Drinking Water Quality

Community Water

DATA & MEASURES 1999-2007

MN EPHT
Environment, Exposure & Health
Minnesota
Environmental
Public Health
Tracking

MINNESOTA MDH DEPARTMENT of HEALTH

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Protecting, maintaining and improving the health of all Minnesotans

December 2009

Dear Colleague:

The Minnesota Department of Health (MDH) is pleased to present the first series of reports of the Minnesota Environmental Public Health Tracking (MN EPHT) program. The purpose of the report is to share environmental and health tracking data with the public, in accordance with Minnesota Statutes, section 144.996, Subdivision 1.2.

Environmental public health tracking is a public health tool that uses a variety of existing data sources to provide information about environmental hazards, chemical exposures and population health in our state, as well as what preventative actions can be taken to protect the public. The value of environmental public health tracking increases with each year of data collection.

In 2009 MN EPHT became part of the National Environmental Public Health Tracking Network (Tracking Network) under a cooperative agreement grant, joining New York City and 21 other states in the Tracking Network. This grant from the Centers for Disease Control and Prevention (CDC) will help support ongoing data collection and the development of a web-based information system for the public to access MN EPHT data in the years ahead. Improved public access to current, accurate information will help inform individual decisions as well as public policy to prevent disease and promote health.

An electronic version of this report is available on the MN EPHT website: http://www.health.state.mn.us/tracking/. For more information about this report, please contact MN EPHT at 651-201-4987 (toll free: 1-800-205-4987) or health.tracking@state.mn.us.

Sincerely,

Sanne Magnan, M.D., Ph.D.
Commissioner
P.O. Box 64975
St. Paul, MN 55164-0975

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Report on Drinking Water Quality Data & Measures: 1999-2007

MN EPHT Report | December 2009

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Requests for more information about this report may be addressed to:

Minnesota Environmental Public Health Tracking
Minnesota Department of Health
651-201-5900
Toll Free: 1-800-205-4987
TDD phone number: 651-201-5797
health.tracking@state.mn.us

or

Report Writer
Deanna Scher, Ph.D.
Health Risk Assessment Unit
Minnesota Department of Health
651-201-4922
deanna.scher@state.mn.us

Requests for information about the MDH Drinking Water Protection Program may be addressed to:

Minnesota Drinking Water Protection Program
Division of Environmental Health
Minnesota Department of Health
651-201-4700
health.drinkingwater@state.mn.us

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Introduction to MN EPHT

The environment can mean many things to many people. For Environmental Public Health Tracking (EPHT), the environment is defined as our air, our water, our food, and our surroundings. The environment plays an important role in health and human development. The Minnesota Environmental Public Health Tracking (MN EPHT) system brings together existing data in the state about environmental hazards, population exposure, and health outcomes.

EPHT data may be used to:

- Recognize patterns and evaluate trends in environmental conditions, population exposure and rates of disease
- Measure impacts of public health interventions
- Identify populations most affected or most vulnerable
- Identify opportunities for research and/or public health interventions to reduce exposures to potential environmental health hazards and prevent disease

Minnesota Statutes, section 144.996, directs the Minnesota Department of Health (MDH) to establish an environmental health tracking program. The goal of MN EPHT is to provide information that can be used to plan and evaluate actions to prevent diseases and promote healthy environments in Minnesota. By making data on environmental hazards, exposures and health available in one place and by systematically monitoring those data, an environmental public health tracking program can create new opportunities for learning about the risks of environmental exposures and for understanding the relationships between the environment and health.

National Tracking Network Data and Measures

MN EPHT works in partnership with other states as part of the Centers for Disease Control and Prevention's (CDC) National Environmental Public Health Tracking Network (Tracking Network). Since MN EPHT began in 2007, the program has been collecting and analyzing data in 8 content areas that the Tracking Network has identified as priorities shown in the table below.

Tracking Network Content Areas 2007

Environmental Hazards	Exposures	Health Outcomes
Air quality Drinking water quality	Childhood blood lead exposure	Hospitalizations Cancer Carbon monoxide poisoning Reproductive outcomes Birth defects

Within each content area, tracking measures are used as indicators of population health with respect to environmental factors. These measures are summary characteristics or a statistic, such as a sum, percentage, or rate. Tracking measures are used to assess health, or a factor associated with health, in a population through direct or indirect measures. For example, because the amount of lead in paint in older homes is difficult to measure, MN EPHT uses blood lead measurements in children to indicate both the lead paint hazard and the risk for childhood lead poisoning. Similarly, MN EPHT measures levels of a pollutant in the environment as an indicator of possible exposure.

Nationally consistent data and measures (NCDMs) were developed by CDC in collaboration with national, state, and local environmental health partners. NCDMs allow for data from any state's EPHT system to be integrated into the Tracking Network, a national database of environmental hazards, environmental exposures, and health effects. Except where noted, MN EPHT has prepared Minnesota data and measures according the NCDM standards.

Healthy People 2010

Healthy People 2010 is a set of disease prevention and health promotion objectives for the Nation to achieve by the year 2010. Healthy People 2010 has two goals: increase quality and years of healthy life, and eliminate health disparities. These two goals are supported by 467 objectives in 28 focus areas. Healthy People 2010 is an instrument to improve health and a valuable tool for those who work to improve health.[1]

Several of the Tracking Network's measures align with Healthy People 2010 objectives. Where applicable, Healthy People 2010 objectives are provided in order to provide context for how Minnesota compares in reaching national health targets.

MN EPHT Data and Measures Reports

This report is one in a series of first reports produced in 2009 for MN EPHT and compiles available community water system data from 1999-2007. EPHT is a growing program, and the MN EPHT and the Tracking Network will be adding new content areas over time. Updates to the drinking water quality content area as well as new content area data will be reported and made available on our website. For more information about MN EPHT or the CDC Tracking Network, please visit:

MN EPHT: http://www.health.state.mn.us/tracking
National Tracking Network: http://ephtracking.cdc.gov

Community Drinking Water Quality Data Highlights

- Minnesota has 965 community water systems that serve approximately 80% of residents.
- In 2007, 96% of Minnesotans received drinking water from community water systems that met all Safe Drinking Water Act standards.
- Beginning in 2006, approximately 2% of people were served by community water systems that did not comply with new, lower arsenic standard of 10 ppb.
- In response to implementation of the lower arsenic Maximum Contaminant Level in 2006, the number of people receiving water with a 3-year mean arsenic concentration ≥ 10 ppb dropped from 22,442 in 1999-2001 and 19,497 in 2002-2004 to 8,783 in 2005-2007.
- From 1999-2007, less than 1% of people served by community water systems were exposed to mean or maximum annual nitrate concentrations above 10 mg/L.
- From 1999-2007, 2-4% of people served by community water systems were exposed to average annual levels of nitrate in the 3 to <10 mg/L range. Although concentrations below 10 mg/L appear to protect infants from methemoglobinemia, elevated concentrations may indicate that the water source is vulnerable to contamination.
- Less than 0.3% of community water systems (supplying less than 0.2% of the population) violated the standard for disinfection byproducts (HAA5 or TTHM) in any given year.
- Potential population exposure to water with disinfection byproduct levels exceeding the Maximum Contaminant Level was consistently at or below 0.1% each year. For over 95% of consumers, yearly average TTHM and HAA5 levels were less than 40 ug/L and 30 ug/L respectively (corresponding to less than half of the Maximum Contaminant Level values).
- Less than 1% of community water systems have exceeded the lead action level each year since 2003.

Data Source Acknowledgement: The MN EPHT Program gratefully acknowledges the Drinking Water Protection Program, part of Minnesota Department of Health's Division of Environmental Health, for providing the data on drinking water quality in Minnesota presented in this Tracking Report.

Community Water Systems and Health

People drink and use water daily, making the quality of our drinking water an important public health issue. Roughly 90% of people in the United States get their home drinking water from Community Water Systems (CWS) while 10-15% of Americans rely on smaller water supplies (mostly household wells).[2, 3] CWS are public water systems that serve 15 locations or 25 people year-round. Under the Safe Drinking Water Act (SDWA), the Environmental Protection Agency (EPA) sets drinking water standards for public water systems. The risk of developing a disease from drinking water supplied by a CWS is considered low because the majority of CWS meet all water quality standards. The SDWA does not apply to private wells which serve fewer than 25 individuals. Owners of private wells are responsible for ensuring that their well water is safe from contaminants.

Community water systems (CWS) were selected by the Tracking Network for initial drinking water quality tracking because data exist for these systems nationwide. Tracking water quality information will allow for the exploration of potential relationships between drinking water and human health in Minnesota.

Drinking water contains some contaminants at low levels and the risk of developing a disease from the drinking water is increased if contaminant levels increase. Drinking water can be contaminated by natural sources, like heavy metals in rock and soil, or by human activities, like chemical run-off from agricultural land. Contamination may occur in the source water that the water system uses such as wells, reservoirs, lakes, or rivers. Contamination could be introduced due to problems with the water treatment system, or it may occur after finished drinking water leaves the distribution system. The effects of some drinking water contaminants are well known while others are not understood. Sensitive groups, such as the elderly, children, and pregnant women, may be more likely to suffer ill effects.

People can be exposed to contaminants by:

- Drinking water
- Eating foods prepared with water
- Inhaling water droplets or chemicals released from water
- Absorbing chemicals through the skin while bathing

The risk of developing a specific disease depends on:

- The contaminant
- The duration of exposure
- The level of the contaminant in the water
- A person's individual susceptibility

The primary means of preventing health problems caused by contaminants in drinking water is to ensure that drinking water meets or exceeds federal drinking water standards to protect public health. State agencies, water suppliers, and water engineers work together to help ensure that drinking water contamination levels are as low as possible.

Community Water Systems (CWS) in Minnesota

A Healthy People 2010 objective is to increase the number of people receiving drinking water through community water systems (CWS) that meet Safe Drinking Water Act (SDWA) standards. Under SDWA, EPA established regulations to ensure that CWS supply safe drinking water. Compliance, or the act of meeting all drinking water regulations, ensures the public is receiving safe water, free from disease-causing agents. In 1995, 85% of persons served by CWS in the U.S. received drinking water that met SDWA regulations. Healthy People 2010 has a target goal to increase this number to 95%. As of 2007, systems for which no health-based violations were reported increased to 92% in the U.S.[4] In 2007, 96% of Minnesotans served by CWS received drinking water that met SDWA standards.[5]

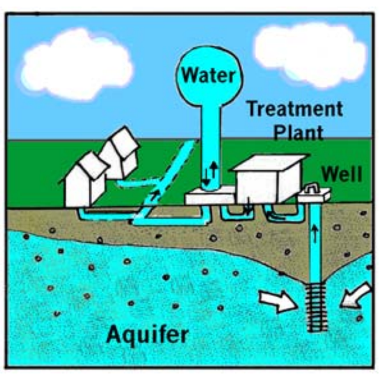
Minnesota has 965 CWS that serve approximately 80% of Minnesota residents (Table 1).

Table 1: *Percent of total population served by Community Water Systems (CWS).*

Total # CWS[1]	Population on CWS[2]	Total MN population[3]	Percent total population on CWS
965	4,163,094	5,197,621	80.1%

[1] As of February 2008. [2] Based on service population estimates provided by the individual systems. [3] 2007 U.S. Census estimate.

Figure 1: *Illustration of a CWS using groundwater.*



Provided Courtesy of the Ohio Environmental Protection Agency
http://www.epa.ohio.gov/ddagw/dwbasics.aspx

Figure 1 provides an example of a CWS using groundwater. Water is pumped up from wells which are drilled into the ground to capture water below the surface. Next, the water often undergoes some form of treatment so that it will be safe to drink. After leaving the treatment plant, water is often pumped to an elevated tank from which water flows by gravity through a network of pipes leading from a treatment plant to customers' plumbing systems (i.e., distribution system) to users' tap.

Most CWS in Minnesota use groundwater from underground sources, tapped by wells, as their source of water (Figure 2a). However, the small number of systems using surface water, drawn from lakes or rivers, includes the CWS serving the state's largest cities. This increases the percent of the population served by surface water systems (Figure 2b).

Figure 2a: *Percent CWS by primary water source, 2008.*

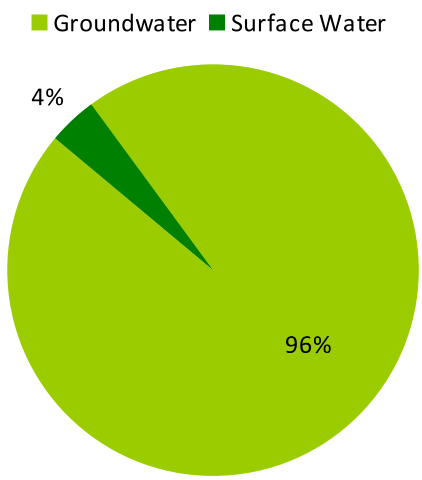
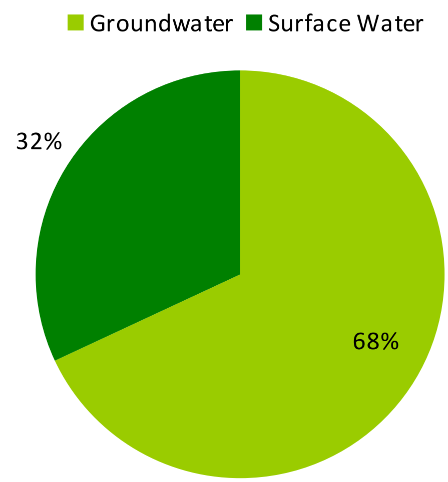


Figure 2b: *Percent population served by primary CWS water source, 2008.*



Similarly, although most CWS are "small" or "very small" in Minnesota based on the number of people served, the majority of the population is served by "large" or "very large" systems, as seen in Table 2.

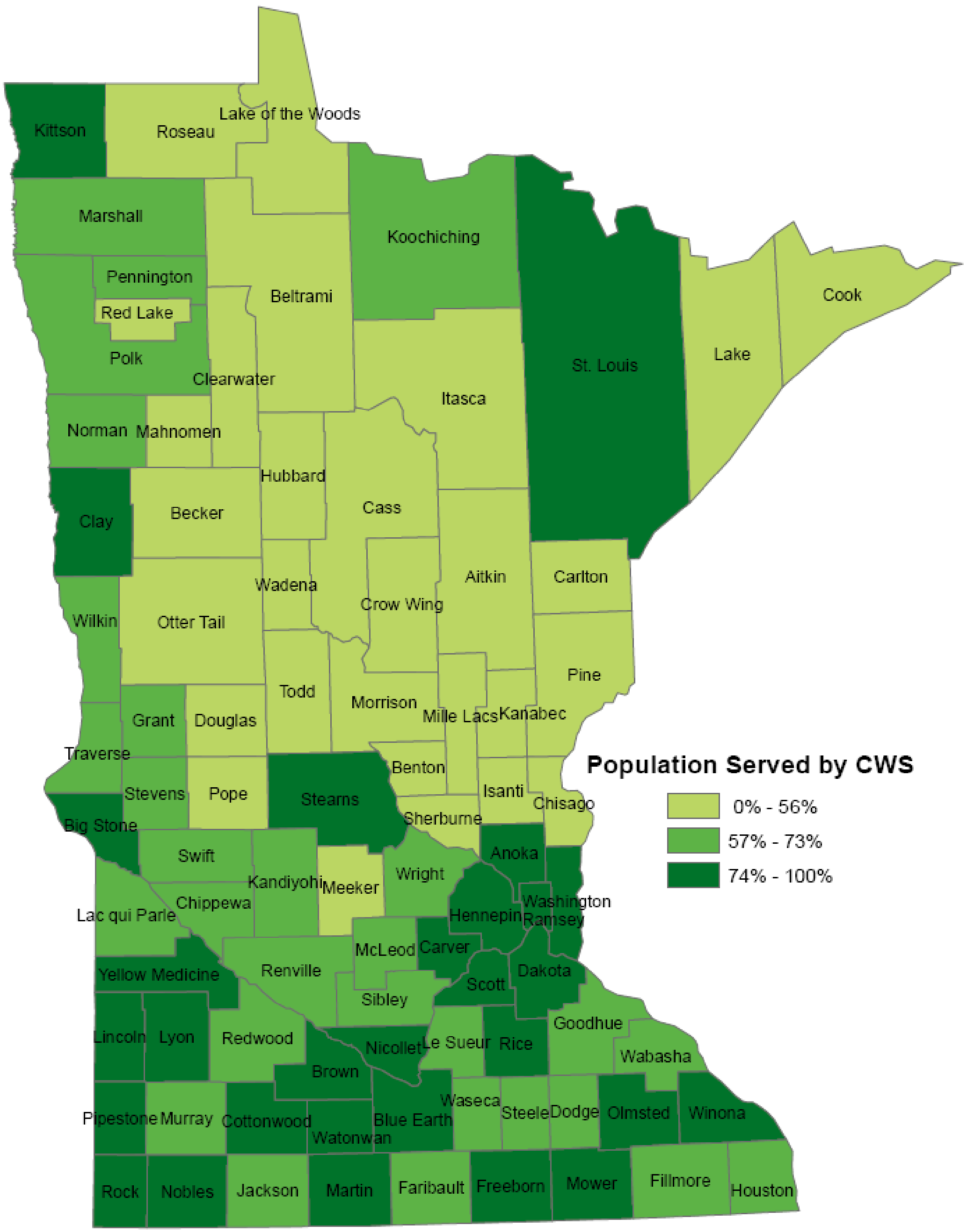
Table 2: *Percent CWS by size and percent population served by CWS size in Minnesota.†*

System size (based on number people served)	Percent CWS	Percent population served by CWS
Very large (>100,000)	<1	19
Large (10,001-100,000)	9	58
Medium (3,301-10,000)	9	11
Small (501-3,300)	32	10
Very small (25-500)	50	2

† As of February 2008

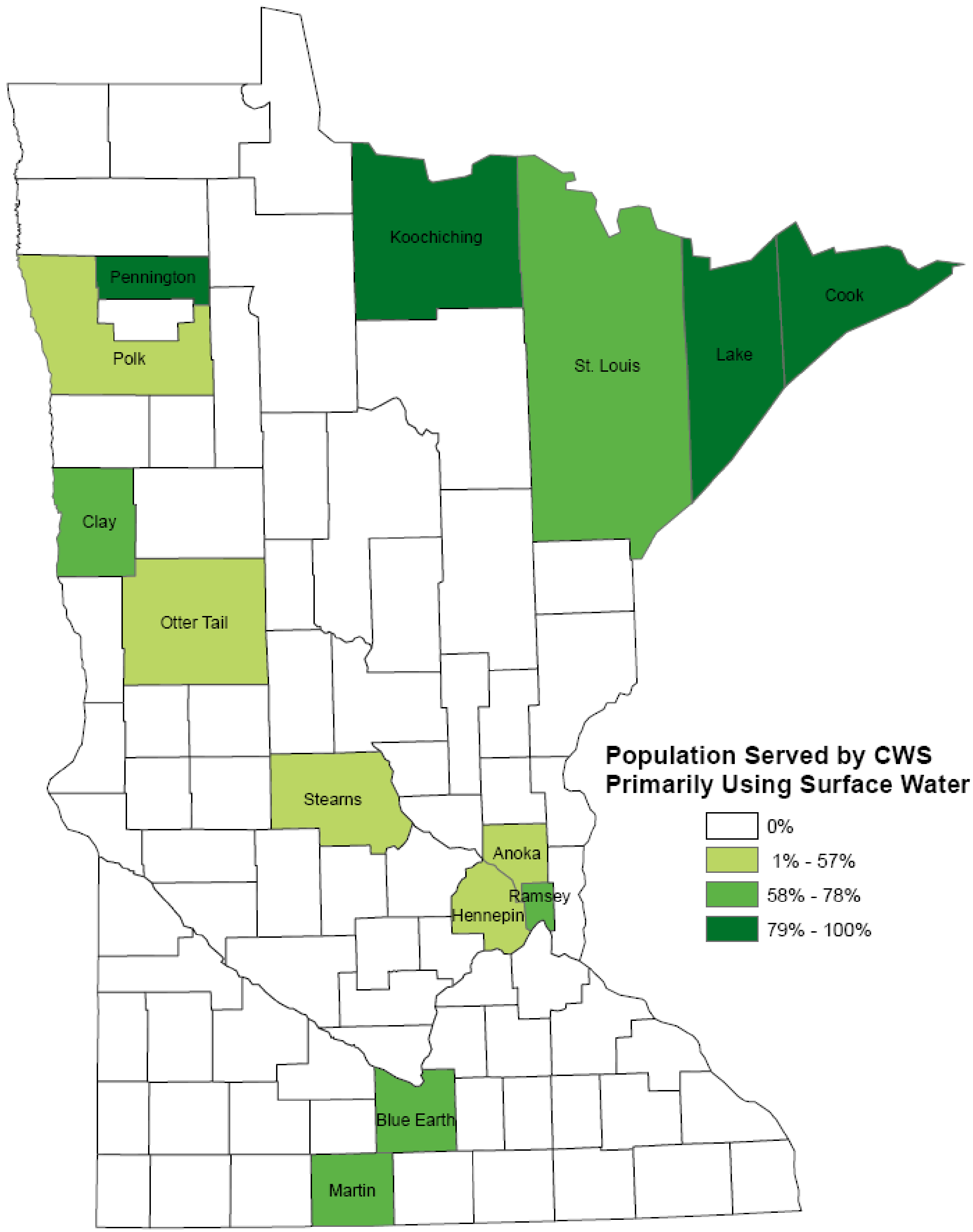
Although EPHT drinking water quality measures are state-wide, the percent of the Minnesota population getting their water from a CWS varies by county, as shown in Figure 3. The percent of the population served by CWS primarily using surface water versus groundwater also varies by county, as shown in Figure 4.

Figure 3: *Percent total population served by CWS, Minnesota, 2008.* †



† Estimates should not be considered absolute measures of population served, as CWS service areas may span county jurisdictions and population served may be over- or underestimated by water operators.

Figure 4: *Percent of population served by CWS using surface water as primary source, Minnesota, 2008.* †



† Estimates should not be considered absolute measures of population served, as CWS service areas may span county jurisdictions and population served may be over- or underestimated by water operators.

The MDH Drinking Water Protection Program is responsible for assuring public water supply systems in Minnesota comply with the SDWA and for working with systems to resolve contamination issues. When a water system has a problem that might pose a public health risk, such as a violation, the system must notify its customers. If it is a serious situation, the system must notify the public within 24 hours; for less serious problems, within 30 days. In addition, water suppliers send customers a "Consumer Confidence Report' each year which contains information about the system's water. The report includes information on where the water comes from, how it is treated, the list of the chemicals tested for, and the highest concentration of each chemical found in the past year.

Monitoring Community Water Systems to Protect Health

All U.S. public water systems are required to provide drinking water that meets SDWA standards. EPA establishes drinking water standards for individual contaminants and groups of contaminants. There are currently water quality standards and monitoring requirements for over 90 contaminants. Typically, EPA establishes a Maximum Contaminant Level (MCL) and associated compliance monitoring requirements, such as monitoring frequency, for each contaminant. When it is not possible to measure a contaminant in drinking water, EPA establishes drinking water Treatment Technique Requirements (TTR), which are required processes intended to reduce the level of a contaminant in drinking water. Compliance with MCLs and TTRs is the basis of determining whether the drinking water meets public health regulatory standards.

In establishing an MCL or TTR, EPA evaluates studies on:

- Health effects (toxicology and epidemiology)
- Occurrence of the contaminant in water
- Effectiveness and cost of treatment to remove the contaminant

Based on analysis of this information, EPA sets an MCL Goal (MCLG) and either an MCL or a TTR. The MCLG is a non-enforceable concentration of a drinking water contaminant, set at the level at which no known or anticipated adverse effects on human health occur and which allows an adequate safety margin. The enforceable standards (MCL or TTR) are set as close to the MCLG as technologically and economically feasible.

Although MCLs and TTRs apply to all public water systems, the associated monitoring requirements vary. Monitoring requirements are contaminant- or contaminant group-specific. The frequency of monitoring for a contaminant also varies based on the type of source water and results of previous samples. Surface water systems typically monitor more frequently than groundwater systems because the occurrence of contaminants is more variable over time. Systems that do not detect contaminants or detect them only at very low levels compared to the MCL monitor less frequently. Monitoring frequency may also depend on service population size and water treatment used. Regulations and state drinking water agencies specify sample locations and acceptable assessment methods. Drinking water standards and monitoring requirements change over time. EPA periodically reviews and, if necessary, revises existing regulations, based on new health effects, treatment techniques, analytical methods and contaminant occurrence information. New regulations can be developed for previously unregulated contaminants.

In Minnesota, monitoring the quality of drinking water in public water supply systems is a joint responsibility of MDH and the state's public water supply systems. Local water supply systems are responsible for taking some of the required water samples, according to a schedule established by MDH. MDH staff collects the remainder of the required samples. Certified laboratories test the water samples for a broad variety of possible contaminants.

Drinking Water Quality Measures

The Tracking Network drinking water quality measures for community water are:

Level of Contaminant in Finished Drinking Water

Contaminant levels give an indication of the extent of contamination across CWS. The contaminant level is measured two ways: in comparison to a benchmark level, such as the MCL, and in terms of average or maximum contaminant concentrations.

Potential Population Exposure to Contaminants in Finished Drinking Water

The potential for exposure in the population is measured in two ways: by the amount and proportion of the population that is provided water at or above a benchmark, (usually the MCL), and in terms of average or maximum contaminant concentrations. For population-based measures, the denominator is total state population served by CWS, not total state population.

The Tracking Network contaminants being tracked in CWS over time are:

- Disinfection byproducts
- Arsenic
- Nitrate
- Lead

State drinking water information systems, like the Minnesota Drinking Water Information System (MNDWIS) at MDH, store drinking water quality data used to ensure that public water systems meet state and EPA standards for safe drinking water. These data are the only consistent set of public drinking water quality data nationwide. The Tracking Network has adapted these data for public health uses. MN EPHT uses MNDWIS as the data source for Tracking Network measures. The Tracking Network selected 1999 as the start year for tracking drinking water quality. Only SDWA compliance samples are included; no other monitoring samples were used to derive the measures.

The following general exclusions apply to the measures:

- Non-community public water systems (relatively small systems that serve transient populations such as restaurants or campgrounds or those serving people in a non-domestic setting for only part of the day such as schools or office buildings), are not included. Bottled water, which is regulated by Food and Drug Administration standards, is not included.

- Drinking water supplied by household wells is not included. Approximately one million Minnesotans rely on private wells for drinking water. Unlike community water systems, there is no uniform source of data for water systems such as private wells that are not regulated by EPA. Of the four initial contaminants tracked in community water systems, arsenic and nitrate are of particular concern for private well users.
- Results are reported only for currently active CWS (n=965 as of February 2008) even though not all 965 systems were active during the entire period 1999-2007. Sampling results from inactive systems that were active prior to February 2008 are not included in these measures. Decisions about how to include systems that were not active throughout the entire initial reporting period were made by the Tracking Network. A driving factor was the inaccessibility of historical data in some states.

Two modifications, not specifically prescribed by the Tracking Network in developing the nationally-consistent measures, were made to the Minnesota data to improve its accuracy and reliability:

- Sampling results from emergency wells were excluded. Since these wells are used for emergency purposes only and are returned to an inactive status as soon as possible, people are unlikely to drink water from these wells. This was mainly an issue for nitrates and to a lesser extent, arsenic.
- If a CWS purchased some or all of its finished drinking water from another system and was therefore not required to conduct its own monitoring, sampling results from the supply system were substituted for the purchasing system.

A. Arsenic

Arsenic is a toxic chemical element occurring naturally in the environment and as a by-product of some agricultural and industrial activities. Arsenic can enter drinking water through the ground or as run-off into surface water sources. Higher levels tend to be found in groundwater due to naturally occurring arsenic in soil and minerals. Levels of arsenic found in drinking water systems vary widely across the nation and within Minnesota itself. Groundwater in some parts of Minnesota contains higher levels of arsenic, particularly the west-central and northwestern regions, although arsenic can be found throughout the state and can vary from one well to the next within a small area. For most people, food (and particularly fish and shellfish) is the primary source of exposure to arsenic. However, the organic forms of arsenic usually found in food are generally considered less toxic than the inorganic forms.

Arsenic ingestion has been linked to both cancerous and non-cancerous health effects. The Department of Health and Human Services, the EPA and the International Agency for Research on Cancer have identified inorganic arsenic as a human carcinogen based on lung, bladder, liver, and skin cancers.[6] Other adverse effects include cardiovascular disease, developmental and reproductive effects, diabetes, and skin changes such as pigmentation changes and thickening (hyperkeratosis).

Residents of community water systems can find out the arsenic levels, if any, in their drinking water by reading the Water Quality Report (often referred to as the Consumer Confidence Report) issued each year by their water utility. Those wishing to take extra precautions may install a point-of-use water treatment system in their home. Distillation, reverse osmosis, columns of anion exchange, and columns of absorptive media may be used to reduce arsenic levels. For more information on point-of-use devices, see: http://www.health.state.mn.us/divs/eh/water/com/fs/pou.html.

For private well owners, the only way to know if an *existing* well contains arsenic is to have it tested. The test typically costs about $30-$40. To make sure that a laboratory is certified by MDH to test drinking water for arsenic, see: http://www.health.state.mn.us/divs/phl/cert/allcertlabs.html. Starting in August 2008, an amendment to the Well Rules in Minnesota required all new potable water-supply wells to be tested for arsenic. The results must be provided to the well owner and MDH. Initial results from this sampling emphasize how important it is for private well owners to test their existing wells for arsenic. Of the first 3,069 water samples reported to MDH, 1,314 (42.8%) samples contained detectable arsenic and 266 samples (8.7%) exceeded 10 µg/L. The majority of wells with elevated arsenic were located in west central Minnesota, but some were scattered throughout Minnesota, and a somewhat high number of these wells have been clustered in the northwest and west Twin Cities Metro counties.

EPA first issued a drinking water standard of 50 µg/L for arsenic in 1975. In 2001, EPA revised the regulatory drinking water standard on the basis of bladder and lung cancer risks. The standard took effect in 2006 and reduced the MCL to 10 µg/L. Because it is a carcinogen, the Maximum Contaminant Level Goal (MCLG) for arsenic has been set at zero. Compliance with the arsenic MCL is based on the average concentration of four consecutive quarterly samples (or an annual average) for each well, unless fewer samples would cause the running annual average to be exceeded.

All CWS are required to monitor for arsenic at each entry-point to the distribution system. Systems monitor for arsenic under a standardized monitoring frequency schedule consisting of three compliance periods of three years each. The frequency of monitoring within each compliance period is based on source water type and the level of arsenic observed in past samples. Routine required monitoring is annual for surface water and once every 3 years for ground water, with quarterly monitoring once a sample exceeds 10 µg/L. With a state-granted monitoring waiver, the sampling frequency can be reduced to once every 9 years. To receive a waiver, groundwater systems must have at least 3 rounds of monitoring results and surface water systems must have at least 3 years of monitoring results under 10 µg/L.

A.1. Annual percentage and number of CWS with arsenic MCL violations and number of people served by CWS with arsenic MCL violations.

From 1999 to 2005, no Minnesota resident received water from a CWS that exceeded EPA's arsenic drinking water standard of 50 µg/L. After January 22, 2006, when the lower MCL of 10 µg/L took effect, a number of CWS fell out of compliance. These systems have either come into compliance or are still undergoing planning and engineering efforts to meet the stricter standard of 10 µg/L. By the end of 2007, 11 CWS still exceeded the standard. Starting in 2006, approximately 2% of Minnesotans were exposed to water from a CWS that did not comply with new standard.

Table 3: *Annual percentages and counts of CWS and people served by a CWS with an arsenic MCL violation, Minnesota, 1999-2007.*

	CWS with violation		People served by CWS with violation	
Year	**%**	***Count***	**%**	***Count***
1999	0.0	*0*	0.0	*0*
2000	0.0	*0*	0.0	*0*
2001	0.0	*0*	0.0	*0*
2002	0.0	*0*	0.0	*0*
2003	0.0	*0*	0.0	*0*
2004	0.0	*0*	0.0	*0*
2005	0.0	*0*	0.0	*0*
2006*	1.9	*18*	1.8	*74,518*
2007*	2.1	*20*	1.8	*75,203*

* New stricter standard in effect in these years

A.2. Three-year mean arsenic concentration in CWS and number of people served by various categories of arsenic concentrations.

Mean arsenic concentrations are shown in five categories (<3, 3 to <5, 5 to <10, 10 to <15, and 15+ µg/L) for the last three 3-year arsenic compliance periods. Mean concentration was determined by 1) averaging by sampling point by quarter, then 2) averaging by sampling point by year; then 3) averaging by system by year; and then 4) averaging by system by 3-year compliance period.

An increase in the number of systems with no sampling (due to arsenic monitoring waivers described in Section A, "Arsenic") is seen over time. A large decrease in the number of people receiving water at relatively higher arsenic concentrations is seen in the most recent compliance period compared to the two earlier periods, as expected in response to implementation of the lower MCL. Specifically, the number of people receiving water with a 3-year mean arsenic concentration ≥ 10 ppb went from 22,442 in 1999-2001 and 19,497 in 2002-2004 to 8,783 in 2005-2007. In each compliance period, the water delivered to over 95% of community water recipients had average arsenic levels less than 30% of the current MCL, i.e. less than 3 µg/L.

Table 4: *Number of CWS and people served by a CWS by mean arsenic concentration by compliance period, according to arsenic concentration sampling category, Minnesota, 1999-2007.*

Compliance Period	Arsenic concentration category (µg/L)	CWS in arsenic category		Population served in arsenic category	
		Count	Percent	Count	Percent
1999-2001	No sampling	74	7.7	30,275	0.7
	< 3	744	77.1	3,971,267	95.4
	3 to <5	59	6.1	63,927	1.5
	5 to <10	51	5.3	75,183	1.8
	10 to <15	13	1.3	9,639	0.2
	15+	24	2.5	12,803	0.3
2002-2004	No sampling	428	44.4	1,808,135	43.4
	< 3	426	44.1	2,215,968	53.2
	3 to <5	32	3.3	45,178	1.1
	5 to <10	43	4.5	74,316	1.8
	10 to <15	14	1.5	7,800	0.2
	15+	22	2.3	11,697	0.3
2005-2007	No sampling	519	53.8	2,451,762	58.9
	< 3	348	36.1	1,535,334	36.9
	3 to <5	42	4.4	112,227	2.7
	5 to <10	39	4.0	54,988	1.3
	10 to <15	7	0.7	3,716	0.1
	15+	10	1.0	5,067	0.1

B. Nitrate

Nitrate (NO_3) is a common contaminant found in Minnesota groundwater. Natural background concentrations of nitrate in groundwater are low (< 1 mg/L), but higher levels of contamination may occur in agricultural areas and shallow aquifers. Contamination is also more likely in geologically-sensitive areas, such as deep sandy glacial outwash depots in central Minnesota. Elevated nitrate levels in groundwater are often caused by run-off from barnyards or feedlots, excessive use of fertilizers, septic systems, and decaying plant debris. Sources of nitrate produced as a result of human activities are increasing and have increased nitrate levels in water resources. Since nitrate is very soluble in water and does not bind to soils, it has a high potential to migrate to groundwater.

If an infant is fed water or formula made with water that is high in nitrate, a potentially fatal blood disorder called "blue baby syndrome" (or methemoglobinemia) can develop. Bacteria which are present in an infant's stomach convert nitrate to nitrite (NO_2), a chemical which can interfere with the ability of the infant's blood to carry oxygen. Infants younger than six months of age are more sensitive than adults, and can develop blue baby syndrome from intake of nitrate higher than 10 mg/L. In addition to infants, pregnant women and those with heart or lung diseases are also more susceptible to methemoglobinemia.

Potential adverse health effects of long-term exposure to high nitrate levels in drinking water (and diet) have been investigated over many decades. Studies have examined the association between nitrate consumption and risk of specific cancers, reproductive outcomes, birth defects, and other chronic diseases. While findings have been inconsistent or inconclusive, researchers continue to explore potential associations between long-term exposure to nitrate and adverse effects. As studies are not conclusive at this time, health standards continue to focus on protecting infants from methemoglobimia.

Residents of community water systems can find out the nitrate levels, if any, in their drinking water by reading the Water Quality Report (often referred to as the Consumer Confidence Report) issued each year by their water utility. If the levels exceed the MCL for nitrate, the system must notify the public via newspapers, radio, TV, and other means. Additional actions, such as providing alternative drinking water supplies, may be required to prevent serious risks to public health. For private well owners, the only way to know if an existing well contains nitrates is to have it tested. The price for the test typically ranges from $7 to $25. Well water should be tested annually, as nitrate levels fluctuate over time. To make sure that the laboratory is certified by MDH to test drinking water for nitrate, see: http://www.health.state.mn.us/divs/phl/cert/allcertlabs.html. All new wells are required to be tested for nitrates.

All systems are required to monitor for nitrate at each entry-point to the distribution system; however, the frequency of monitoring depends on source water type and the level of nitrate observed in past samples. Routine nitrate monitoring is required annually for CWS using groundwater and quarterly for CWS using surface water. Sampling frequency may be increased or decreased depending on previous monitoring results.

The SDWA sets MCLGs and MCLs for both nitrate and nitrite. The MCLG of 10 mg/L for nitrate was based on human studies of methemoglobinemia in young children. The MCL is also set at 10 mg/L, and any exceedance of the MCL is potentially serious because there is no additional margin of safety between the MCLG and the MCL. If the average of an initial and confirmation water sample is greater than 10 mg/L, the water system must conduct quarterly nitrate monitoring, issue public notification, and pursue remediation of the contamination. The MCLG and MCL for nitrite are both 1 mg/L. States have different laboratory and reporting methods for nitrate and nitrite. In Minnesota, total nitrate-nitrite as nitrogen is reported and compared to the nitrate MCL of 10 mg/L.

B.1. Annual percentage and number of CWS with any nitrate MCL violation; annual percentage and number of people served by CWS with any nitrate MCL violation

Both the number and percentage of CWS with any nitrate violation and the number and percentage of people receiving water from CWS in which a nitrate violation occurred were less than 1% in every year between 1999 and 2007 and no trends were evident over time. No CWS exceeded the standard for nitrate by the end of 2007.

Table 5: *Annual percentage and count of CWS and people served by CWS with a nitrate MCL violation, Minnesota, 1999-2007.*

	CWS with violation		People served by CWS with violation	
Year	**%**	***Count***	**%**	***Count***
1999	0.3	*3*	0.5	*21,947*
2000	0.0	*0*	0.0	*0*
2001	0.0	*0*	0.0	*0*
2002	0.0	*0*	0.0	*0*
2003	0.2	*2*	0.1	*4,043*
2004	0.1	*1*	0.1	*3,643*
2005	0.0	*0*	0.0	*0*
2006	0.2	*2*	0.0	*431*
2007	0.2	*2*	0.0	*431*

B.2. Annual mean and maximum nitrate concentrations in CWS, and number of people served by CWS of various categories of nitrate concentrations

From 1999-2007, the percentage of CWS with mean and maximum yearly nitrate levels above 10 mg/L was less than 0.5% each year (mean range 0.0-0.2%, max range 0.0-0.4%). The highest number of CWS with yearly mean and maximum concentrations >10 mg/L were 2 and 4 respectively. No trends over time are evident. The percentage of people served by CWS with mean yearly nitrate levels above 10 mg/L was ≤0.1% each year while the percentage of people served by CWS with maximum yearly nitrate levels above 10 mg/L was ≤0.1% each year except 1999 (0.6%). Due to the relatively frequent requirement to sample for nitrate, most systems with no data in past years were likely not yet active.

Although the number of people exposed to mean or maximum nitrate concentrations above 10 mg/L is relatively low (<1%), a larger proportion of the population in Minnesota is exposed to elevated levels of nitrate below the MCL. For example, in 2007, 378,249 people (9%) and 574,255 people (14%) were served by CWS with mean and maximum nitrate concentrations in the >1-10 mg/L range respectively. Although concentrations below the MCL appear to protect infants from methemoglobinemia, it is not clear if these levels are protective of other health effects that may be associated with nitrate exposure. Nitrate concentrations elevated above 1-3 mg/L may also indicate that the water source is vulnerable to contamination and in this way, nitrate serves as an indicator chemical.

Table 6: *Count and percentage of CWS and people served by a CWS by mean nitrate concentrations within nitrate concentration sampling categories, Minnesota, 1999-2007.*

		Water Systems		Population	
Year	**mg/L**	**%**	**Count**	**%**	**Count**
1999	≤ 1	76.7	740	89.9	3,744,482
	> 1 - 3	8.8	85	5.7	238,198
	> 3 - 5	4.6	44	1.9	77,373
	>5 - 10	1.9	18	1.8	73,673
	>10 - 15	0.0	0	0.0	0
	>15	0.1	1	0.0	1,003
	No sampling	8.0	77	0.7	28,365
2000	≤ 1	77.7	750	91.3	3,799,424
	> 1 - 3	8.8	85	5.8	242,449
	> 3 - 5	4.0	39	1.4	58,881
	>5 - 10	1.8	17	0.9	35,517
	>10 - 15	0.2	2	0.1	2,510
	>15	0.0	0	0.0	0
	No sampling	7.5	72	0.6	24,313
2001	≤ 1	78.2	755	77.2	3,211,987
	> 1 - 3	9.2	89	19.8	823,676
	> 3 - 5	4.4	42	1.6	66,838
	>5 - 10	1.8	17	0.9	38,532
	>10 - 15	0.1	1	0.0	1,003
	>15	0.0	0	0.0	0
	No sampling	6.3	61	0.5	21,058

		Water Systems		Population	
Year	mg/L	%	Count	%	Count
2002	≤ 1	78.4	757	89.7	3,735,879
	> 1 - 3	9.7	94	7.1	293,985
	> 3 - 5	4.1	40	1.9	80,316
	>5 - 10	1.6	15	0.7	30,997
	>10 - 15	0.1	1	0.0	1,003
	>15	0.0	0	0.0	0
	No sampling	6.0	58	0.5	20,914
2003	≤ 1	79.9	771	90.3	3,757,936
	> 1 - 3	8.2	79	6.7	279,947
	> 3 - 5	5.2	50	1.7	69,185
	>5 - 10	1.5	14	0.8	34,909
	>10 - 15	0.0	0	0.0	0
	>15	0.0	0	0.0	0
	No sampling	5.3	51	0.5	21,117
2004	≤ 1	80.5	777	89.4	3,720,300
	> 1 - 3	9.3	90	7.0	291,903
	> 3 - 5	4.7	45	2.5	102,624
	>5 - 10	1.3	13	0.7	31,204
	>10 - 15	0.0	0	0.0	0
	>15	0.0	0	0.0	0
	No sampling	4.1	40	0.4	17,063
2005	≤ 1	82.4	795	91.5	3,809,314
	> 1 - 3	8.6	83	5.9	245,039
	> 3 - 5	4.5	43	1.6	67,498
	>5 - 10	1.6	15	0.7	28,804
	>10 - 15	0.0	0	0.0	0
	>15	0.0	0	0.0	0
	No sampling	3.0	29	0.3	12,439
2006	≤ 1	81.2	784	90.7	3,775,049
	> 1 - 3	10.2	98	6.4	268,099
	> 3 - 5	4.9	47	1.8	76,840
	>5 - 10	1.2	12	0.7	30,966
	>10 - 15	0.1	1	0.0	31
	>15	0.0	0	0.0	0
	No sampling	2.4	23	0.3	12,109
2007	≤ 1	81.3	785	90.8	3,780,356
	> 1 - 3	9.8	95	5.6	234,949
	> 3 - 5	4.8	46	2.7	112,620
	>5 - 10	1.8	17	0.7	30,680
	>10 - 15	0.0	0	0.0	0
	>15	0.0	0	0.0	0
	No sampling	2.3	22	0.1	4,489

Table 7: *Count and percentage of CWS and people served by maximum nitrate concentrations within nitrate concentration sampling categories, Minnesota, 1999-2007.*

		Water Systems		Population	
Year	**mg/L**	**%**	**Count**	**%**	**Count**
1999	≤ 1	74.8	722	84.9	3,535,954
	> 1 - 3	9.1	88	9.0	376,139
	> 3 - 5	2.3	22	2.4	101,130
	>5 - 10	5.4	52	2.3	97,325
	>10 - 15	0.3	3	0.6	23,178
	>15	0.1	1	0.0	1,003
	No sampling	8.0	77	0.7	28,365
2000	≤ 1	76.0	733	82.0	3,412,249
	> 1 - 3	9.3	90	12.7	529,032
	> 3 - 5	1.5	14	1.9	77,954
	>5 - 10	5.5	53	2.8	116,996
	>10 - 15	0.3	3	0.1	2,550
	>15	0.0	0	0.0	0
	No sampling	7.5	72	0.6	24,313
2001	≤ 1	76.4	737	69.8	2,907,733
	> 1 - 3	9.4	91	23.6	980,540
	> 3 - 5	2.5	24	3.8	157,318
	>5 - 10	5.2	50	2.3	93,935
	>10 - 15	0.2	2	0.1	2,510
	>15	0.0	0	0.0	0
	No sampling	6.3	61	0.5	21,058
2002	≤ 1	77.1	744	84.4	3,513,479
	> 1 - 3	9.5	92	9.8	406,669
	> 3 - 5	1.8	17	2.5	105,991
	>5 - 10	5.5	53	2.8	115,038
	>10 - 15	0.1	1	0.0	1,003
	>15	0.0	0	0.0	0
	No sampling	6.0	58	0.5	20,914
2003	≤ 1	78.2	755	84.3	3,509,817
	> 1 - 3	8.3	80	9.1	380,551
	> 3 - 5	2.9	28	3.7	155,919
	>5 - 10	5.0	48	2.2	90,773
	>10 - 15	0.3	3	0.1	4,917
	>15	0.0	0	0.0	0
	No sampling	5.3	51	0.5	21,117
2004	≤ 1	78.2	755	82.0	3,413,665
	> 1 - 3	9.9	96	11.2	465,872
	> 3 - 5	2.7	26	4.2	172,960
	>5 - 10	4.7	45	2.1	88,617
	>10 - 15	0.2	2	0.1	4,877
	>15	0.1	1	0.0	40
	No sampling	4.1	40	0.4	17,063
2005	≤ 1	80.4	776	84.3	3,509,971
	> 1 - 3	8.9	86	10.5	435,571
	> 3 - 5	2.6	25	2.7	111,832
	>5 - 10	5.1	49	2.2	93,281
	>10 - 15	0.0	0	0.0	0

		Water Systems		Population	
Year	mg/L	%	Count	%	Count
	>15	0.0	0	0.0	0
	No sampling	3.0	29	0.3	12,439
2006	≤ 1	79.7	769	84.1	3,500,661
	> 1 - 3	9.9	96	10.1	420,890
	> 3 - 5	2.8	27	2.8	116,131
	>5 - 10	5.1	49	2.7	113,272
	>10 - 15	0.1	1	0.0	31
	>15	0.0	0	0.0	0
	No sampling	2.4	23	0.3	12,109
2007	≤ 1	79.4	766	86.1	3,584,310
	> 1 - 3	9.7	94	8.7	362,769
	> 3 - 5	3.4	33	2.7	112,634
	>5 - 10	5.1	49	2.4	98,852
	>10 - 15	0.1	1	0.0	40
	>15	0.0	0	0.0	0
	No sampling	2.3	22	0.1	4,489

C. Disinfection Byproducts (DBP)

Public water may contain microorganisms such as viruses and bacteria that can cause serious illnesses such as gastrointestinal disorders, diarrhea and even death. Many public water suppliers disinfect their water to kill these microbes. Chlorine is the most commonly used disinfectant, and is sometimes used in combination with other disinfectants such as ozone, chloramine, chlorine dioxide, and ultraviolet light. Disinfection byproducts (DBPs) are a family of chemicals formed when these disinfectants react with naturally occurring organic material (e.g., decomposing plants) in the source water. Several hundred DBPs in more than a dozen chemical classes have been identified.

The levels of DBPs depend upon the nature of the source water and type of disinfection and can change with seasons of the year, rainfall, and distance from the treatment plant to the consumer's tap. Surface water source CWS are often more likely to have higher DBP levels than groundwater source CWS because groundwater does not contain as much organic matter. Water system operators adjust water treatment methods to both limit the formation of disinfection byproducts and protect people from waterborne disease.

There are several ways in which people may be exposed to DBPs besides drinking tap water. DBPs may be inhaled when using tap water (e.g., cooking, showering). The hotter the water, the more likely it is that DBPs will be released into the air. Small amounts of DBPs can also be absorbed through the skin when bathing or swimming.

Health risks from exposure to the levels of DBPs found in drinking water are not well understood. Only a limited number of DBPs have been studied for their effects on human health. Some studies have found that people who drink chlorinated surface water have a higher risk of developing cancer of the bladder, rectum and colon. Other studies have suggested a potential association between exposure to disinfection byproducts during pregnancy and certain reproductive and developmental effects (e.g., miscarriages, premature births, low birth weight, and birth defects). There remains considerable debate in the scientific community about the significance of these findings. Animal, microbial, in vitro and modeling studies also have indicated toxicity or carcinogenicity of a wide variety of DBPs.

Residents of community water systems can find out the DBP levels, if any, in their drinking water by reading the Water Quality Report (often referred to as the Consumer Confidence Report) issued each year by their water utility. Granulated activated carbon (GAC) filters are effective in lowering DBP levels in drinking water and several types of GAC filters are available for home use. For volatile DBPs, exposure can be reduced by using taking shorter and cooler showers or baths, using shorter wash cycles for dishes and clothes, and ventilating enclosed spaces/rooms after water has been used. DBPs are not commonly found in private well water because it is not chlorinated on a regular basis and does not usually contain the necessary organic materials to form DBPs. Well owners should properly flush out their private well system after adding chlorine for disinfection purposes.

All CWS that disinfect their water (generally all surface water systems and many groundwater systems) are required to monitor for disinfection byproducts in the distribution system.

Currently, SDWA standards exist for two classes of halogenated organic DBPs, haloacetic acids (HAAs) and trihalomethanes (THMs), and for two inorganic compounds, bromate and chlorite Typically, larger surface water systems monitor more frequently and smaller systems using groundwater monitor less frequently. Systems may also qualify for reduced monitoring under two waivers (Very Small System Waiver or 40/30 Certification Waiver).

HAA5 and TTHM were chosen by the Tracking Network for drinking water quality tracking. Both groups are formed during disinfection with chlorine and chloramine. "HAA5" is the sum of five HAAs: monochloroacetic, dichloroacetic, trichloroacetic, monobromoacetic, and dibromoacetic acids. "TTHM" is the sum of four chlorine- and bromine-containing trihalomethanes: chloroform, bromodichloromethane, dibromochloromethane, and bromoform. Although there are many known DBPs as well as unidentified DBPs present in disinfected water, TTHM and HAA5 are considered useful indicators of the presence of many DBPs, given the prevalence of chlorine disinfection and their occurrence at typically higher levels than other DBPs. The MCL is 60 µg/L for HAA5 and 80 µg/L for TTHM. These levels are calculated as the running annual average of quarterly samples.

As shown in the "Key Dates" box below, the fact that the majority of CWS in Minnesota use groundwater and are small in size influences when a CWS was first required to comply with DBP regulations. Many CWS in Minnesota were not required to monitor for DBPs until 2004.

Key dates in DBP monitoring requirements for water supply systems using disinfectants

1981 – present: THMs for water systems serving 10,000 or more people.
2002 – present: THMs and HAAs for surface water systems and ground water systems under direct influence of surface water serving > 10,000 people.
2004 – present: THMs and HAAs for all other community water systems.

As shown in Table 8, only 64% of CWS in Minnesota currently disinfect. The majority of systems that do not disinfect do not conduct any DBP sampling. Of the CWS that do disinfect, the majority (78%) are only required to sample once every 3 years. As a result of CWS characteristics in Minnesota, the amount of DBP monitoring data may be sparse compared to other states.

Table 8: *Current DBP Sampling Frequency in Minnesota, 2008.†*

	None	Bi-monthly	Quarterly	Annually	Triennially	Total
No Disinfection	249 (72%)	4 (1%)	8 (2%)	23 (7%)	60 (17%)	344 (36%)
Disinfection	17 (3%)	5 (1%)	19 (3%)	98 (16%)	482 (78%)	621 (64%)

† Inclusion of systems that receive some or all finished drinking water from a wholesale system may introduce irregular results.

C.1. Number and percentage of CWS with DBP MCL violations; Number and percentage of people served by CWS with DBP MCL violations (HAA5 and TTHM)

No DBP MCL violations occurred between 1999 and 2003, likely due to the small percentage of systems in Minnesota that were required to monitor for DBPs prior to 2004. From 2004 to 2007, less than 0.3% of CWS (supplying less than 0.2% of the population) violated either the HAA5 or TTHM standard in any given year, as seen in Table 9.

Table 9: *Annual number and percentage of CWS and people served by CWS with a DBP violation, Minnesota, 1999-2007.*

	Annual percentage and count of CWS with DBP MCL violation		Annual percentage and count of people served by CWS with DBP MCL violation	
Year	**%**	***Count***	**%**	***Count***
1999	0.0	*0*	0.0	*0*
2000	0.0	*0*	0.0	*0*
2001	0.0	*0*	0.0	*0*
2002	0.0	*0*	0.0	*0*
2003	0.0	*0*	0.0	*0*
2004	0.2	*2*	0.1	3,820
2005	0.1	*1*	0.1	*3,444*
2006	0.1	*1*	0.0	*1,170*
2007	0.1	*1*	0.0	*1,170*

As shown in Table 10, when examined by quarter, very little difference is seen in the overall percent of DBP violations due to the small total number of exceedances that occurred over this time period. Less than 0.3% of CWS (supplying less than 0.2% of the population) violated DBP drinking water standards in any given quarter. No seasonal pattern in violations is seen, likely due to how the running annual average is calculated.

Table 10: *Quarterly percentage and number of CWS and people served by a CWS with DBP violations, Minnesota, 2004-2007.*†

		Water Systems		Population	
Year	**Quarter**	**%**	***Count***	**%**	***Count***
2004	1	0.0	*0*	0.0	*0*
	2	0.2	*2*	0.1	*3,820*
	3	0.2	*2*	0.1	*3,820*
	4	0.2	*2*	0.1	*3,820*
2005	1	0.1	*1*	0.1	*3,444*
	2	0.1	*1*	0.1	*3,444*
	3	0.1	*1*	0.1	*3,444*
	4	0.0	*0*	0.0	*0*
2006	1	0.0	*0*	0.0	*0*
	2	0.1	*1*	0.0	*1,170*
	3	0.1	*1*	0.0	*1,170*
	4	0.1	*1*	0.0	*1,170*
2007	1	0.1	*1*	0.0	*1,170*
	2	0.1	*1*	0.0	*1,170*
	3	0.0	*0*	0.0	*0*
	4	0.0	*0*	0.0	*0*

† There were no DBP violations in any year or quarter prior to 2004.

Given four quarters per year and two DBP standards (for TTHM and HAA5), there could be up to eight violations per year in a CWS. As shown in Table 11, more than 99.5% of the systems had no violations in any year. Systems that violated a DBP standard in a given year did so more than once (i.e., in >1 quarter). Between 1999 to 2007, the proportion of the population served by systems with no DBP violations ranged from 99.9% to 100.0%.

Table 11: *Number and percentage of CWS and people served by a CWS by category of the number of DBP violations, Minnesota, 2004-2007.†*

		Water Systems		Population	
Year	**Violations**	**%**	***Count***	**%**	***Count***
2004	0	99.8	*963*	99.9	*4,159,274*
	1-2	0.0	*0*	0.0	*0*
	3	0.0	*0*	0.0	*0*
	4-5	0.0	*0*	0.0	*0*
	6	0.2	*2*	0.1	*3,820*
	7-8	0.0	*0*	0.0	*0*
2005	0	99.9	*964*	99.9	*4,159,650*
	1-2	0.0	*0*	0.0	*0*
	3	0.0	*0*	0.0	*0*
	4-5	0.0	*0*	0.0	*0*
	6	0.1	*1*	0.1	*3,444*
	7-8	0.0	*0*	0.0	*0*
2006	0	99.9	*964*	100.0	*4,161,924*
	1-2	0.0	*0*	0.0	*0*
	3	0.1	*1*	0.0	*1,170*
	4-5	0.0	*0*	0.0	*0*
	6	0.0	*0*	0.0	*0*
	7-8	0.0	*0*	0.0	*0*
2007	0	99.9	*964*	100.0	*4,161,924*
	1-2	0.0	*0*	0.0	*0*
	3	0.1	*1*	0.0	*1,170*
	4-5	0.0	*0*	0.0	*0*
	6	0.0	*0*	0.0	*0*
	7-8	0.0	*0*	0.0	*0*

† There were no DBP violations in any quarter or year prior to 2004.

Adding up the number of months of water received by all Minnesota residents served by CWS provides the number of person-months. Percentage of person-months is the sum of the CWS populations multiplied by the number of months in which no DBP violation occurred. This is an estimate of the potential population exposure to water contaminants in CWS. From 1999 to 2007, potential population exposure to water with DBP levels exceeding the MCL was consistently at or below 0.1%, as shown in Table 12.

Table 12: *Percent of 'person-months' for which no DBP MCL violations occurred for a CWS, Minnesota, 1999-2007.*

Year	% Person-months
1999	100.0
2000	100.0
2001	100.0
2002	100.0
2003	100.0
2004	99.9
2005	99.9
2006	100.0
2007	100.0

C.2. Annual number of people served by CWS by mean DBP concentration

The following tables present the number and percentage of people who received water with different levels of TTHM and HAA5 from 2004-2007. Only a small percentage of systems in Minnesota were required to monitor for DBPs prior to 2004. For over 95% of consumers, average TTHM and HAA5 levels corresponded to less than half the MCLs. Figures 5 and 6 present 2007 data relative to the MCLs.

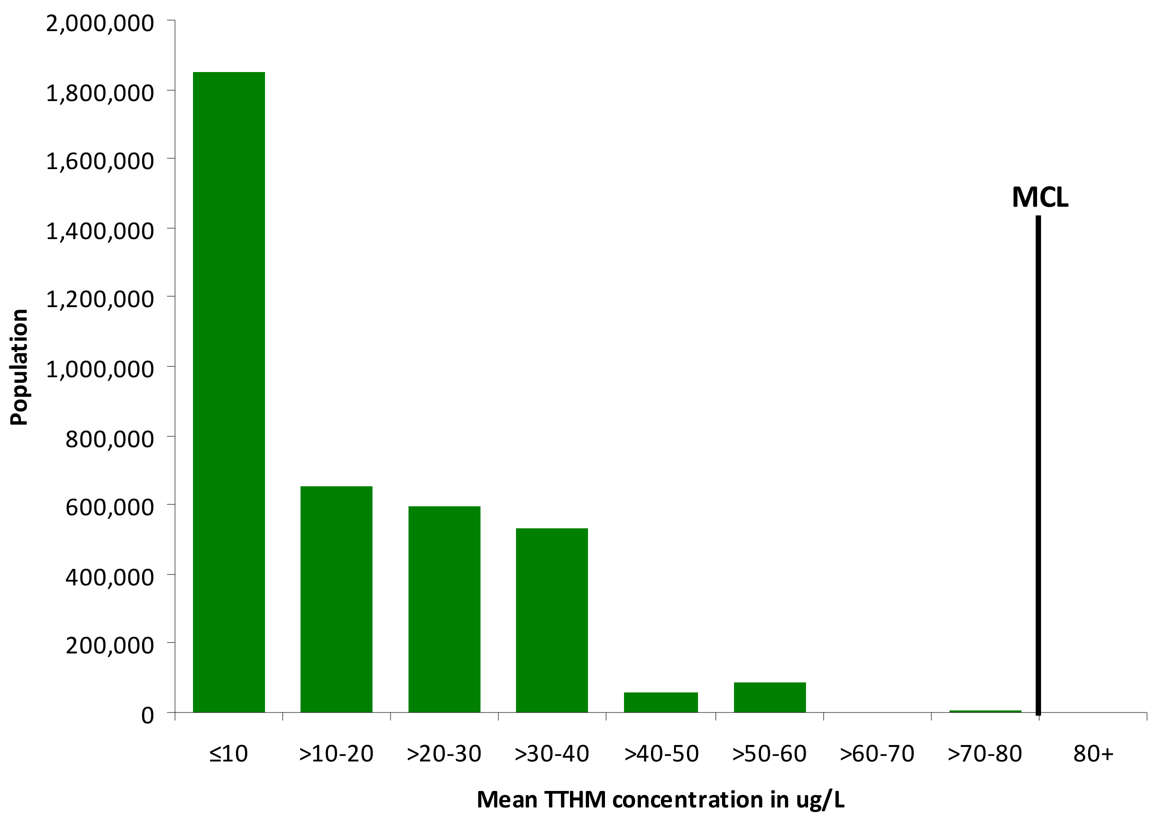
Table 13: *Number and percentage of people served by CWS at various TTHM concentrations, Minnesota, 2004-2007.*

	2004		2005		2006		2007	
TTHM	Population		Population		Population		Population	
Mean Concentration	Count	Percent	Count	Percent	Count	Percent	Count	Percent
≤10 μg/L	1,730,057	41.6%	2,047,570	49.2%	1,876,706	45.1%	1,851,023	44.5%
>10-20 μg/L	389,194	9.3%	610,061	14.7%	909,129	21.8%	650,916	15.6%
>20-30 μg/L	588,143	14.1%	597,619	14.4%	764,470	18.4%	592,919	14.2%
>30-40 μg/L	516,807	12.4%	492,187	11.8%	110,059	2.6%	531,547	12.8%
>40-50 μg/L	34,209	0.8%	52,775	1.3%	45,094	1.1%	55,367	1.3%
>50-60 μg/L	8,5550	0.2%	84,120	2.0%	11,319	0.3%	86,569	2.1%
>60-70 μg/L	30,345	0.7%	3,803	0.1%	727	0.0%	2,042	0.0%
>70-80 μg/L	4,129	0.1%	5,755	0.1%	0	0.0%	4,484	0.1%
80+ μg/L	2,570	0.1%	1,170	0.0%	845	0.0%	1,239	0.0%
Missing	782,090	18.8%	268,034	6.4%	444,745	10.7%	386,988	9.3%
Total	4,163,094		4,163,094		4,163,094		4,163,094	

Table 14: *Number of people served by CWS by various HAA5 concentrations, Minnesota, 2004-2007.*

HAA5 Cutpoint	2004 Population Count	2004 Percent	2005 Population Count	2005 Percent	2006 Population Count	2006 Percent	2007 Population Count	2007 Percent
≤10	1,327,947	31.9%	2,434,112	58.5%	2,229,704	53.6%	2,173,300	52.2%
>10-20	1,112,238	26.7%	229,787	5.5%	1,149,899	27.6%	655,134	15.7%
>20-30	120,543	2.9%	951,355	22.9%	32,428	0.8%	482,481	11.6%
>30-40	14,164	0.3%	31,131	0.7%	23,408	0.6%	112,237	2.7%
>40-50	27,959	0.7%	7,999	0.2%	3,518	0.1%	5,824	0.1%
>50-60	0	0.0%	1,307	0.0%	0	0.0%	218	0.0%
60+	3,444	0.1%	110	0.0%	970	0.0%	229	0.0%
Missing	1,556,799	37.4%	507,293	12.2%	723,167	17.4%	733,671	17.6%
Total	4,163,094		4,163,094		4,163,094		4,163,094	

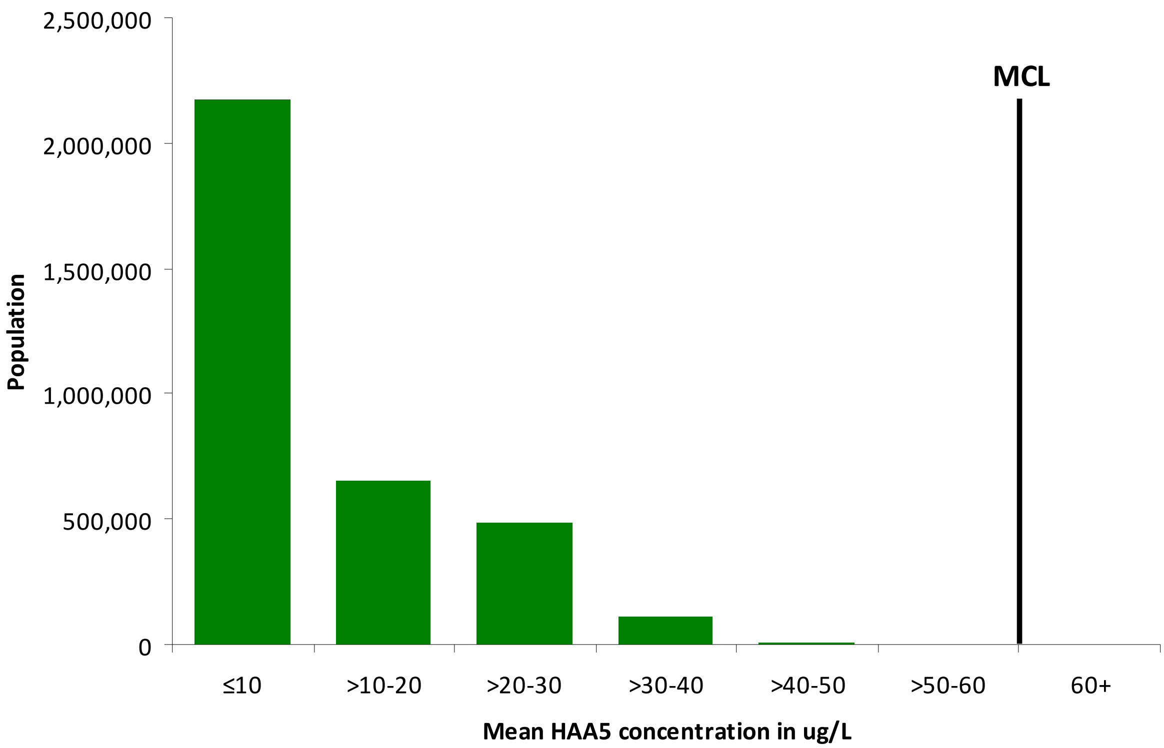
Figure 5: *Distribution of number of people by mean TTHM concentration compared to the MCL for 2007.†*



The Maximum Contaminant Level (MCL) of 80 µg/L is indicated as a black bar.

† No sampling data were available for 386,988 people served by CWS in 2007.

Figure 6: *Distribution of number of people by mean HAA5 concentration compared to the MCL for 2007.†*



The Maximum Contaminant Level (MCL) of 60 µg/L is indicated as a black bar.
† No sampling data were available for 733,671 people served by CWS in 2007.

D. Lead

Lead is rarely found in source water, but enters tap water through corrosion of household lead-based plumbing materials. Health risks are greatest for children six years old and under because this is when the brain is rapidly developing. Although the primary source of lead exposure for most children is lead-based paint in older homes, lead in drinking water can add to that exposure. EPA estimates that 10 to 20 percent of a child's exposure to lead may come from lead in drinking water.[7] Infants who consume mostly mixed formula can receive 40-60% of their exposure to lead from drinking water.[6] Children's exposure to lead can result in delays in physical or mental development (e.g., lower IQ scores in children). For adults, lead exposure can result in kidney problems or high blood pressure.

There are several ways to reduce exposure to lead in drinking water. Water that stands idle in pipes for long periods of time is more likely to absorb lead from the plumbing system. Flush taps before using water for drinking or cooking. Hot water dissolves lead more quickly than cold water, so do not use water from the hot-water faucet for cooking or drinking. It is especially important not to use the hot water for making baby formula. Some treatment devices and a few types of water filters can reduce the amount of lead in drinking water. Many laboratories can test your water to see if lead is a problem. Fees will vary between labs. To make sure the laboratory is certified by MDH to test drinking water for lead, see: http://www.health.state.mn.us/divs/phl/cert/allcertlabs.html. For more information on simple precautions one can take to reduce levels of lead in home drinking water, see: http://www.health.state.mn.us/divs/eh/water/com/fs/letitrun_english.html

All CWS are required to monitor for lead in drinking water. Lead is measured at household taps in high risk homes. The number of sites and samples required varies by the size of the population served. Initially, samples are taken every 6 months. Systems can then qualify for reduced monitoring (annually, triennially, once every 9 years) if they meet certain criteria.

Since lead contamination generally occurs from corrosion of household lead pipes, it cannot be directly detected and removed by the water system. Instead, EPA requires water systems to control the corrosiveness of their water if the level of lead at home taps exceeds the Action Level (AL). The AL for lead has been set at 15 µg/L, the level EPA considers, given present technology and resources, the lowest level to which water systems can reasonably be required to control this contaminant should it occur in drinking water at their customers' home taps. If more than 10% of taps sampled exceed the lead AL of 15 µg/L, water systems must take additional steps to reduce corrosion. The MCLG for lead is set at zero.

An AL exceedance is not an MCL violation but can trigger other requirements that include:

- water monitoring
- corrosion control treatment
- source water treatment
- public education
- lead service line replacement

D.1. Annual number and percent of CWS with any lead action level exceedance

As many as 15 CWS have exceeded the AL for lead between 1999-2007. Over the past five years, <1% of CWS in Minnesota have exceeded the lead AL. Due to the nature of the lead sampling, no measure linking population data by CWS is recommended by the Tracking Network.

Table 15: *Annual percentage and count of CWS with lead action level exceedances, Minnesota, 1999-2007.*

	CWS with lead action level exceedances	
Year	**%**	***Count***
1999	1.6	*15*
2000	1.2	*12*
2001	1.2	*12*
2002	1.0	*10*
2003	0.3	*3*
2004	0.4	*5*
2005	0.8	*13*
2006	0.8	*8*
2007	0.4	*4*

Strengths and Limitations of Data Sources and Measures

These measures are part of the first multi-state initiative to use contaminant data to track trends and ultimately integrate environmental information with health effect data to explore potential relationships between drinking water and human health. State drinking water information systems ("MNDWIS" in Minnesota) have many strengths that make them an ideal data source for tracking. MNDWIS includes information on all community water systems in the state (except those within tribal land boundaries). Additionally, the data are available for multiple years and can be used in time trend analyses. Because the data are structured based on national reporting requirements set by EPA, core data formats and data elements are similar across states. The measures are simple to calculate, unambiguous, and readily comprehended as an indicator for the absolute and relative magnitude of the problem of drinking water contamination at levels that may pose a health risk, as well as the absolute and relative size of the population potentially at risk.

The following limitations should be considered when interpreting the measures:

- Some factors may lead to over- or understating the extent of population receiving water that violates standards or contains higher concentrations of contaminants:
  - The entire population served by each system in violation is reported, even though only part of the total population served may have received water that was out of compliance. Particularly for some contaminants (e.g., DBPs) and/or systems which have more than one point in the distribution system where water is supplied, water quality may vary between different parts of the distribution system. For arsenic, the means of values may not represent actual concentrations at residential service connections due to system hydraulic characteristics and differences in water flow through each entry point to the distribution system.
  - Violations stated on an annual basis may suggest a longer duration of violation than may be the case, as some violations may be as brief as a day.
  - Some violations may be unreported, particularly if monitoring is infrequent—leading to undercounting. Sampling may be too infrequent to capture high levels or short-term variability. For some contaminants that vary substantially in water (e.g., nitrates), high levels may not be captured by even quarterly sampling.
  - Systems with sampling waivers (and no data as a result) may conservatively bias the measures, since waivers are justified by monitoring data showing low or no contamination potential. It can be assumed that systems with a waiver have non-detectable to low levels of the contaminant.
  - The accuracy of the system population information is not well characterized and should not be considered absolute measures of population served. Water operators derive population estimates using census estimates, number of water connections or some other means. Further, system population is a current estimate, so population-based estimates for past years may be inaccurate (likely over-estimated). Historical information on population served is not available. In Minnesota, population estimates are updated approximately every 18 months; however, the measures may overestimate/underestimate the number of affected people.

- Water quality measures may not reflect actual human exposure to contaminants for the following reasons:
  - Human behaviors (e.g., showering and bathing time, amount of tap water consumed, bottled water use, and exposure to water at workplaces or other locations outside the home) greatly influence exposure, complicating efforts to adequately estimate exposure from home tap water. For some contaminants (e.g., nitrate, arsenic) drinking water is not the sole or even primary source of dietary intake.
  - Measures based on MCL violations are not directly related to human health outcomes, particularly since establishment of MCLs is based on engineering and cost considerations as well as human health risks. Although the MCL is presented as a "bright line" threshold, it does not translate into people who may be at risk versus not at risk . Also, MCLs do not address peak exposures, but may provide a valid indicator of persistently elevated contaminant levels.
- Additional limitations include the following:
  - Trends can be confounded by the fact that water quality standards and treatment requirements change over time. Thus, an apparent increase in violations over time may result from a new or more strict standard rather than a decline in the quality of drinking water.
  - Sample results below the limit of detection (LOD) were entered as ½ LOD for arsenic and nitrate. Sample results < LOD were entered as 0.0 for disinfection byproducts. Decisions regarding values < LOD were made by the Tracking Network. Although no sensitivity analyses were conducted to characterize how these two approaches impact the measures, it is possible that they may produce biased estimates of the mean if a large proportion of samples are < LOD.
  - The number of systems above a concentration corresponding to the MCL may not equal the number of systems in violation of the MCL. Presenting average concentrations by calendar year is not usually consistent with how MCL violations are calculated (i.e., typically based on running averages).
  - SDWA compliance data include only a handful of the hundreds of known DBPs, most of which occur in chemical classes other than THMs and HAAs. Measured concentrations of THMs and HAAs may not be good predictors of exposure to other DBPs or overall DBP exposure. Even among the THMs and HAAs, different DBPs have been found to produce different health effects. It is therefore more useful to track individual DBP species, not just class totals.

As of the time of this report (December 2009), the tracking network was in the process of reviewing and revising the drinking water quality measures, with the goal of addressing a number of these limitations.

Acronyms

AL	Action Level
CDC	Centers for Disease Control and Prevention
CWS	Community Water Systems
DBPs	Disinfection Byproducts
EPHT	Environmental Public Health Tracking
EPA	Environmental Protection Agency
HAAs	Haloacetic Acids
HAA5	5 Haloacetic Acids
LOD	Level of Detection
MCL	Maximum Contaminant Level
MCLG	Maximum Contaminant Level Goal
MDH	Minnesota Department of Health
µg/L	Micrograms per liter
mg/L	Milligrams per liter
MNDWIS	Minnesota Drinking Water Information System
MN EPHT	Minnesota Environmental Public Health Tracking
NCDM	Nationally Consistent Data and Measures
SDWA	Safe Drinking Water Act
THMs	Trihalomethanes
TTHMs	Total Trihalomethanes
TTR	Treatment Technique Requirements

Glossary

Action Level (AL): the level of lead or copper which, if exceeded, triggers treatment or other requirements that a water system must follow

Aquifer: a natural underground layer, often of sand or gravel, containing water

Arsenic: a semi-metal element in the periodic table; it enters community drinking water supplies from natural deposits in the earth or from agricultural and industrial practices

CDC: the Centers for Disease Control and Prevention, a part of the U.S. Department of Health and Human Services, is the nation's public health agency that works to ensure health protection through promotion, prevention, and preparedness

Community Water System (CWS): a public water system that serves year-round residents of a community, subdivision, or mobile home park that has at least 15 service connections or an average of at least 25 residents

Compliance: the act of meeting all state and federal drinking water regulations

Compliance period: time period that CWS must monitor for contaminants in order to meet all state and federal drinking water regulations

Contaminant: anything found in water (including microorganisms, minerals, chemicals, elements that emit radiation, etc.) which may be harmful to human health

Corrosion: the gradual decomposition or destruction of a material by chemical action; corrosion starts at the surface of a material and moves inward.

Disinfection byproducts (DBPs): form when disinfectants used to treat community drinking water react with naturally occurring materials in the water (e.g., decomposing plant material); EPA regulates two classes of DBPs: total trihalomethanes (TTHM) and haloacetic acids (HAA5)

Disinfectant: a chemical (commonly chlorine, chloramine, or ozone) or physical process (e.g., ultraviolet light) that inactivates microorganisms such as bacteria, viruses, and protozoa

Distribution system: a network of pipes leading from a treatment plant to customers' plumbing systems

EPA: the United States Environmental Protection Agency leads the nation's environmental science, research, education and assessment efforts; the mission of the EPA is to protect human health and the environment

Environmental Public Health Tracking (EPHT): the ongoing collection, integration, analysis, interpretation, and dissemination of data from environmental hazard monitoring, and from human exposure and health effects surveillance

Entry point: site sampled that is representative of each well or source after treatment and before the first customer, unless the state designates another sampling point as more representative

Epidemiology: the study of human populations to identify the occurrence and causes of disease; epidemiology studies often compare the health status of a group of persons who have been exposed to a suspect agent with that of a comparable non-exposed group

Finished drinking water: water that has been treated and is ready to be delivered to customers

Groundwater: the water that systems pump and treat from aquifers (natural reservoirs below the earth's surface)

Haloacetic Acids (HAA): a family of organic compounds that are formed when chlorine or other disinfectants used to control microbial contaminants in community drinking water react with naturally occurring organic and inorganic matter in water

HAA5: the sum of five regulated haloacetic acids (monochloro-, dichloro-, trichloro-, monobromo-, dibromo- acetic acids); a widely occurring class of distribution byproducts (DBPs) formed during disinfection with chlorine and chloramine

Healthy People 2010: launched by the Department of Health and Human Services in January 2000 as a comprehensive, nationwide health promotion and disease prevention agenda; contains 467 objectives within 28 focus areas designed to serve as a framework for improving the health of all people in the U.S. during the first decade of the 21^{st} century

Inorganic contaminants: mineral-based compounds such as metals, nitrates, and asbestos; these contaminants are naturally-occurring in some water, but can also get into water through farming, chemical manufacturing, and other human activities

Lead: a toxic metal found in natural deposits; it is commonly used in household plumbing materials and water service lines

Maximum Contaminant Level (MCL): the maximum permissible level of a contaminant in water which is delivered to any user of a public water system; the MCL is set as close to the maximum contaminant level goal (MCLG) as feasible, which the Safe Drinking Water Act defines as the level that may be achieved with the use of the best available technology, treatment techniques, and other means which EPA finds are available, taking cost into consideration; some states set MCLs which are more strict than EPA

Maximum Contaminant Level Goal (MCLG): the maximum level of a contaminant in community drinking water at which no known or anticipated adverse effect on the health of persons would occur, and which allows an adequate margin of safety; MCLGs are non-enforceable public health goals and are sometimes they are set at a level which water systems cannot meet, since MCLGs consider only public health and not the limits of detection and treatment technology

Measure: for tracking, a measure is a specific way to calculate a value from the data describing population health, hazard or exposure; measures should be clearly and uniquely defined such that, given the appropriate data, the value of the measure could be calculated in a consistent fashion (like a statistic)

Methemoglobinemia: a disorder characterized by the presence of a higher than normal level of methemoglobin in the blood; methemoglobin is a form of hemoglobin that does not bind oxygen; infants under 6 months of age are particularly susceptible to methemoglobinemia caused by nitrates ingested in drinking water

Minnesota Department of Health (MDH): the state government agency in Minnesota that focuses on protecting, maintaining and improving the health of all Minnesotans; consists of seven major divisions, including Community and Family Health, Compliance Monitoring, Environmental Health, Health Policy, Health Promotion and Chronic Disease, Infectious Disease Epidemiology Prevention and Control, and Public Health Laboratory

Minnesota Drinking Water Information System (MNDWIS): Minnesota's Safe Drinking Water Information System used to help manage the information necessary to supervise public drinking water systems; it houses three major categories of information: inventory, sampling, and monitoring data

Minnesota Environmental Public Health Tracking Program (MN EPHT): As defined in Minnesota Statutes, section 144.995, a state program for the ongoing collection, integration, interpretation, and dissemination of environmental hazard, exposure, and health effects data. MN EPHT produces a network or system of integrated data in the state about environmental hazards, population exposure, and health outcomes; MN EPHT works in partnership with other states as part of CDC's National Environmental Public Health Tracking Network (Tracking Network).

Micrograms per liter (µg/L): one microgram of a substance dissolved in each liter of water; this unit is equal to parts per billion (ppb) since one liter of water is equal in weight to one billion micrograms

Microbial contamination: contamination of a water source by disease-causing micro-organisms

Milligrams per liter (mg/L): one milligram of a substance dissolved in each liter of water; this unit is equal to parts per million (ppm) since one liter of water is equal in weight to one million milligrams

Monitoring: testing that water systems must perform to detect and measure contaminants; ublic water supply systems in Minnesota are required to sample treated—or "finished"—water on a regular basis and submit the samples to the MDH laboratory for analysis; the samples are tested for a broad range of potential contaminants, and if unacceptable levels of contaminants are found, the water supply owner or operator is legally responsible for informing the people who use the water and for taking steps to eliminate potential health hazards

National Environmental Public Health Tracking Network (Tracking Network): a web-based, secure network of standardized health and environmental data; the Tracking Network is a product of CDC's National Environmental Public Tracking Program, drawing data and information from state and local tracking networks as well as national-level and other data systems; it provides the means to identify, access, and organize hazard, exposure, and health data from these various sources and to examine and analyze those data on the basis of their spatial and temporal characteristics

Nationally Consistent Data and Measures (NCDM): adaptation of a single set of national standards for data collection, analysis and reporting to enable CDC to compile a core set of nationally consistent data and measures across multiple states

Nitrate: an inorganic compound occurring naturally in the environment; elevated nitrate levels in community drinking water are usually associated with the use of fertilizer, or the breakdown of human and animal waste; nitrate is a health concern primarily for infants under the age of six months

Organic contaminants: carbon-based chemicals, such as solvents and pesticides, which can get into water through runoff from cropland or discharge from factories

Person-month: A person month is defined as one person receiving water for one month

Public water system: any water system which provides water to at least 25 people for at least 60 days annually; there are differing standards for public water systems of different sizes and types

Running average: the average of all values in a specific field up to any given record; commonly used with time series data to smooth out short-term fluctuations and highlight longer-term trends or cycles; for TTHM, HAA5 and arsenic, the MCL is based on a running annual average

Sample: water that is analyzed for the presence of EPA-regulated drinking water contaminants; depending on the regulation, EPA requires water systems and states to take samples from source water, from water leaving the treatment facility, or from the taps of selected consumers

Safe Drinking Water Act (SDWA): passed by Congress in 1974 to protect public health by regulating the nation's public drinking water systems. SDWA authorizes the US EPA to set national health-based standards for drinking water to protect against both naturally-occurring and man-made contaminants that may be found in drinking water; US EPA, states, and water systems then work together to make sure that these standards are met

Source water: water in its natural state, prior to any treatment for drinking

Surface water: the water that systems pump and treat from sources open to the atmosphere, such as rivers, lakes, and reservoirs

Toxicology: the study of the adverse effects of chemical, physical or biological agents on living organisms and the ecosystem

Treatment Technique Requirement (TTR): specific water treatment practices, such as filtration or corrosion control, required to reduce the level of a contaminant in community drinking water; requirements are set for contaminants in drinking water that are difficult or costly to measure and is used instead of a Maximum Contaminant Level (MCL)

Trihalomethanes (THM): One of a family of organic compounds named as derivatives of methane. THMs are generally the by-product from chlorination of community drinking water that contains organic material. The resulting compounds (THMs) are suspected of causing cancer.

TTHM: total trihalomethanes are a widely occurring class of Disinfection Byproducts (see DBPs) that include chloroform, bromoform, bromodichloromethane, and dibromochloromethane

Violation: a failure to meet any state or federal drinking water regulation

Waiver: provisions available by which States may waive sampling requirements if certain conditions are met, granted on a contaminant-by-contaminant basis; waivers may be issued for a maximum of 3, 6, or 9 year periods, depending on the contaminant and system-specific conditions

Water supply system: the collection, treatment, storage, and. distribution of potable water from source to consumer

Wholesale system: a public water system that supplies finished water to one or more other public water systems

Sources:
Health, U.S. 2008 Appendix II: Definitions and Methods
Last, John M. 2001. *A Dictionary of Epidemiology 4th ed.* Oxford: Oxford University Press.
EPA: http://www.epa.gov
CDC Tracking Network glossary: http://www.cdc.gov/nceh/tracking/lib/glossary.htm

Drinking Water Quality Resources

Minnesota Department of Health, Drinking Water Protection Program
http://www.health.state.mn.us/divs/eh/water/index.html

Minnesota Department of Health, Well Management Program
http://www.health.state.mn.us/divs/eh/wells/index.html

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American Water Works Association
http://www.awwa.org/

Minnesota Section American Water Works Association
http://www.mnawwa.org/

EPA Drinking Water and Health Advisories
http://www.epa.gov/waterscience/criteria/drinking/

EPA Office of Ground Water & Drinking Water
http://www.epa.gov/ogwdw/

EPA Reference Guides to Drinking Water Rules and Standards
http://www.epa.gov/safewater/publicoutreach/quickreferenceguides.html

Minnesota Pollution Control Agency (MPCA)
http://www.pca.state.mn.us/

Minnesota Rural Water Association
http://www.mrwa.com/

CDC Drinking Water
http://www.cdc.gov/healthywater/drinking/

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