WATER QUALITY IN DANE COUNTY

Overview, current challenges, and recommendations

JULY 2017

Public Health
MADISON & DANE COUNTY
Healthy people. Healthy places.

INTRODUCTION

Access to quality drinking water resources is an essential necessity for the stability and welfare of our communities. As the recent water crisis in Flint, Michigan vividly demonstrated, limited access to quality drinking water quickly and directly impacts the health of exposed residents, erodes the public trust, and threatens the economic vitality of impacted areas.[1] Therefore, due to the far reaching implications of drinking water quality on individual and community health, access to healthy water resources should be viewed through the lens as an unquestionable human right and protected with due diligence.

Human activity and land use practices can heavily impact the delicate balance of the natural water cycles (i.e. hydrologic cycle) that support ground and surface water systems in which communities rely for drinking water, industry, and recreation (Figure 1). This impact can directly influence the availability of water resources and introduce contaminants that can degrade the quality of drinking water and increase the likelihood of adverse health outcomes to exposed populations.[2-5]

A variety of factors independent of the hydrologic cycle can also impact drinking water quality.[3, 5-9] This degradation of quality can be from the direct contamination of ground water resources but can also result from the delivery of water to the consumer via aging water system infrastructure and poor quality household piping that can leach contaminants into the water. Everyone is not exposed to the contamination equally; potential disparities in the availability of quality drinking water may result in unduly burdening of minority and low-income communities. In other words, the risk of waterborne disease and poor drinking water quality is typically not random and usually preventable.[3, 6-8]

CONTENTS

Drinking Water Quantity & Quality

Current Water Quality Challenges in Dane County

Regulations & Standards

Sustainability of Resources

Recommendations & Investment

DRINKING WATER QUANTITY & QUALITY

HOW THE WATER CYCLE WORKS

The water cycle consists of circulation of moisture between the surface waters, atmosphere, and land that allows for the recharging of ground water resources.[2,4-5] Ground water is a renewable resource when the rate of water discharge from pumping and natural outflow does not exceed the rate of ground water recharge.[4]

Contamination of drinking water resources can result from a variety of man-made and natural sources. The geologic and hydrologic conditions encountered by the ground water play a key role in both the infiltration and recharge of water drawn into the aquifer but also leaching of contaminants, including manganese, arsenic, hexavalent chromium, radium and uranium from the rock and soils. Excessive pumping of water for drinking water, agricultural, and industrial uses can jeopardize the lifespan of the water resource and accelerate the release of naturally occurring drinking-water contaminants from the surrounding geology.

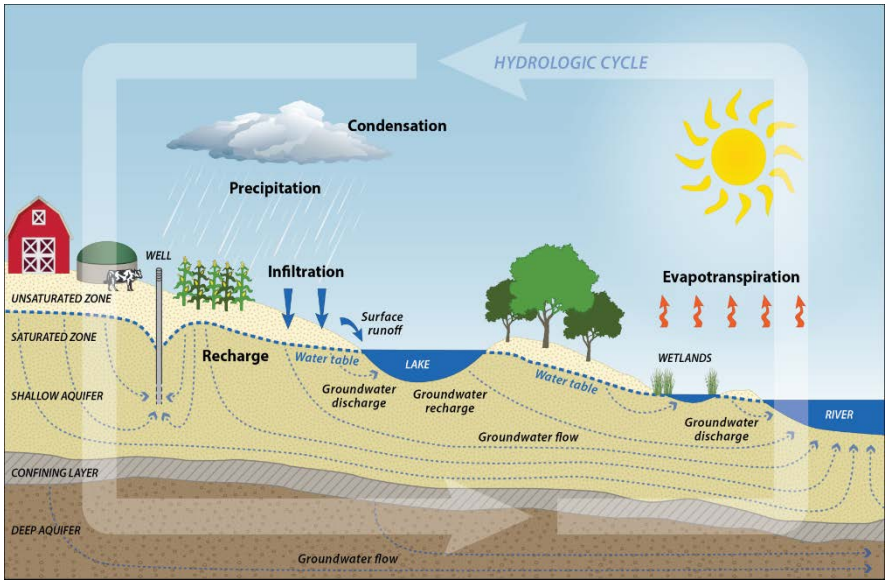

Figure 1. Hydrologic Cycle
Bruce, J.L. (2015). *Hydrologic Cycle*. U.S. Geological Survey,

In addition to pumping, land use practices, urban development, and industrial processes greatly contribute to the degradation of ground and surface water resources if appropriate monitoring, regulation, and control efforts are not followed. These sources can introduce unacceptable levels of heavy metals, polychlorinated biphenyls (PCBs), volatile organic compounds (VOCs), bacteria, viruses, and/or other potential contaminants into Dane County drinking water supplies.[3] Weather events including heavy rains, winter snow melt, and flooding can exacerbate the contamination of ground and surface water resources from both natural and man-made sources.

Examples of potential man-made sources of contamination to drinking water in Dane County:

- Road salt use and storage – chloride and sodium
- Homes and businesses built prior to 1978 –pipes, solder, fixtures, and interior and exterior paints containing lead
- Fertilizer, animal waste, and/or pesticide application and storage – pathogens, nitrates and pesticides
- Dry cleaning sites – chlorinated VOCs
- Industry – PCBs and VOCs
- Petroleum/ fuel storage tanks – petroleum hydrocarbons
- Gas stations and motor vehicle repair – VOCs, heavy metals, and PCBs
- Municipal sewer lines/ septic tanks or sewage storage – Pathogens (bacteria, protozoa and viruses)
- Disinfection byproducts -VOCs
- Natural sources – radium, hexavalent chromium (Cr^{+6})

PRIVATE WELLS & WATER QUALITY

Private wells are particularly vulnerable to contamination, compared to municipal wells, due to more shallow well depth.[3] The absence of regulatory testing requirements of private wells can also contribute to the potential difference in water quality compared to Dane County residents served by municipal wells.

The most common contaminants degrading private well water quality include many naturally occurring chemicals including arsenic, chromium, radon, and uranium. Contamination from nearby residential, industrial, commercial, and agricultural areas also contribute to degraded drinking water resources from the use of fertilizers and pesticide and the presence of livestock, animal feeding operations, bio-solid applications, manufacturing processes and spills, sewer overflows, and waste water treatment systems.[3,6]

Water from private wells should be tested annually and after flooding events to monitor for harmful contaminates.

Water testing is essential to evaluating the quality of private wells and identifying potential contamination to protect the safety of individuals consuming the water from this source. However, despite the essential need to monitor water quality in private wells, several barriers deter this needed testing including, but not limited to, lack of knowledge of testing recommendations by state and local health departments, limited understanding of potential

health consequences, language barriers, cost of testing, and fear of changes in property value and additional treatment and/or repair costs that may follow testing. Individually and cumulatively, these barriers to private well monitoring influence the likelihood of reduced water quality and increased risk of disease development from exposure to elevated levels of harmful contaminants. The Wisconsin Department of Natural Resources (WI DNR) recommends that private wells should be tested annually; especially after flooding events due to an elevated risk of well water contamination caused by the weather event.[3, 6]

If a private well is the source of the drinking water to your home please review the following websites for additional information about testing recommendations and kit availability, results, and well maintenance and disinfection (if needed):

- http://www.publichealthmdc.com/environmental/wells/
- http://dnr.wi.gov/topic/wells/privatewelltest.html

CURRENT WATER QUALITY CHALLENGES IN DANE COUNTY

LEAD

Exposure to lead in the drinking water can lead to neurological and behavioral disorders in children and adolescents that include learning disabilities, behavioral problems, impaired hearing, lowered attention span, and sleeping disorders. Children under the age of 6 years of age are particularly at risk due to the rapid brain development during this formative time period that can be adversely impacted by exposure to this neurotoxin.[3, 7, 9] Although most exposures in this sensitive population occur from lead paint chips and contaminated dust and soil, significant exposures can also occur from drinking water. Large scale exposures to contaminated drinking water, as was shown in Michigan, can devastate an entire community.[1] Regardless of the route of exposure, childhood lead poisoning can result in mental and behavioral challenges that can have life-long consequences by impacting

educational attainment, employment opportunities, and socioeconomic status that can have generational implications.[7, 9]

The exposures to lead and many other contaminants demonstrate significant disparities in regards to the populations exposed, levels of exposure, and duration and frequency of exposure(s). Typically, disparities of exposure are associated with a variety of potential variables that increase risk of exposure such as the age and quality of housing, socioeconomic status, proximity to agricultural and/or industrial operations, and source of drinking water (e.g. municipal or private well, lakes). In the case of lead, contamination of drinking water could occur due the water delivery via older lead-containing service lines, improper or lack of treatment of drinking water with naturally occurring or man-made sources of lead, and leaching from lead containing water pipes and/or lead-containing fixtures or solders found in homes built before 1986 when the Safe Drinking Water Act (SDWA).[3-5, 7, 9-11] Homes built prior to the ban of lead-containing household paints in 1978 may contain lead paint and lead contaminated dust exposure hazards; this lead exposure risk is especially true for homes built prior to 1950 when lead containing indoor paints were widely used. [3-5,7, 9]

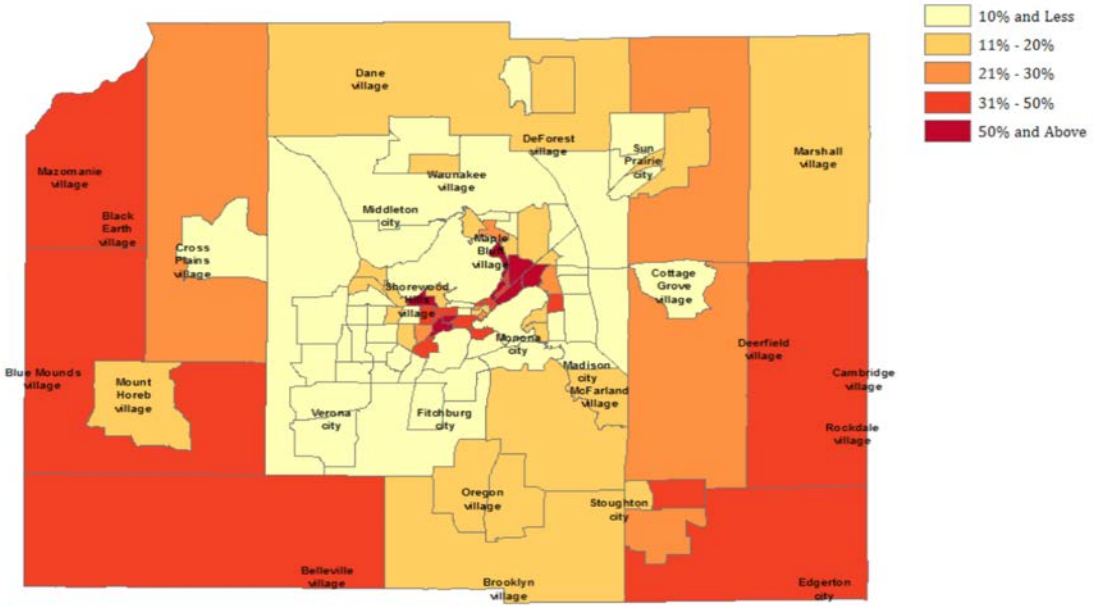

Figure 2. Dane County homes built prior to 1950
Data provided by the United States Census Bureau

In the City of Madison, both public and most private portions of the lead service lines have been replaced following a decade long effort that was completed in 2011; the first city in the United States to complete this monumental task and remove the source of drinking water contamination.[11] Other communities in Dane County have not replaced drinking water service lines that continue to pose a potential contamination threat to residents. Despite this effort by the City of Madison, it does not eliminate potential exposure from lead-containing plumbing fixtures and corroding pipes in older homes; another significant source of lead in drinking water supplies. This is a challenge throughout Dane County with the largest density

of older homes found on and around the isthmus area of the City of Madison and rural areas around the county, creating potential disparities in drinking water quality consumed by Dane County families; typically affecting individuals and families with a lower level of socioeconomic status.

NITRATE & PESTICIDES

Application of fertilizers in agricultural areas greatly contributes nitrogen into Dane County drinking water. Nitrate continues to pose a long-term threat to drinking water quality in our communities due to the potential impacts to exposed populations; excess nitrate in the body can interfere with the oxygen-carrying potential of blood in exposed children leading to anoxia or "blue baby syndrome" (methemoglobinemia) in infants as well as other possible adverse human health outcomes. Data provided by the WI DNR indicated that roughly 20% of private samples compared to approximately 5% of municipal samples have shown high levels of nitrate, above the state and federal public drinking water standard of 10 mg/L nitrate established for public water systems. Many of these private well samples also test positive for coliform bacteria; a further demonstration of the potential disparity between the quality of water between private or public well water supplies and past land use practices of the community.[3]

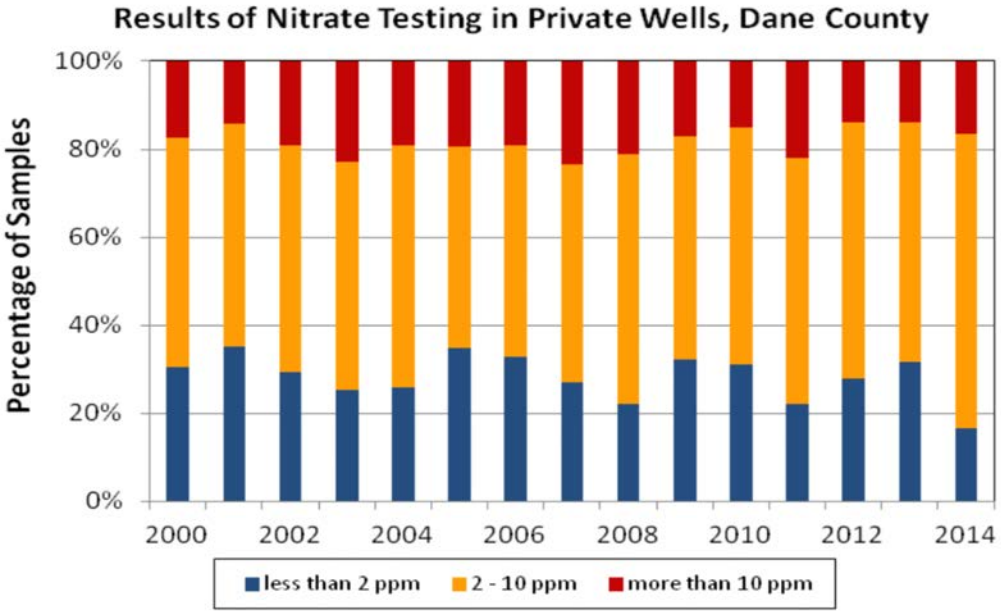

Figure 3. Private well nitrate levels
Data provided by WI Department of Natural Resources

The United States Environmental Protection Agency (US EPA) along with WI DNR is responsible for ensuring the safety of public drinking water resources but does not regulate private wells. Therefore, the voluntary testing of these wells is an imperative to maintain quality drinking water and protect the health of individuals using a private well as a primary drinking water source. This is especially the case in shallow wells located in agricultural areas

with high fertilizer applications. As shown in the figure below, there are strong and consistent spatial patterns in average nitrate concentrations that reflect the density of agricultural activity across Dane County with the highest levels reported in the eastern portion and high areas in the landscape of the county, north of Lake Mendota, and the south-central areas of the county. These are also the areas of Dane County were the highest density of agricultural land use occurs. Lower groundwater nitrate concentrations are particularly evident in the more forested northwestern part of the county and near surface water features.[14]

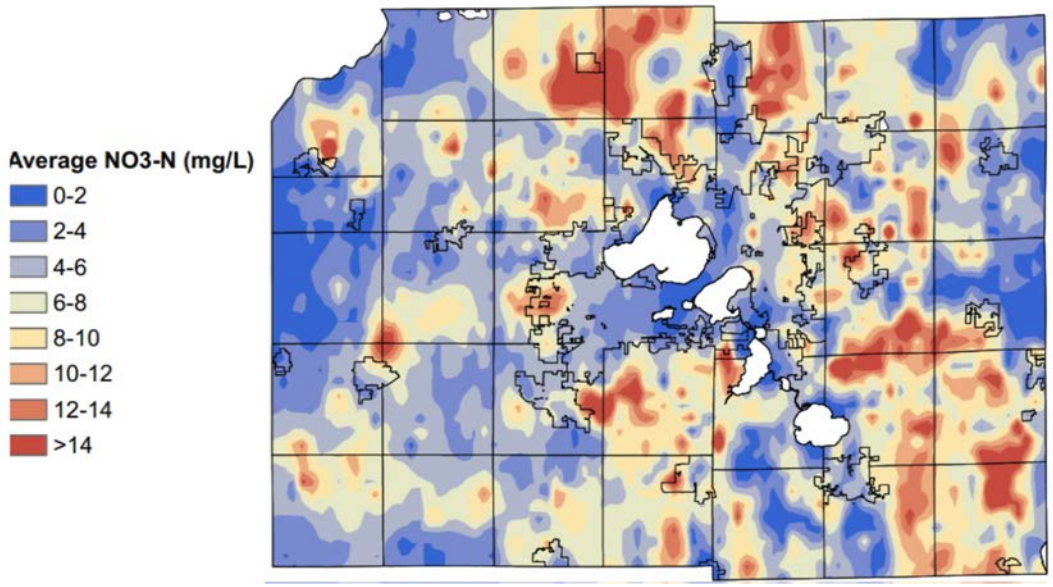

Figure 4. Distribution of nitrate concentrations in Dane County shallow wells[4]

In addition to nitrate, shallow private wells situated adjacent to agricultural areas also have the highest risk of pesticide contamination. Based on application schedules, the levels of pesticides in drinking water can often vary widely from month to month and from season to season.[15] Similar to the rest of the state, the main source of pesticides in groundwater in Dane County is agricultural herbicide and insecticide application; only around 30 of the over 90 different pesticides used on Wisconsin crops have health-based enforcement standards in groundwater. Among the pesticide with enforceable ground water standards, atrazine, alachlor, and their metabolites are commonly detected in private wells in agricultural areas.[16] Dane County is currently in a prohibition area for atrazine which has resulted in declines in its levels.

CHLORIDE AND SODIUM

Over six decades of road salt application has resulted in significant increases in chloride and sodium levels in area groundwater resources. Although the levels are not yet a human health hazard, a continued increase will degrade the aesthetic quality of Dane County drinking water.[3, 17]

Average annual chloride levels in all City of Madison municipal wells have doubled in the last 20 years but not equally among the individual wells; currently, five wells have the highest reported levels of chloride in the City of Madison[3]. It is notable, that chloride is present in one well (well 14) at 125 mg/L, half of the secondary drinking water quality standard. The natural background level of chloride is only a few mg/L.[16] Chloride levels continue to increase in some of the city wells that draw water from both the upper and lower aquifers near main traffic thoroughfares.

The figure below compares past chloride concentrations in deeply cased wells, which draw water from the lower aquifer and wells with short casings, which draw water from both the upper and lower aquifers. The bisecting line represents the median concentration and the upper and lower edges of the box represent the 75th and 25th percentile, respectively. Shallow private wells near roadways are particularly vulnerable to road salt impacts. Public Health Madison & Dane County (PHMDC) laboratory has measured chloride levels ranging from 1.5 to 970 mg/L in Dane County private wells.

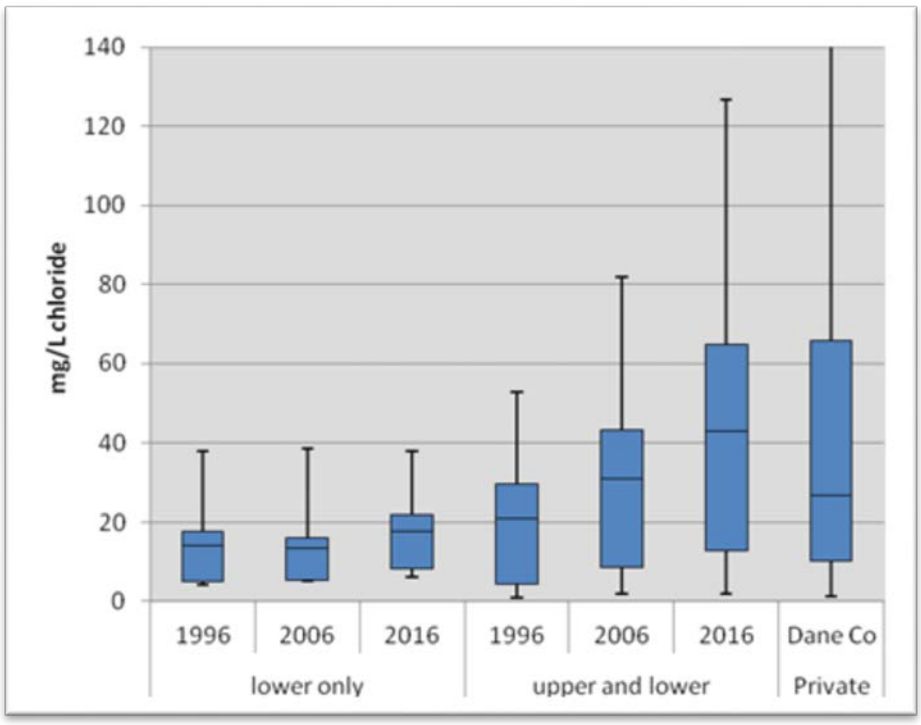

Figure 5. Chloride concentration trends in Madison municipal wells[17]

Road salt has also increased sodium in our drinking water, although at a slower rate than chloride. This elevation may increase sodium intake of municipal and private well water users. Although the majority of sodium is derived from food, increases in drinking water sodium may be problematic for individuals on restricted sodium diets if water consumption is not included in the sodium exposure calculation.[18] In Dane County, the average sodium content has risen from 6.5 mg/L to 12.0 mg/L in the past 20 years; current median and maximum levels are 7.9 mg/L and 41.7 mg/L, respectively.

Additional information concerning specific contaminants, including current data resources, sources of exposure, and potential health implications is available in the Madison and Dane County Environmental Health Report Card Series and the Dane County Road Salt reports.

http://www.publichealthmdc.com/publications/roadSalt.cfm

http://www.publichealthmdc.com/publications/envReportCard.cfm

BOTTLED WATER USE

In most cases, the reliance on bottled water as a replacement for tap water delivered from municipal wells and properly maintained and tested private wells is unnecessary in Dane County. Drinking water delivered via municipal systems are controlled by the strict standards established by the US EPA that regulate the production, distribution and quality of water including regulations targeting water source protection, operation of drinking water systems, contaminant levels, and reporting requirements.[19, 20] In comparison, bottled water is regulated by the United States Food and Drug Administration (US FDA) according to specific regulations designed to hold manufacturer's responsible for the production of safe consumer products. Although the US FDA has adopted several of the primary and secondary water standards established by the US EPA to protect drinking water quality, bottled water is not held to the same frequency of testing, priority of inspection, and strict reporting requirements as drinking water delivered from municipal water systems.[19] Therefore, despite the intense marketing campaigns of beverage companies, bottled water is not any safer than public drinking water unless there is a contamination event of public or private water delivery systems.[19 - 21]

Several considerations including cost, energy use, and environmental impacts of bottled water should be understood before choosing a bottled water product over tap water. Bottled water is considerably more expensive than tap water with an average wholesale cost of around $1.20 per gallon compared to the approximate cost of $0.01 for 5 gallons of tap water; equivalent to around 600 gallons for the cost of a gallon of bottle water.[21, 22] The retail cost of bottled water purchased from locations such as grocery stores, gas stations, food cart, or street vendor are typically much higher than wholesale cost for a smaller quantity leading to the cost savings of tap water to be more dramatic; overtime, this cost savings can become quite substantial.

Secondly, the pumping, processing, bottling, transportation, and disposal of bottled water products creates a sizeable carbon footprint due to the energy use and the production of greenhouse gas and toxic chemical emissions from plastic manufacturing and product transportation. In fact, according to a 2006 report, approximately 17 million barrels of oil is used per year to create the over 900,000 tons of plastics used to manufacture the bottles used by the bottled water industry; only around 35% of these bottles are actually recycled. The result is billions of plastic bottles enter our landfills or contribute to the garbage stream in our oceans that damage ecosystems and contributing to the creation of floating garbage islands.[21, 23 - 25]

It is also important to realize that despite the imagery of mountain streams and beautiful glaciers commonly found on bottled water packaging approximately 40 – 60% of these products are filtered, packaged tap water.[20, 21] Although the majority of bottled water products are produced and distributed on a regional scale, the removal of community drinking water resources for bottling purposes increases the rate of consumption of the resource that can jeopardize availability and sustainability of quality drinking water for that community. In addition, an increased consumption of bottled water can reduce revenues of local governmental water utilities that can potentially impact the capacity of the local utility to provide necessary improvements in water delivery infrastructure and increase the price of municipal drinking water to residents.[25]

The reliance on bottled water products is critical during emergencies when the water quality of a community is compromised; otherwise it is unnecessary and economically and environmentally unsound as a replacement for tap water.

REGULATIONS & STANDARDS

The Safe Drinking Water Act (SDWA) was established in1974 and amended in subsequent years to protect drinking water resources in the United States. The law authorized the US EPA to set minimum performance standards to protect drinking water delivery by public water systems (PWSs)[11]. Since the first drinking water standards went into effect in 1977, the SDWA has seen several significant revisions including, but not limited to, new contaminant standards, monitoring and reporting requirements, timelines for review, measures to protect drinking water aquifers, and creation of new and adjustment of existing standards.[26, 27]

The US EPA, together with the states (WI DNR for Wisconsin) and other partners, protect public health by ensuring safe drinking water via the monitoring and enforcement of the SDWA. The standards include the National Primary Drinking Water Regulations (NPDWRs) for substances with potential adverse human health impacts and national secondary drinking water standards (NSDWRs) for substances that adversely affect human welfare (appearance or odor). These primary and secondary standards cover over 200 contaminants, including microorganisms, disinfectants and disinfection byproducts, inorganic chemical, organic chemicals, and radionuclides.[26-28]

The Safe Water Drinking Act protects public health by setting contaminant standards and monitoring and reporting requirements.

The table below includes standards and guidelines for select, common chemical contaminants encountered in Dane County drinking water.

Table 1. Regulations and standards

Chemical	MCLG (mg/L)	MCL / Action Limit (mg/L)	Secondary Drinking Water Standard (mg/L)
Chloride			250
Lead	Zero	0.015*	
Copper	1.3	1.3*	
Nitrate	10	10	
Atrazine	0.003	0.003	
Alachlor	0.0004	0.002	
VOCs (multiple compounds)	varies	varies	
PCBs	Zero	0.0005	
Radium 226+228	Zero	5*	
Uranium	Zero	0.03	

***** Indicates Action Limit

- MCLG: Non-enforceable health goal Maximum Contaminant Level Goal, a level with no known or anticipated adverse health effects
- MCL: Legally enforceable Maximum Contaminant Level, the highest level of a contaminant that is allowed in drinking water
- Action Level: Triggers treatment or other requirement to reduce the level of a contaminant in drinking water, such as corrosion control for lead and copper
- The Secondary Drinking Water Standard: A non-enforceable guideline regarding aesthetic effects (taste, odor, color)[28]

SAFE WATER DRINKING ACT COMPLIANCE IN DANE COUNTY

Low levels of nitrate, copper, lead and some other metals are common in drinking water of many public water systems of Dane County villages and cities.[3] Although elevated lead levels have been reported from some distribution system water samples (Mt Horeb and Stoughton and occasionally in the City of Sun Prairie) from the latest testing, all water systems are in compliance with the US EPA Lead and Copper Rule as reported in the WI DNR's Consumer Confidence Report. Among all 33 tested water systems, the 90th percentile level of lead ranges from 0.77 to 7.44 µg/L, with the exception of one, Stoughton Waterworks, were no lead was reported (although 4 of 60 samples exceeded the Action Limit). In Dane County, eight municipal water systems use polyphosphates to prevent scaling / corrosion. Other metals encountered in some public water system water include arsenic, chromium, nickel selenium and thallium.

Low, below regulatory levels of VOCs, including chlorinated hydrocarbon and disinfection byproducts have been reported and are the constituents of concern in some Dane County public water supplies. Many public water systems also report low level gross alpha radioactivity and some report radium 226 and 228 from natural sources at levels below the regulatory limits.

SUSTAINABILITY OF RESOURCES

The appropriate use and protection of water supplies is critical to our community in order to maintain a sustainable resource for high quality drinking water in Dane County communities. The overuse or inefficient use of ground water resources can have both direct and indirect consequences to individual and community health by lowering access to quality drinking water, increasing susceptibility to ground water to contamination, and impacting Dane County surface water by reducing water supplies to these sources from an imbalanced hydrologic cycle.

Over the past decade, an average of 46.3 million gallons of water was pumped each day in Dane County to supply residential, agricultural, industrial, and commercial water demands; approximately 17 billion gallons annually. These totals include the nearly 30 million gallons per day (an average of 10.7 billion gallons annually) pumped by the City of Madison. However, during this same time period, the City of Madison and Dane County has made significant progress in the reduction of residential use of water.

These reductions derived from improved technology and behavior changes have also contributed to an overall decrease during the past decade (2005 compared to 2014) of total water pumped from the ground water resources supplying Dane County and the City of Madison despite annual increases in populations.

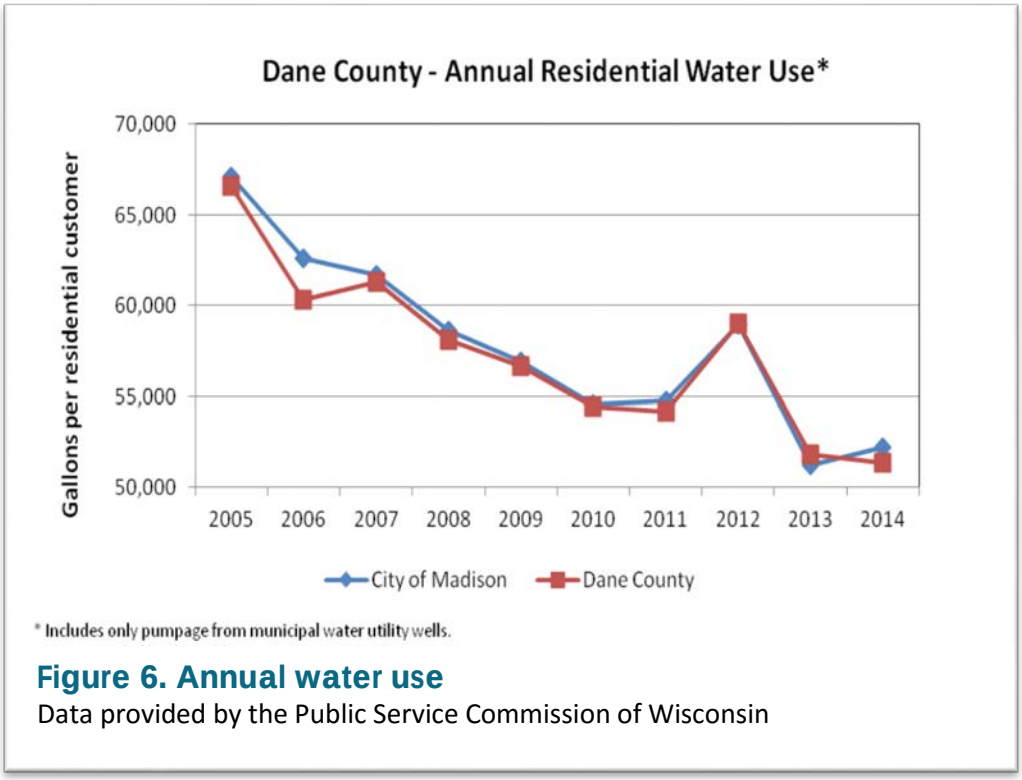

Figure 6. Annual water use
Data provided by the Public Service Commission of Wisconsin

Continued improvement and expansion of interventions at the individual and community level are needed to maintain the reported reduction in water usage, further decrease water demands, and improve the efficiency of water use in order to preserve ground water quality and lengthen the life of the aquifer.

Additional detailed information about water use and conservation of Dane County ground water resources is available in the Madison and Dane County Environmental Health Report Card Series – Sustainability report:

- http://www.publichealthmdc.com/publications/documents/2014RptCardSust.pdf

RECOMMENDATIONS & INVESTMENT

The alteration of hydrological cycle processes poses several challenges for water supply management. Increased efforts are required to protect groundwater resources to ensure adequate supply of safe drinking water. Planning and management of increased groundwater use and withdrawal must also account for climate change and climate variability, plans for flooding and drought, population growth and land use, as well as, potential nonpoint pollution impacts of expanded agricultural production. Dane County water managers are already integrating plans and implementing efforts tied to capacity building, including water and energy efficiency and conservation measures, maintaining the quantity and quality of source water as well as preparing for emergency response and recovery. Resilience to extreme weather events of climate change also requires increased capacity from storm water collection, conveyance and storage.

Increased community outreach should be encouraged, especially to immigrant populations in Dane County, about municipal water quality, testing recommendations for private wells, and the unnecessary reliance on bottled water as a primary drinking water source.

Well head protection is designed to safeguard sources of water. Most public city and village PWSs have a wellhead protection plan and ordinance and several have a storm water utility and management plan. Implementation of enhanced wellhead protection should be encouraged to reduce recharge of contaminated water. Improved information is needed on water quality conditions in the particular aquifer zones that are tapped by wells to evaluate the potential human health implications and possible mitigation approaches.

Water managers and users must also address the challenge of funding the upgrades and replacement of aging infrastructure. Management plans should pay attention to people, places and infrastructure that are the most vulnerable; particularly in poor, minority and rural communities facing water challenges.

Continued public education and testing of domestic wells are needed; this is especially true among homeowners with private wells. These residents are not required to monitor private wells and may not be aware that contaminants from man-made sources may be present in ground water from current or previous land uses or activities or natural contaminants from the geology of the area. Annual private well testing and more frequent testing after flooding or other changes in the well should be encouraged. Pesticide testing should also be encouraged as pesticide contamination is often found to occur concurrently with nitrate contamination. Policies requiring mandatory testing could be put in place if voluntary testing continues to ineffective.

To protect drinking water sources, further agricultural best management practices, including cover crops and vegetation buffers and implementation of nutrient management plans should be encouraged to guide judicial nutrient applications to balance crop needs and available nutrients, considering timing and rate and application method. For permit applications of manure spreading, permitting authority should consider vulnerability of the location for nitrate contamination to protect sensitive land.

REFERENCES

1.) United States Environmental Protection Agency. (2016). Flint drinking water documents. Retrieved from: https://www.epa.gov/flint/flint-drinking-water-documents

2.) Public Health Madison and Dane County. (2016). Madison and Dane County environmental health report card series – 2014: Sustainability. Retrieved from: http://www.publichealthmdc.com/publications/documents/2014RptCardSust.pdf

3.) Public Health Madison and Dane County. (2015). Madison and Dane County environmental health report card series – 2014: Water quality. Retrieved from: http://www.publichealthmdc.com/publications/documents/2014RptCardWater.pdf

4.) United States Department of the Interior. (2016). Summary of the water cycle. Retrieved from: http://water.usgs.gov/edu/watercyclesummary.html

5.) Donaldson, S. (2007). The effects of urbanization on the water cycle. Retrieved from: https://www.unce.unr.edu/publications/files/nr/2004/FS0443.pdf

6.) Wisconsin Department of Natural Resources. (n.d.). Test your private well water annually. Retrieved from: http://dnr.wi.gov/topic/wells/privatewelltest.html

7.) Public Health Madison and Dane County. (2016). Madison and Dane County environmental health report card series – 2014: Healthy homes and communities. Retrieved from: http://www.publichealthmdc.com/publications/documents/2014RptCardHHC.pdf

8.) Gilliom, R.J. (2007). Pesticides in U.S. streams and groundwater. Retrieved from: http://pubs.acs.org/doi/pdf/10.1021/es072531u

9.) Centers for Disease Control and Prevention. (2016). Water - Sources of lead. Retrieved from: https://www.cdc.gov/nceh/lead/tips/water.htm

10.) United States Environmental Protection Agency. (2017). Use of lead free pipes, fittings, fixtures, solder and flux for drinking water. Retrieved from: https://www.epa.gov/dwstandardsregulations/use-lead-free-pipes-fittings-fixtures-solder-and-flux-drinking-water

11.) United States Environmental Protection Agency. (2004). Understanding the Safe Drinking Water Act. Retrieved from: https://www.epa.gov/sites/production/files/2015-04/documents/epa816f04030.pdf

12.) Public Health Madison and Dane County. (2016). Road salt report – 2015. Retrieved from: http://www.publichealthmdc.com/publications/documents/RoadSaltRpt2015.pdf

13.) Schmidt, S. (2016, February 1). Failure at the faucet. First in the nation: City of Madison replaced all lead pipes. Retrieved from: http://wisconsinwatch.org/2016/02/first-in-the-nation-city-of-madison-replaced-all-lead-pipes/

14.) McDonald, C.P., M. J. Parsen, R. C. Lathrop, K. K. Sorsa, K. R. Bradbury and M. T. Kakuska (2015) Characterizing the sources of elevated groundwater nitrate in Dane County, Wisconsin. Final Report to WDNR for Wisconsin Groundwater Joint Solicitation Program, Project #218

15.) National Pesticide Information Center. (2016). Drinking water and pesticides. Retrieved from: http://npic.orst.edu/envir/dwater.html

16.) Wisconsin Groundwater Coordinating Council Report to the Legislature. (2016). Pesticides. Retrieved from: http://dnr.wi.gov/topic/groundwater/documents/GCC/GwQuality/Pesticides.PDF

17.) Public Health Madison and Dane County. (2017). Road salt report – 2016. Retrieved from: http://www.publichealthmdc.com/publications/documents/RoadSaltRpt2016.pdf

18.) Public Health Madison and Dane County. (2014). Sodium in drinking water. Retrieved from: http://www.publichealthmdc.com/documents/SodiumDrinkingWater.pdf

19.) Posnick, L.M. & Kim, H. (2002). February/ March 2002. Ask the regulators – bottled water regulation and the FDA. Retrieved from: http://www.fda.gov/Food/FoodborneIllnessContaminants/BuyStoreServeSafeFood/ucm077079.htm#authors

20.) Doria, M. F. (2006). Bottled water versus tap water: Understanding consumers' preferences. *Journal of Water and Health*, *4*(2), 271 – 276.

21.) Public Health Madison and Dane County. (2010). A question of water: The tap vs. the bottle. Retrieved from: http://www.publichealthmdc.com/documents/BottledvsTap20110204.pdf

22.) International Bottled Water Association. (2016). How much does bottled water cost? Retrieved from: http://www.bottledwater.org/economics/real-cost-of-bottled-water

23.) International Bottled Water Association. (2016). Recycling. Retrieved from: http://www.bottledwater.org/education/recycling

24.) United States Environmental Protection Agency. (2016). Toxicological threats of plastic. Retrieved from: https://www.epa.gov/trash-free-waters/toxicological-threats-plastic

25.) Hu, Z., Morton, L.W., & Mahler, R.L. (2011). Bottled water: United States consumers and their perceptions of water quality. *International Journal of Environmental Research and Public Health*, 8, 565 – 578.

26.) Cox, W.E. (1997). Evolution of the Safe Drinking Water Act: A search for effective quality assurance strategies and workable concepts of Federalism. *William & Mary Environmental Law and Policy Review*, 21(1). Retrieved from: http://scholarship.law.wm.edu/wmelpr/vol21/iss1/3/

27.) United States Environmental Protection Agency. (2016). Summary of the Safe Drinking Water Act. Retrieved from: https://www.epa.gov/laws-regulations/summary-safe-drinking-water-act

28.) United States Environmental Protection Agency. (2016). Table of regulated drinking water contaminants. Retrieved from: https://www.epa.gov/ground-water-and-drinking-water/table-regulated-drinking-water-contaminants

www.publichealthmdc.com
July 14, 2017