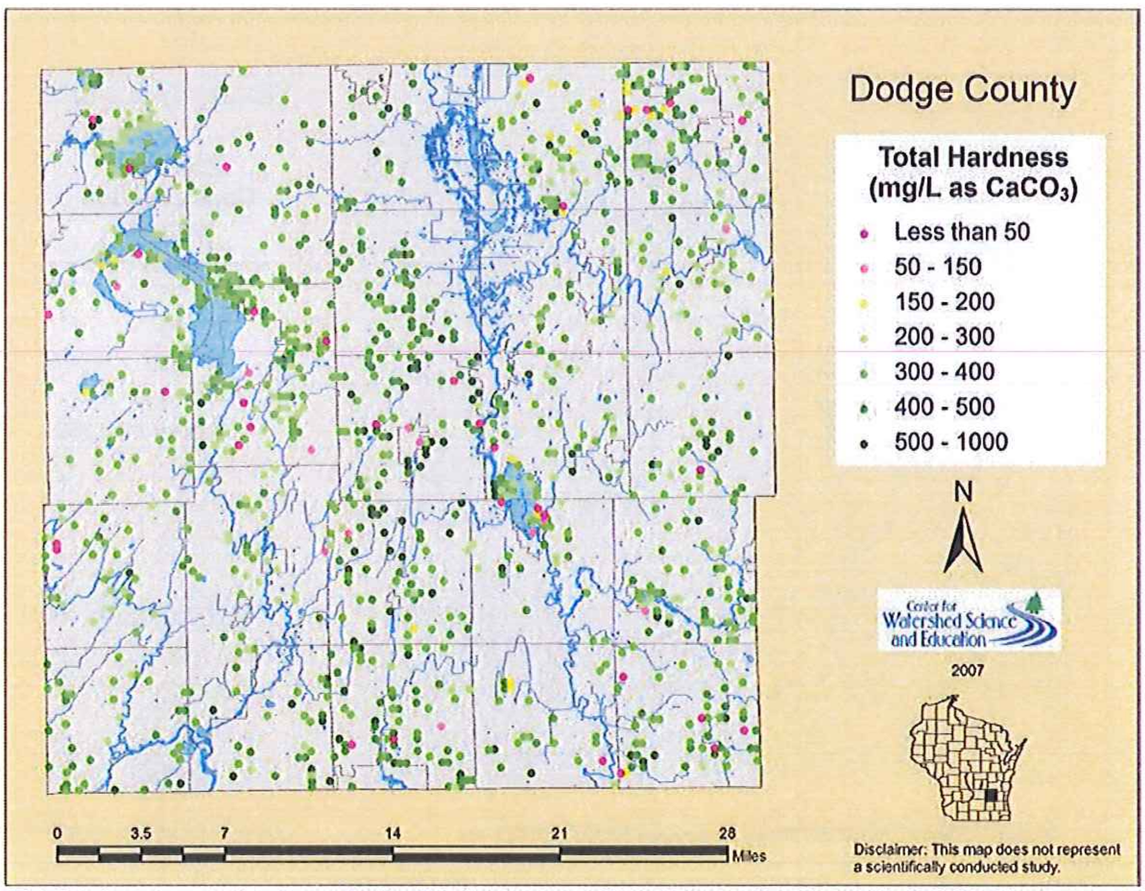
Total Hardness

Water hardness results when minerals, generally calcium and magnesium, dissolve naturally into groundwater from soil or limestone and dolomite rocks. There are no drinking water standards for hardness; however, high hardness is usually undesirable because it can cause lime buildup (scaling) in pipes and also in water heaters, which over time will decrease water heater efficiency. In addition, calcium and magnesium react with soap to form a "scum", decreasing the cleaning ability of the soap and increasing bathtub rings and graying of white laundry.

The ideal range for total hardness is typically between 150 and 200 mg/L or ppm $CaCO_3$. Water that is naturally low in calcium and magnesium (often referred to as soft water) may be corrosive. Soft water contains less than 150 mg/L of total hardness as $CaCO_3$.

Water that contains more than 200 mg/L $CaCO_3$ is considered hard. Water softeners are commonly used to reduce problems associated with hard water. The water softening industry measures hardness in grains per gallon. 1 grain/gallon = 17.1 mg/L $CaCO_3$.

Groundwater in Dodge County is generally hard with about 62% of all samples reporting hardness values above 200 mg/L $CaCO_3$. Hard water is typical of wells that are located in areas with dolomite bedrock. Many of the wells along lakes showed lower hardness values, likely the result of shallower wells pulling water from unconsolidated deposits. Some wells in the northeastern portion also show lower than average hardness. Some of these wells may be deep wells drilled into underlying sandstones. Water in the sandstone aquifer generally contains less calcium and magnesium than water from dolomite aquifers.



Total hardness concentrations from private well testing programs. Water that was softened was not included in this map. (1994-2006 data)

pH

The pH is a measure of the hydrogen ion (acid) concentration in water. A pH of 7 is neutral. Values above 7 are alkaline or basic; those below 7 are acidic. In Wisconsin pH is commonly found between 6.0 and 9.0.

Low values are most often caused by the lack of carbonate minerals such as limestone and dolomite in the aquifer. Some contaminant sources such as landfills or mine drainage may also lower pH.

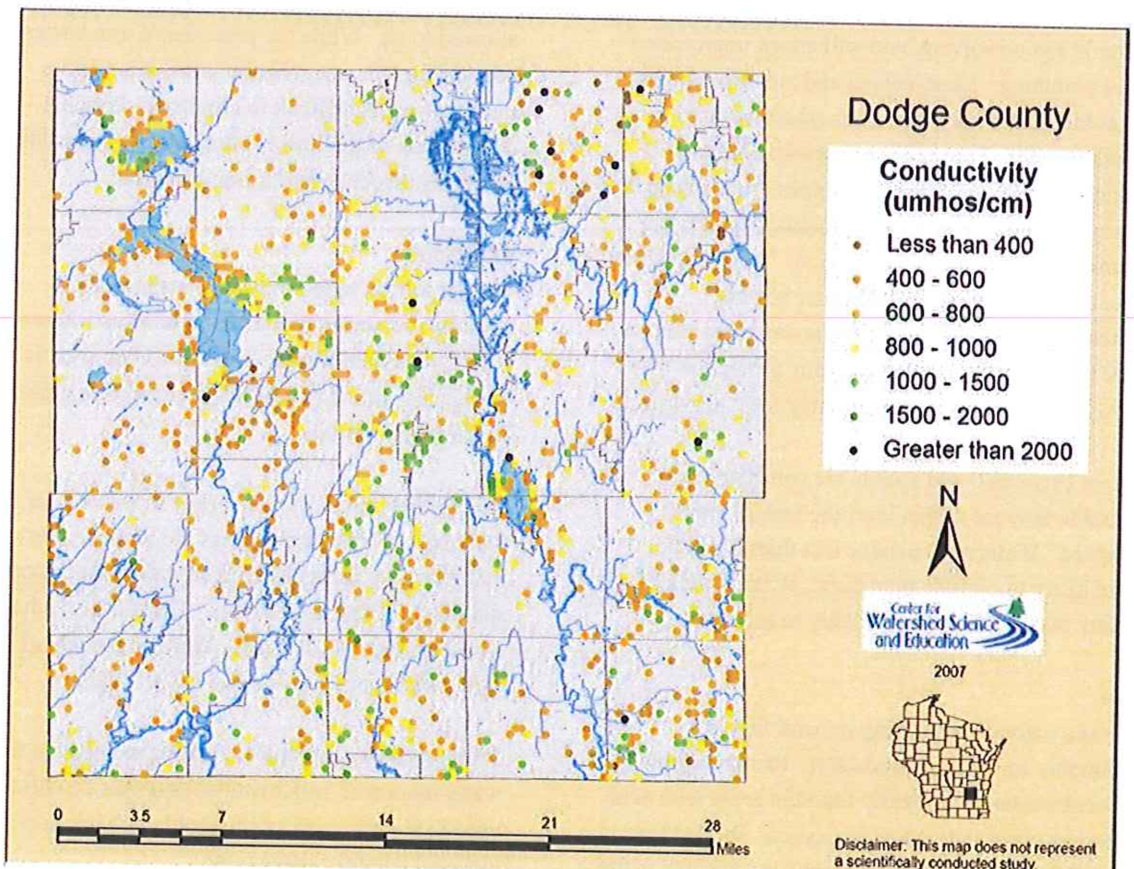
A change of 1 pH unit is a 10-fold change in acid level. Acidic water is often corrosive and can react with plumbing. The lower the pH value the more corrosive the water will be. It may be important to note that pH values are often slightly higher in the laboratory than at your well, because carbon dioxide gas (CO_2) leaves water when it is exposed to air. If corrosion is a problem, neutralizing filters can often be installed to counteract the effects of acidic water.

Alkalinity

Alkalinity is the measure of water's ability to neutralize acid, and is related to pH. Like total hardness, it results from the dissolution of carbonate minerals such as limestone and dolomite. Water that is low in alkalinity is more likely to be corrosive. Because it results from the dissolution of carbonate minerals, it is generally close to the hardness value. A lower alkalinity value could indicate significant amounts of other anions such as chloride or sulfate.

Conductivity

Conductivity (specific conductance) is a measure of the ability of water to conduct an electrical current. Conductivity is a test of overall water quality and is not a health concern. It is related to the amount of dissolved ions in water, the more dissolved ions in the water the greater the conductivity.



Conductivity results from private well testing programs. (1994-2006 data)

Typically calcium and magnesium represent the majority of dissolved ions in solution. As a result, conductivity (measured in μmhos/cm at 25° C) is about twice the hardness (mg/L $CaCO_3$) in most uncontaminated waters in Wisconsin. If the conductivity is much greater than twice the hardness, it may indicate the presence of contaminants such as sodium, chloride, nitrate, or sulfate, which may be human-influenced or natural. Changes in conductivity may indicate changes in water quality.

Saturation Index

The saturation index (SI) is a measurement used to determine the tendency of lime (calcium carbonate) to precipitate (form a solid and settle out) from water or for the water to corrode household plumbing. It is calculated from pH, alkalinity, calcium hardness and conductivity data. Water with a low pH, low alkalinity, and low hardness value will result in corrosive water. Water that is high in pH, alkalinity and hardness will likely produce scale.

Water is a good solvent, and will attack unprotected metal plumbing. Lead, copper and zinc from pipes and solder joints may then leach (dissolve) into drinking water. Symptoms of corrosive water include pinhole leaks in copper pipes or green stains on plumbing fixtures. Lime precipitate (scale) is a natural protection against corrosion. Too much scale, however, will plug pipes and water heaters, decreasing their efficiency. Water softeners prevent scale buildup, but also decrease any protection from corrosion the unsoftened water may have provided.

Values between 0 and 1 units are considered the most desirable because at this level the water is fairly balanced. Water with a value less than 0 will be more likely to corrode plumbing. Water with a SI greater than 1 will be more likely to form scale.

Iron

Iron is a naturally occurring mineral that is commonly found in groundwater. Increased iron concentrations are typically found in areas with acid waters or water that is low in oxygen. While there are no known health effects caused by drinking water that contains iron, concentrations greater than 0.3 mg/L are associated with aesthetic problems relating to taste, odor and color. Thirty-five percent of samples tested in Dodge County showed levels of iron exceeding the aesthetic limit.

Reddish-orange staining of bathroom fixtures and laundry can often be attributed to high levels of iron in the water. Low levels of iron can often be treated with a household water softener, which also eliminates problems associated with hard water, although using a water softener to remove iron is not recommended if your water is naturally soft. Iron removal can also be accomplished using aeration techniques or a permanganate water treatment system.

Taste and odor problems can be magnified by the presence of iron bacteria, which thrive in wells that have a high concentration of iron. Homes that have iron bacteria often first notice that the water smells like raw sewage or rotten eggs. People also report slimy water or report an oily sheen on water that is allowed to sit. While the presence of iron bacteria is not considered to be a health issue, it is often a nuisance and is difficult to eliminate. Periodic disinfection of the well is often used to control the problems associated with iron bacteria.

Manganese

Similar to iron in groundwater, manganese is naturally occurring and is found in areas where water is low in oxygen such as areas of wet or organic soils. Manganese found in groundwater can be a nuisance for aesthetic reasons.

The aesthetic limit of manganese in water is set at 0.05 mg/L. This is because of the tendency for manganese to form black precipitates that can cause staining of plumbing fixtures. There is also a health advisory level of 0.3 mg/L. Thirteen percent of the well tests reported levels above 0.05 mg/L.

While it can be difficult to remove manganese using water treatment, iron treatment systems can often be used to control some of the problems associated with elevated levels of manganese.

Summary

Even though it's often buried deep underground, and we can't see it, groundwater is one of Dodge County's most valuable natural resources. A clean and dependable supply of groundwater provides safe drinking water, supports a healthy economy, and maintains our lakes, rivers and streams. Unless people are willing to sacrifice any of these qualities, the community must be committed to managing groundwater resources wisely.

Groundwater is a local resource and is replenished by the rain and snow that infiltrate the soil. Many everyday activities that we do on the land surface have the potential to impact the quality and quantity of our groundwater resources below. While there are some naturally occurring contaminants, most of the unwanted chemicals in groundwater are a direct result of human activity. These activities can also affect lakes, rivers and wetlands, which are intimately connected to groundwater.

The more than 2,100 homeowners who had their private wells tested between 1994 and 2006 helped to create a better picture of current groundwater quality in Dodge County. Dodge County groundwater is generally characterized by having high hardness, a pH greater than 7.0, and high alkalinity. While the testing showed many private well provide drinking water that meets or exceeds drinking water standards, test results revealed that groundwater quality has been impacted to some degree by local land-use.

Results indicated that nearly 32% of all wells tested had concentrations of nitrate-nitrogen above 2 mg/L, an indication of local land-use impacts. Ten percent of all wells tested greater than the safe drinking water standard for nitrate-nitrogen. In addition, 21% of the wells tested positive for coliform bacteria and 21% of the wells that were tested for triazine reported detectable levels of this common corn herbicide.

Once groundwater becomes contaminated it is very difficult and costly to clean up, therefore minimizing the extent to which we contaminate groundwater should be the goal of everyone. As a result, communities will need to make wise choices when it comes to managing groundwater and making future land-use decisions. Local governments can only do so much however; everyone in Dodge County will need to make wise personal decisions when it comes to their individual actions that involve using groundwater or making land-use decisions on their property that will potentially affect this underground resource. Groundwater is truly a community resource and every one of us has a critical part to play in protecting groundwater for future generations.

Controlled burns are an important tool used by conservation professionals to manage ecosystems such as grasslands. Setting aside conservation areas can help to protect groundwater quality and quantity.

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Zaporozec, A. and R.D. Cotter. 1985. Major Ground-Water Units of Wisconsin. Wisconsin Geological and Natural History Survey.

Glossary

alluvium - Sediment deposited by flowing water, as in riverbeds, or floodplains.

aquifer - Water bearing geological formations that transmit and store water.

aquitard - A layer or section of the aquifer that impedes water movement.

cone of depression - When pumping water from a well, the water level adjacent to the well is lowered creating a cone where water has been pulled from the aquifer.

discharge area - Area where groundwater is discharged or returned to the earth's surface through springs, seeps, or baseflow.

evaporation - Process by which water changes from a liquid to a gas.

geology - The scientific study of the origin, history, and structure of the earth.

groundwater - Water contained in the empty spaces between soil particles and rock materials below the surface of the earth.

high capacity well - A well that pumps more than 100,000 gallons of water per day.

hydrologic cycle - Also referred to as the water cycle, explains how water is constantly in a state of movement through the environment.

irrigation well - A well that pumps water for the sole purpose of watering crops.

karst topography - An area where bedrock is easily dissolved by water. Generally characterized by connecting cracks and layers between rocks that easily transport water and pollutants to groundwater.

municipal water system - water system owned by a city, village, county, town, federal or state institution; town sanitary district, utility district, public inland lake/rehabilitation district, municipal water district for care or correction, or a privately owned utility serving the foregoing.

point-of-entry - A whole house water treatment system; treats water as it enters the house.

point-of-use - A water treatment system that treats a small amount of water at a particular faucet, typically supplies enough water only for drinking and cooking.

pollutant - A waste material that contaminates soil, air, or water.

recharge area - Area on the land surface where precipitation is able to infiltrate into the soil and percolate down to the saturated zone of an aquifer.

transpiration - The emission of water vapor through the leaves of plants.

water table - Level below the surface of the earth where groundwater exists; separates the saturated zone from the unsaturated zone.

watershed - Area of land that contributes water to a water body through surface water runoff or groundwater.

well - A vertical excavation that extends into a liquid bearing formation. In Wisconsin, wells are drilled to obtain water, monitor water quality, and monitor water levels.

well abandonment – Process of sealing a well that is no longer in use. Unused wells represent a direct conduit to groundwater.

well casing - Metal lining along the inside of a well that prevents unconsolidated material from falling into the well; also controls the part of the aquifer a well receives water from.

Additional Groundwater Resources

- For copies of **WI Department of Natural Resources (DNR)** publications please call **(608)266-0821** or visit http://www.dnr.state.wi.us/org/water/dwg/pubbro.htm.
- For copies of **UW-Extension (UWEX)** publications please call **(877)947-7827** or visit http://www.uwex.edu/ces/.
- The **Wisconsin Geological and Natural History Survey (WGNHS)** has many excellent geology and groundwater resources including maps available from their office. If interested call **(608)263-7389** or for a complete listing visit their website at http://www.uwex.edu/wgnhs/pubs.htm.

Teaching Resources

- **Wisconsin's Groundwater Study Guide**. A curriculum development guide primarily for 6th to 9th grade earth science teachers. Adaptable to older and younger students and informal education settings. For a copy call **(877)268-WELL** or visit http://dnr.wi.gov/org/water/dwg/gw/educate.htm.
- **Groundwater Flow Demonstration Model**. Over the years this two-dimensional model has effectively demonstrated basic groundwater concepts to both children and adult audiences. Offering a glimpse underground, concepts such as groundwater flowpaths, leaking landfills, cones of depression, and groundwater surface water connections are brought to life. For information on ordering a model call **(715)346-4613** or to borrow a model call **(715)346-4276** for a list of available models.

Groundwater Publications

- **Groundwater: Protecting Wisconsin's Buried Treasure.** DNR. PUB-DG-055-06. An easy to read full-color magazine designed to help people learn more about their groundwater resources, what it is used for, common threats, and groundwater protection.
- **Answers to Your Questions about Groundwater**. DNR. PUB DG-049 2003. Answers to many of the common concerns and misconceptions that the average person has about groundwater.
- **Better Homes and Groundwater**. DNR. PUB-DG-070 2004. Easy to do activities to perform in our own backyards to improve and protect the quality of our groundwater resources.
- **Answers to Your Questions on Well Abandonment**. DNR. PUBL-DG-016 2004. This brochure explains the importance of abandoning unused wells to protect groundwater quality and covers procedures for abandoning wells properly.
- **Wellhead Protection: An ounce of prevention…** DNR. PUB-DG-0039 99REV. Brief description of the importance of wellhead protection and initial steps for protecting community water supplies.
- **A Growing Thirst for Groundwater**. DNR. 2004. This article in WI Natural Resources Magazine looks at the rising issue of groundwater quantity in Wisconsin. It also identifies steps which have recently been taken to ensure that there is enough groundwater for our homes and businesses, as well as our state's lakes, rivers, and wetlands. http://www.wnrmag.com/stories/2004/jun04/ground.htm
- **GCC Directory of Groundwater Databases**. DNR. PUB-DG-048 1998. This document from the Wisconsin Groundwater Coordinating Council provides a listing of groundwater related information maintained in computerized and non-computerized databases.

Groundwater Policy

- **Wisconsin Groundwater Coordinating Council Report to the Legislature.** GCC. The Groundwater Coordinating Council is required by s. 15.347, Wis. Stats., to prepare a report which "summarizes the operations and activities of the council..., describes the state of the groundwater resource and its management and sets forth the recommendations of the council.
  Download at http://www.dnr.state.wi.us/org/water/dwg/gcc/Pubdwnld.htm
- **Well Water for Rural Residential Subdivisions: Using groundwater flow models to evaluate options for water supply.** UWEX. 2007. Explores the use of computer groundwater flow models to help communities make informed decisions regarding well construction and placement for rural residential subdivision design.
- GCC Comprehensive Planning and Groundwater Fact Sheets.
  Download at http://www.dnr.state.wi.us/org/water/dwg/gcc/Pubdwnld.htm
  - **Groundwater and its Role in Comprehensive Planning.** GCC. Fact Sheet 1. 2002. This informational sheet provides a basic explanation of what groundwater is and why it is an important consideration when preparing comprehensive plans for local governments.

- **Resources to Help You Protect Your Drinking Water Supply.** GCC. Fact Sheet 2. 2002. This informational sheet identifies state resources available to help communities protect drinking water supplies.
- **Residential Development and Groundwater Resources.** GCC. Fact Sheet 3. 2002. This informational sheet identifies potential considerations of the effects of residential development on groundwater resources and also offers suggestions on how to minimize those impacts.

Drinking Water Publications

- **You and Your Well**. DNR. PUB-DG-002 2003. Basic information and requirements for a properly constructed well.
- **Do Deeper Wells Mean Better Water?** UWEX. G3652. This brochure explores different well construction terminology and explains how well depth can affect water quality.
- **Tests for Drinking Water from Private Wells**. DNR. PUBL-DG-023-04REV. Advises private well owners on the tests and frequency that should be performed on their well to ensure safe drinking water.
- **Choosing a Water Treatment Device**. UWEX. G3558-5. Describes the most common water treatment devices for home use and lists contaminants that each is capable of removing.
- **Bacteriological Contamination of Drinking Water**. DNR. PUB-DG-003-2000. Explains how wells become contaminated with bacteria, how to test for it, and how eliminate bacteria in your well.
- **Improving Your Private Well Water Quality**. UWEX. G3826. This brochure explores ways to improve your private well water quality. Lists common water quality problems or contaminants and describes common approaches to improve water quality, including common water treatment technologies.
- **Lead in Drinking Water**. DNR. PUB-DG-015 2003
- **Copper in Drinking Water**. DNR. PUB-DG-027 2003
- **Arsenic in Drinking Water**. DNR. PUB-DG-062 2006
- **Pesticides in Drinking Water**. DNR. PUB-DG-007 2002
- **Radium in Drinking Water**. DNR. PUB-DG-008 2002
- **Nitrate in Drinking Water**. DNR. PUB-DG-001 2004
- **Volatile Organics in Drinking Water**. DNR. PUB-DG-009 00
- **Iron in Drinking Water**. DNR. PUB-DG-035 01REV
- **Radon in Private Well Water**. DNR. PUB-DG-036 2004
- **Iron Bacteria Problems in Wells**. DNR. PUBL DG-004 2005
- **Sulfur Bacteria Problems in Wells**. DNR. PUBL-DG-005 99 Rev

Useful Websites

Dodge County. Government information source for Dodge County listing services offered through county government and contact information. http://www.co.dodge.wi.us/

Dodge County Land and Water Conservation Department. Under the direction of the Dodge County Land and Water Conservation Committee of the Dodge County Board of Supervisors, the Land and Water Department works to promote sustainable land use management for long-term conservation of land, water and other natural resources. http://www.co.dodge.wi.us/conservation/landserv.html

Groundwater Center. Helping citizens and governments manage the groundwater in Wisconsin wisely, through education, public information, applied research, and technical assistance. http://www.uwsp.edu/cnr/gndwater/

Wisconsin Geological and Natural History Survey. Provide objective scientific information about the geology, mineral resources, water resources, soil, and biology of Wisconsin. Communicate the results of our activities through publications, technical talks, and responses to inquiries from the public. http://www.uwex.edu/wgnhs/index.html

Wisconsin Department of Natural Resources

- **Drinking and Groundwater Section.** Working to safeguard Wisconsin drinking water and groundwater now and in the future. http://www.dnr.state.wi.us/org/water/dwg/
- **Bureau for Remediation and Redevelopment Tracking System.** Allows you to find information on incidents that contaminated soil or groundwater in your area. http://botw.dnr.state.wi.us/botw/Welcome.do

Dodge County Well Testing Summary (1988 - 2007)

Nitrate-Nitrogen (mg/L)		
Range	n	%
None Detected	963	47
0.1 - 2.0	444	22
2.0 - 5.0	193	9
5.0 - 10.0	265	13
10.0 - 20.0	177	9
> 20.0	15	1

Total Hardness (mg/L $CaCO_3$)		
Range	n	%
None Detected	122	6
2.0 - 25.0	56	3
25 - 50	7	0
50 - 150	14	1
150 - 200	27	1
200 - 300	200	10
300 - 400	684	34
400 - 500	731	36
> 500	200	10

Conductivity (umhos/cm)		
Range	n	%
< 50	2	0
50 - 100	3	0
100 - 200	1	0
200 - 500	110	5
500 - 800	1113	55
800 - 1000	533	26
> 1000	278	14

pH		
Range	n	%
< 5.0	0	0
5.0 - 5.5	1	0
5.5 - 6.0	0	0
6.0 - 6.5	1	0
6.5 - 7.0	8	0
7.0 - 7.5	154	8
7.5 - 8.0	1390	68
8.0 - 8.5	481	24
> 8.5	6	0

Saturation Index		
Range	n	%
< (-3.0)	1	0
(-3) - (-2)	6	0
(-2) - (-1)	86	4
(-1) - 0	88	4
0 - 1	1410	69
>1	447	22

Chloride (mg/L)		
Range	n	%
None Detected	50	2
0.5 - 10.0	497	24
10.0 - 25.0	442	22
25.0 - 50.0	563	28
50.0 - 100	332	16
100 - 200	119	6
> 200	41	2

Alkalinity (mg/L $CaCO_3$)		
Range	n	%
None Detected	1	0
2.0 - 25.0	1	0
25 - 50	4	0
50 - 150	19	1
150 - 200	18	1
200 - 300	548	27
300 - 400	1329	65
400 - 500	111	5
> 500	10	0

Triazine (ug/L)		
Range	n	%
None Detected	325	79
0.1 - 0.3	69	17
0.3 - 1.0	13	3
1.0 - 3.0	3	1
> 3.0	0	0

Coliform Bacteria		
Range	n	%
Positive	451	21
Negative	1697	79
E.coli Positive		

Calcium (mg/L)		
Range	n	%
None Detected	10	2
0.1 - 25	100	22
25 - 50	33	7
50 - 200	293	66
> 200	11	2

Magnesium (mg/L)		
Range	n	%
None Detected	21	5
0.1 - 10	85	19
10.0 - 40.0	100	22
40.0 - 100	241	54
> 100	0	0

Iron (mg/L)		
Range	n	%
None Detected	20	4
0.002 - 0.3	280	61
0.3 - 1.0	73	16
> 1.0	85	19

Copper (mg/L)		
Range	n	%
None Detected	69	15
0.001 - 0.13	248	55
0.13 - 1.3	128	28
> 1.3	8	2

Sodium (mg/L)		
Range	n	%
None Detected	0	0
0.1 - 10.0	141	31
10.0 - 30.0	138	31
30.0 - 100	51	11
> 100	118	26

Potassium (mg/L)		
Range	n	%
None Detected	30	7
0.3 - 5.0	316	71
5.0 - 10.0	50	11
10.0 - 50.0	36	8
> 50.0	15	5

Zinc (mg/L)		
Range	n	%
None Detected	16	4
0.001 - 0.1	256	57
0.1 - 1.0	144	32
1.0 - 5.0	29	6
> 5.0	5	1

Manganese (mg/L)		
Range	n	%
None Detected	100	22
0.001 - 0.05	295	65
0.05 - 0.2	48	11
0.2 - 1.0	8	2
> 1.0	0	0

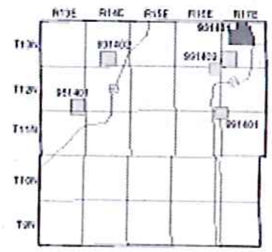
Lead (mg/L)		
Range	n	%
None Detected	253	54
0.002 - 0.015	180	39
0.015 - 0.05	25	5
0.05 - 0.1	6	1
> 0.1	2	0

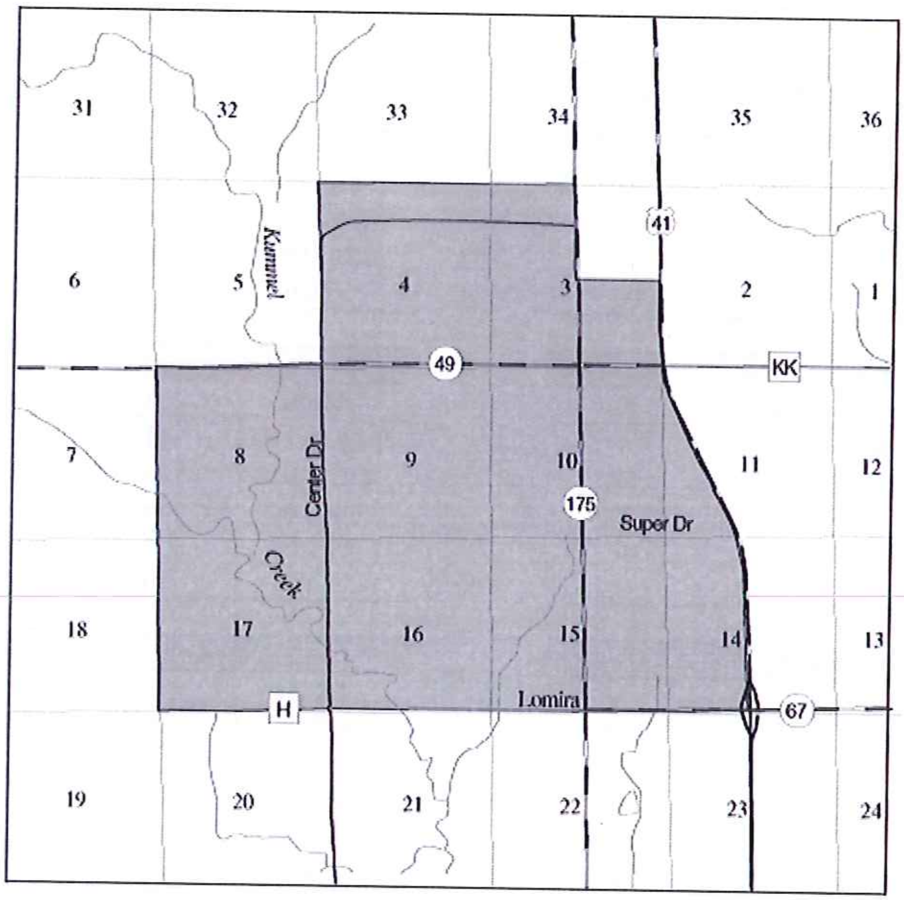
Arsenic (mg/L)		
Range	n	%
None Detected	296	89
0.005 - 0.012	32	10
0.012 - 0.05	5	2
0.05 - 0.1	0	0
> 0.1	0	0

Sulfate (mg/L)		
Range	n	%
None Detected	1	0
0.1 - 20	20	6
20 - 100	251	77
100 - 250	32	10
> 250	22	7

Dodge County
Town of Lomira
T13N R17E **PA 93-14-01**

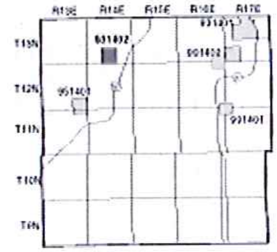
All uses of atrazine prohibited on lands within the shaded regions.
There are five prohibition areas in Dodge County.
Refer to each map for specific locations.





Accessed Online July 18, 2007
http://datcp.state.wi.us/arm/agriculture/pest-fert/pesticides/atrazine/county-maps/dodge/index.jsp

Dodge County
Town of Trenton
T13N R14E **PA 93-14-02**



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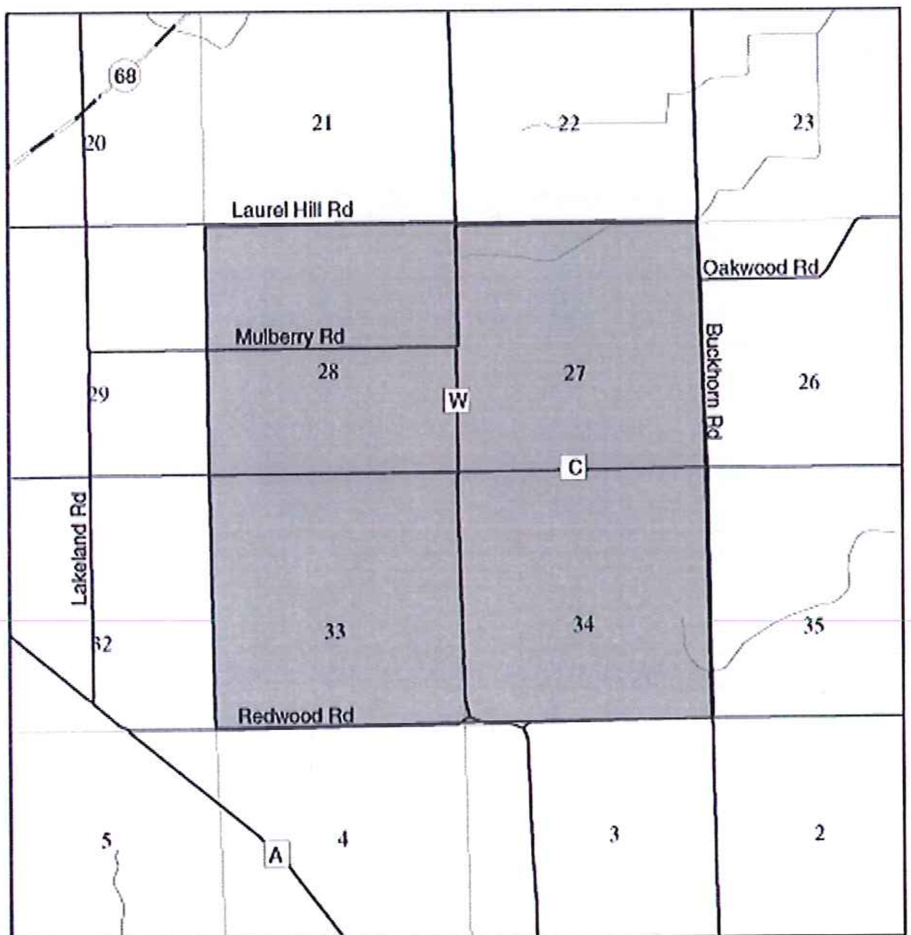
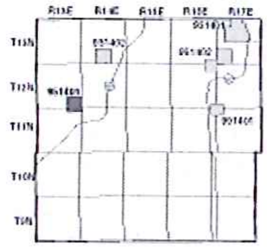
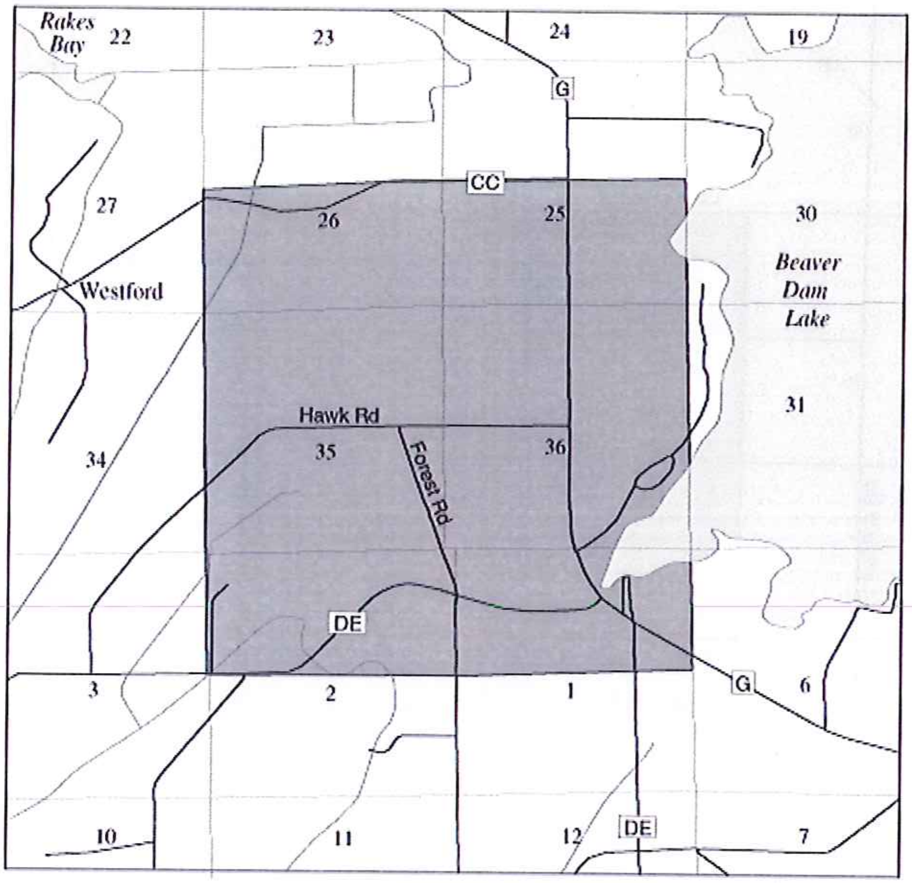


Accessed Online July 18, 2007
http://datcp.state.wi.us/arm/agriculture/pest-fert/pesticides/atrazine/county-maps/dodge/index.jsp

Dodge County
Town of Calamus & Westford
T11-12N R13 E **PA 95-14-01**

All uses of atrazine are prohibited on lands within the shaded regions. There are five prohibition areas in Dodge County. Refer to each map for specific locations.

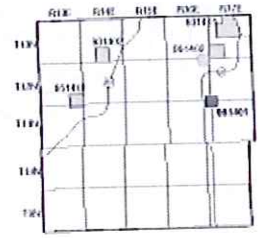


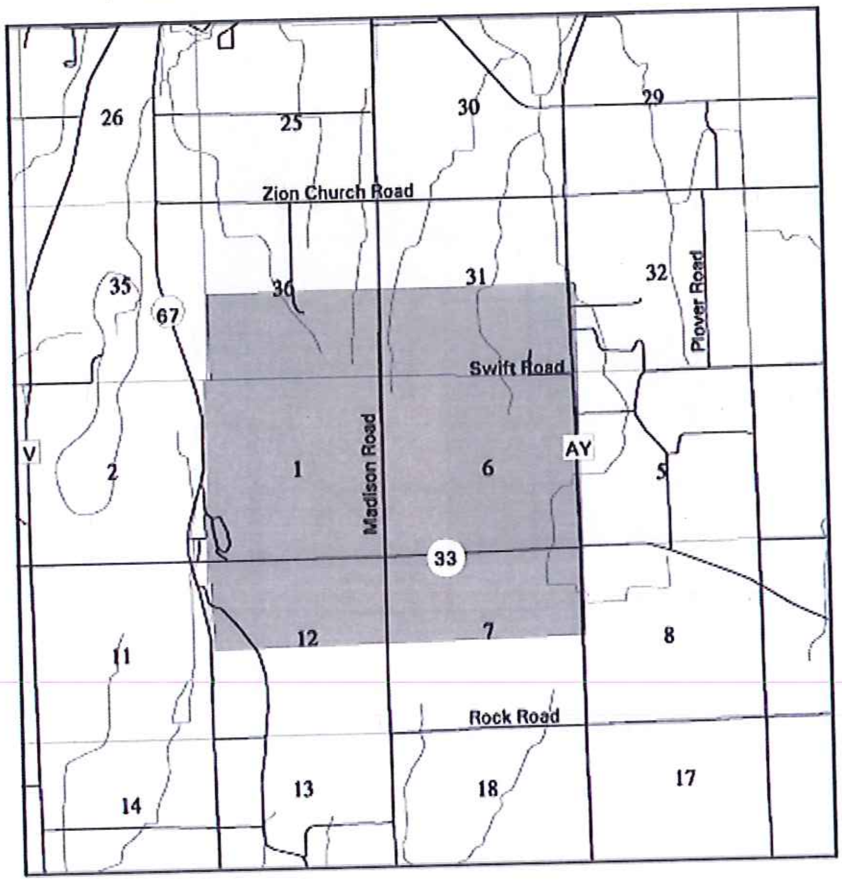


Accessed Online July 18, 2007
http://datcp.state.wi.us/arm/agriculture/pest-fert/pesticides/atrazine/county-maps/dodge/index.jsp

Dodge County
Towns of Herman, Hubbard, Theresa, and Williamstown
T11-12N R16-17E **PA 99-14-01**

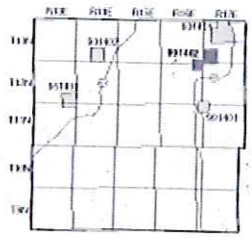
All uses of atrazine are prohibited on lands within the shaded regions. There are five prohibition areas in Dodge County. Refer to each map for specific locations.





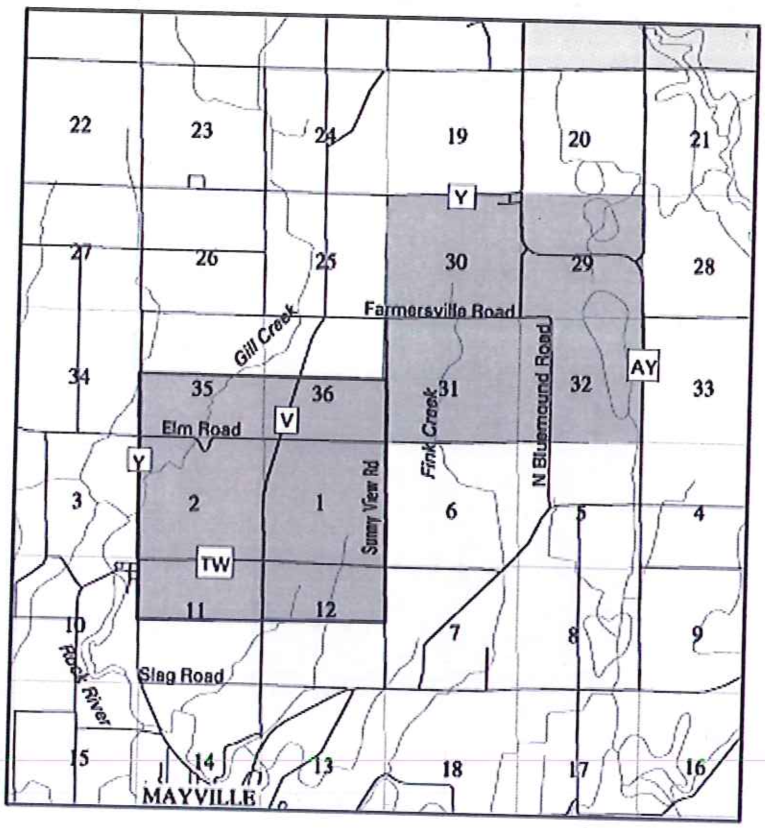
Accessed Online July 18, 2007
http://datcp.state.wi.us/arm/agriculture/pest-fert/pesticides/atrazine/county-maps/dodge/index.jsp

Dodge County
Towns of Leroy, Lomira, and Williamstown
T12-13N R16-17E **PA 99-14-02***



All uses of atrazine are prohibited on lands within the shaded regions. There are five prohibition areas in Dodge County. Refer to each map for specific locations.

*Note: This PA is an expansion of PA 96-14-01



Accessed Online July 18, 2007
http://datcp.state.wi.us/arm/agriculture/pest-fert/pesticides/atrazine/county-maps/dodge/index.jsp