WATER SAMPLING & TESTING

Introduction:
According to the well code, all new drinking water wells are required to be sampled for the presence of coliform bacteria prior to being placed into service. The well owner is ultimately responsible for collecting the samples, and the well contractor is responsible for notifying the well owner of their need to collect the samples.

Some local health departments may require additional sampling such as partial chemical or arsenic. This additional sampling will typically be described on the well construction permit.

General Rules:

- The sampling location selected should reflect the quality of water coming from that portion of the water supply being evaluated.
- For new installations, the sampling tap at the pressure tank is most commonly used.
- For routine monitoring of both existing and new installations, the sampling tap at the kitchen sink is often used.
- Sampling from the well head is the most practical method of determining the quality of water from the well itself. This eliminates the influence from service lines, pressure tanks, valves, etc.

Sampling at the pressure tank evaluates the following:

1. piping (drop pipe and service line)
2. pressure tank
3. pump
4. well structure
5. aquifer

Sampling at the kitchen sink evaluates the following:

1. piping (drop pipe and service line)
2. treatment equipment
3. hot water tank
4. pressure tank
5. pump
6. well structure
7. aquifer

Coliform Bacteria Sampling Procedures:

1. Flush sampling tap (into pail if at pressure tank).
2. Reduce flow.
3. Obtain correct sample container.
4. Remove seal from sampling container.
5. Carefully remove cap and do not set down.
6. Collect sample (do not fill above designated fill line).
7. Recap bottle immediately.
8. Shake bottle to dissolve thiosulfate tablet.
9. Promptly mail or deliver the sample to a certified laboratory for analysis.

Sample Interpretation:

- Coliform is an indicator.
- Coliform distribution is not uniform.
- Sampling is just a “snapshot” in time.
- Repeat unsafe = problem.

RULES

Rule 161:

(2) Prior to placing well into service:

✓ Flush all chlorine (use test kit).
✓ Collect 1 or more samples.
✓ Coliform shall not be present.

(3) Owner responsible for collection of water sample.
(3) Driller must notify owner of the requirement to sample.

(4) A driller is not required to redisinfect a well or pump installation if unacceptable results are obtained from a tap other than the sampling faucet.

Rule 158:

Sampling tap must be installed:

✓ At least 8 inches above the floor.
✓ In a convenient location.
✓ Downturned faucet.

Drinking Water Sampling and Testing Overview

Laboratory

The DNRE drinking water laboratory and numerous other private laboratories provide testing services for the evaluation of drinking water. The DNRE lab testing services include physical, chemical and microbiological analyses.

It is recommended that individuals use laboratories certified by the state of Michigan to analyze drinking water samples. A laboratory may be certified, but only for microbiological analysis and perhaps not for volatile organic compounds (VOC), even if the laboratory has the capability to perform that testing. To receive a list of state certified labs go to www.michigan.gov/deq and click on "Water", then "Drinking Water", then "Contamination Investigation".

General

If investigating a specific problem, always consider how the well location (including sample location) is related to suspect sources of potential problems.
When selecting a sampling point, consider the following:

- Collect the sample as close to the well as possible, generally near the pressure tank. **Caution: Do not enter confined spaces such as well pits to collect samples.**
- Outside taps may be used for sample collection. These taps allow for easy access and more extensive flushing. Typically, these taps supply untreated water.
- Intermediate plumbing or connections to the source may contribute other contaminants.
- Samples should be untreated (without softener, filter, etc.).
- Do not collect samples from plumbing materials not approved by NSF for potable water use.

The water to be sampled should be representative of ground water quality. As a general rule, let the water run at full flow from the sampling point through two pump cycles or 10 minutes before collecting the sample. This may not be practical, as it may be difficult to dispose that volume of water in a basement or crawl space. The water may run through another tap, such as an outside or laundry sink tap for two pump cycles, then flush the sampling tap with 10 to 15 gallons of water into a pail before collection.

For a recently chlorinated well, sample only after the well water is free of chlorine. Check the water for chlorine residual before collecting samples. VOC samples may show disinfection byproducts such as chloroform, bromiform, and other trihalomethanes (THM).

For new wells constructed with approved plastic casing, be aware that volatile organic analyses may detect by-products of construction such as methyl ethyl ketone (MEK) and tetrahydrofuran (THF). Volatile organic analyses of water from new wells may also detect toluene, which can be a by-product of well construction/development. If toluene is present as a result of construction/development, thorough flushing will gradually diminish its concentration.

- After flushing the water supply system at full flow, reduce the water flow to provide a stream of water approximately the size of a pencil diameter.
- Do not open sample container until the moment of sample collection. Do not touch the inside of the bottle or cap.

- Follow the recommended procedures below for the specific type of sampling container(s).
- Do not use felt markers that contain solvents near sample vials. Complete laboratory analysis request form in pencil or waterproof black ink. All sample bottles use the same laboratory form. One form must be completed for each bottle submitted.
- Attach form to sample bottle or enclose within the single mailing container.
- Return samples to the laboratory immediately.
- Types of common analyses are explained below with the bottle, or kit number, in parentheses.

Volatile Organic (36VO)

- Do not collect a sample where chemical odors are detected. Collect the sample in a location free of organic chemical vapors (gasoline, fuel oil, paint, paint thinner, and solvents).
- Do not touch the inside of the cap, septum or bottle. Do not rinse the bottle or allow the water to overflow. A preservative must be added to the bottles at the time of collection. Do not drop the septum out of the cap. If the septum is dropped or touched, do not use the bottle.
- Fill the bottle so as to exclude all air. Fill completely with low flow until water rounds above the top of the bottle. Carefully replace and tighten cap. Invert. If an air bubble appears, remove the cap and carefully add water. Repeat until no air remains in the vial.
- Chill the sample and transport to the laboratory immediately.

Nonvolatile Organic (36NV)

- Do not touch the inside of the cap or bottle.
- Do not rinse the bottle or allow water to overflow. Bottles contain a dechlorinating agent. Fill to bottom of bottle neck.
- Chill sample and transport to the laboratory immediately.

Metals (36ME)

- Do not touch the inside of the cap or bottle.
- Do not rinse the bottle.
- Do not filter LSS samples. The sample will be automatically acidified at the time of sample collection.
- Fill to bottom of bottle neck.
- Transport to the laboratory immediately. Chilling of sample is not required.

Cyanide (36CN (unchlorinated) or 36CNa (chlorinated)), Hydrogen Sulfide by titration (36HS) or Hydrogen Sulfide presence/absence (CH2S), and Ammonia (36AC)

- Do not touch the inside cap or bottle.
- Do not rinse the bottle. Do not allow the water to overflow. These bottles contain a preservative to either keep cyanide or ammonia in solution or to precipitate sulfide in the hydrogen sulfide analysis. Fill to bottom of neck.
- Cyanide samples need to be chilled.
- Hydrogen sulfide and ammonia do not need to be chilled.
- Transport to the laboratory immediately.

Bacteriology (30)

- Do not touch the inside cap or bottle. Do not rinse the bottle or allow overflowing. Bottle contains a dechlorinating agent. Fill vial to 100-milliliter (ml) line.
- Chill sample and transport to the laboratory immediately. United States Environmental Protection Agency (U.S. EPA) holding time limit is 30 hours.

Partial Chemical (32) and Complete Minerals (33)

- Do not touch the inside cap or bottle. Do not rinse the bottle. Fill bottle to bottom of neck.
- Chill sample and transport to the laboratory immediately. U.S. EPA holding time for nitrate (NO_3) and nitrite (NO_2) is 48 hours.

Transporting Samples to Laboratory

Samples kept inside cars during summer months can reach excessive temperatures and adversely affect sample results. Temperature sensitive samples (noted above) during collection day should be kept in an insulated container at approximately same temperature as ground water (50°F, 10°C).

- DO NOT let ice come in contact with laboratory analysis request forms.
- DO USE ice cubes in sealed plastic bags.
- DO USE reusable ice packs (i.e. “Blue Ice” or type with hard plastic shell).

The best method of delivery is transporting directly to the DEQ laboratory the same day as collection inside the insulated container. It is acceptable to mail samples. U.S. Mail will deliver to DEQ laboratory Lansing post office box that is checked twice per day. Bottles must be properly packaged in laboratory mailing containers provided to avoid breakage during transit. UPS provides the best route for sending time sensitive samples or when requesting RUSH analysis.

- Bottles must be properly packaged in laboratory packaging containers bearing address label provided to avoid breakage during transit.
- Time sensitive samples should not be sent this route as arrival to post office may be after staff pick up time (6 and 9:30 AM M-F).
- It is requested samples be mailed so they are received in the DEQ laboratory between Monday and Thursday in order to meet U.S. EPA time requirements.
- It is acceptable to use another package delivery company but check on delivery schedules for time sensitive samples. UPS and FedEx will deliver directly to the DEQ laboratory if properly addressed.

Use this mailing address:

Department of Environmental Quality
Remediation and Redevelopment Division
Laboratory Section
3350 Martin Luther King, Jr. Blvd.
Lansing, Michigan 48906

A Review of Methodologies for Bacterial Analysis

A look at what to test for and the pros and cons of various methods.

Whether it is to meet the requirements of a home sale transaction, new well installation, or quality check for a bottled water run, analysis for bacteria is extremely critical because of the immediate concerns associated with its detection.

What to test for?

For drinking water, there are typically only three bacterial tests that are performed on a regular basis: coliform, *E.coli* (a subset of fecal coliforms) and heterotrophic plate count.

Other tests performed for microorganisms for USEPA Safe Drinking Water Requirements may also include *cryptosporidium, giardia lamblia, legionella* and enteric viruses (see www.epa.gov/safewater/mcl.html for further information on these microbes).

Coliform and *E.coli* are the organisms of choice to test for, as they are a great indicator species of the presence of other possibly harmful bacteria.

Coliforms are naturally present and plentiful in the environment and in feces of warm-blooded animals. *E.coli* bacteria only come from human and animal fecal waste, as they live and grow in the intestines.

Unlike *E.coli* and coliforms, disease-causing bacteria generally do not survive long enough in water to be detected - therefore, monitoring is difficult. It is because of these traits, and the fact that these organisms are easy to test for, that they become the perfect candidates to determine if the water in question is potable. When coliforms or *E.coli* are present in the sample, water should be used with extreme caution, knowing that other organisms of a more harmful nature may also be present.

What test to use?

There are several methods for the testing of coliform, *E.coli* and heterotrophic bacteria that different laboratories may use. The following tests are the most common methods used. (Please note that although not discussed, a reputable laboratory would use standard quality control plates with all methods.)

Presence/Absence Method

The Chromogenic Substrate Test is used most often. It is also affectionately known as the "Presence/Absence Method" because of the type of results generated. This method is very accurate in determining the presence or absence of both coliform and *E.coli* bacteria.

Special enzymatic substrates are added to the samples that are received and the bottles are then incubated for 24 hours. After 24 hours, the samples are examined for any color change in the sampling bottle.

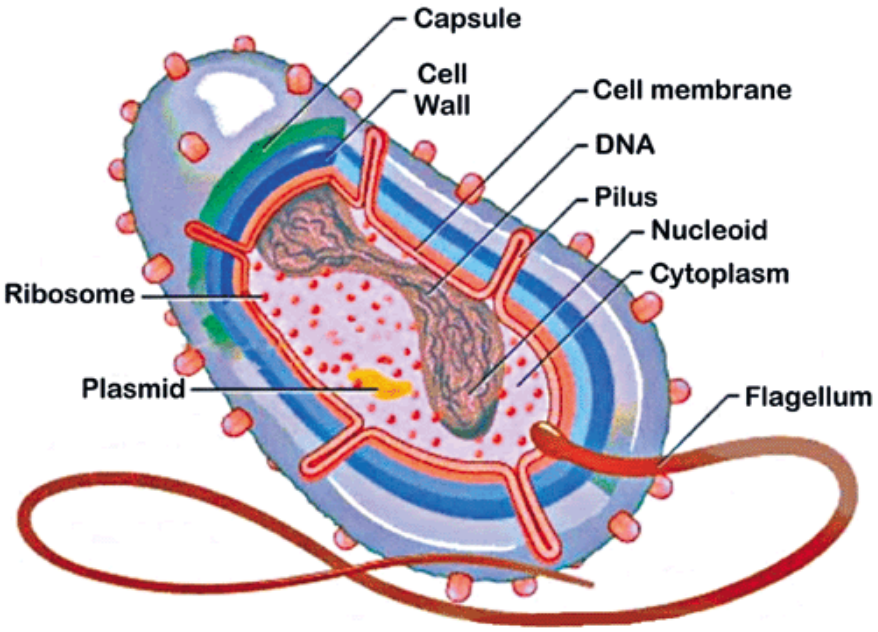
In this technique, Coliform bacteria are defined as the bacteria possessing the enzyme -D-galactosidase. This enzyme cleaves the chromogenic substrate used and results in a release of the chromogen, causing a distinct color change in the sample.

E.coli bacteria are identified because they have an enzyme that results in the release of a fluorogen in the presence of the fluorogenic substrate. The fluorogen can be viewed when observed under long-wavelength UV (black light). One advantage to running this type of test is that there is no interference from other types of non-coliform bacteria. There is often interference observed in some other analytical methods that yield a count of bacteria.

Standard Total Coliform Membrane Filter Procedure
One "count method" is known as the Standard Total Coliform Membrane Filter Procedure. This process is slightly more complex and can take additional time for processing if confirmations of presence results are necessary.

A sample volume of 100ml is initially filtered through a semi-permeable membrane, which has a pore size small enough that coliforms, if present, will not filter through. Once the sample is filtered, the membrane is placed in a special nutrient dish, inverted and incubated for 22 to 24 hours.

The definition of coliforms that pertains to this test is bacteria that produce metallic (golden) sheen within the incubation period. To determine specific colony counts, the analyst uses a specialized microscope.



Bacteria structure

The typical coliform colony has a pink to dark-red color with a metallic surface sheen. Colonies that lack sheen may be pink, red, white or colorless and are considered to be non-coliform colonies. If there is a colony in question, it goes through the "confirmation" process in which colonies are taken from the sample and transferred to a different broth or medium that, after an additional incubation period, causes a color change in the presence of coliforms. Unfortunately, if there is a large presence of non-coliform bacterial colonies only a "too numerous to count, non-coliform" result can be reported. Sometimes it is not known if there are coliforms on the plate that were “masked out” or unable to be seen.
This test is usually only recommended if an actual count of bacteria must be obtained - to meet regulatory requirements for example.

Standard Plate Count Test
In the Standard Plate Count test there are essentially three different methods and four different media that are approved for use. The end result of all these methods is that an estimate of the number of live heterotrophic bacteria in the water can be determined.

An approved counting aid specified by the method should be used to determine the results and counts should be done promptly after incubation. This test can be extremely useful in situations when an odor is detected at a site but coliforms are absent.

How to sample?
In order to obtain accurate results, extreme caution must be exercised in the collection procedure of a bacteria sample. To obtain the best sample that will yield truly representative results:

· Use only approved sealed, sterilized and properly preserved containers for sampling.
· Do not collect samples after a disinfection or "shock treatment" has occurred – any residual chlorine in the system can mask out a problem that may still be there. Sample after regular use has occurred for one to two weeks.
· Wash and disinfect hands prior to sampling or wear sterile gloves.
· Properly disinfect the spigot or sampling point to eliminate any contamination of the sample from the surface of the spigot. Proper disinfection would be to use either an alcohol swab or exposure to a hot flame.
· Do not open or break the seal on the bottle until ready to sample – be sure not to touch the inside of the cap or bottle after opening.

Summary
A bacteria test is not as simple as it may seem. Different tests are used to achieve different results and are based on the need for the analysis.

The presence/absence test is the best to generally determine if there may be a coliform or E.coli problem that could indicate a health concern. If a count of bacteria is necessary for meeting regulatory requirements or treatment clarification, a membrane filtration or standard plate count test may be ideal.

Related Information (Article Sidebar) - <u>Understanding Bacteria</u>
Bacteria are one of the oldest and most plentiful organisms on Earth, and bacteria is simply everywhere. Consider this: as many as 2.5 billion bacteria can be found in one gram (about the size of a paperclip) of fertile soil.
Although typically associated with being harmful, the health of our planet and all life depends on the activities of bacteria. Bacteria are found in the deepest depths of the ocean, in all layers of the earth, in our bodies and in the air around us. Bacteria are prokaryotes or single-celled organisms that lack a true nucleus. Without having a true nucleus to enclose the DNA - the hereditary material that defines the organism - it is allowed to float randomly within the cell.

Bacterial organisms may also be composed of a cell wall (some also have a thick outer capsule for protection), cell membrane, pili, cytoplasm, nucleoid, plasmid, ribosomes and flagellum (see diagram). Flagellum are especially significant as they provide the bacterial cell with the ability to move within their surrounding environment.

One of the significant qualities of bacteria is its ability to reproduce rapidly by binary fission.
During this process, chromosomes will replicate and a new cell wall will form between the identical sets to form two new cells called daughter cells.

Each daughter cell contains an exact copy of the genetic information originally contained in the parent cell. This process continues with each daughter cell allowing the population to increase by geometric progression.

Related Information (Article Sidebar) – 4 Stages of Bacterial Growth

As conditions are often not optimum, except in the case of a laboratory setting, bacteria populations typically cycle through four defined stages or phases of growth.

The first, or lag phase, is the time period when the bacteria become accustomed to their environment and there is fairly slow growth.

In the second phase, called the log phase, the bacteria have adapted, conditions are conducive for growth, and growth occurs exponentially. With a large population, competition for food overcomes the growth rate and the population then enters the stationary phase.

As toxins build and food sources dwindle, the population enters the fourth and final death phase. As enough bacteria die off and nutrients replenish, the cycle starts again.

This helps explain why at any given day or time, bacterial colony counts may differ in test results depending at what point in the cycle process the sample was taken.

Related Information (Article Sidebar) – Structure of a Simple Bacterium

Capsule - Only some have this; a sticky substance external to the cell wall that protects the bacteria from white blood cell attack.

Cell wall - Usually very rigid and offers protection to the organism.

Cell membrane - Also known as the plasma membrane, it regulates the passage of substances into and out of the cytoplasm of the cell.

Cytoplasm - The fluid that fills the cell and gives it shape.

Nucleoid - The region in the cytoplasm where the DNA is usually located.

Pilus (plural: pili) - A structure that extends out of the bacteria that allows it to transfer DNA to another cell.

Ribosome - Tiny structures that carry out the protein synthesis for the cell located in the cytoplasm.

Plasmid - The small chromosome that carries extra genes; only found in some bacteria.

Flagellum - Tiny whip-like structures found in numerous species that are used for locomotion of the organism.

Tami E. Castelli, technical support and accounts manager with National Testing Laboratories, Ltd. (NTL), Cleveland, works with water treatment equipment manufacturers and dealers, well drillers, contractors, engineers and consultants in the water industry. Castelli can be contacted by email at tcastelli@ntllabs.com.

FACT SHEET

Contaminants in Well Water

Wondering what microorganisms (germs) and chemicals can be found in your well water, and what they can do to your health? Here is a list of some of them. Please see the "Well Water Testing FAQs" sheet for details on how to test your well water.

Microorganisms	Health Effects*
	* Healthy individuals may have mild or no symptoms from these infections. They will usually recover without long-term health problems. However, persons with weakened immune systems may have more severe or life-threatening illnesses.
Bacteria	
Campylobacter	▪ Diarrhea (sometimes bloody), cramping, abdominal pain, and fever
Escherichia coli (*E. coli*) O157:H7	▪ Bloody or non-bloody diarrhea, stomach cramps; little or no fever ▪ Can cause hemolytic uremic syndrome (HUS) and kidney failure in young children or the elderly
Salmonella	▪ Diarrhea, typhoid fever, stomach cramps ▪ Infection can spread from intestines to blood and other body sites, causing serious illness
Shigella	▪ Watery or bloody diarrhea, fever, upset stomach ▪ Vomiting and stomach cramping may also occur
Viruses	
Enterovirus	▪ Usually causes mild upper respiratory, "flu-like" symptoms with fever and muscle pains, or a rash ▪ Meningitis is less common, and illnesses that affect the heart and brain may occur, but are very rare
Hepatitis A	▪ Jaundice (yellowing of eyes and skin), dark urine, tiredness, loss of appetite, nausea, vomiting, fever, stomach ache ▪ Most infected adults will show symptoms while children often do not have symptoms (but could still pass the virus to others)
Norovirus (Norwalk)	▪ Upset stomach, cramps, vomiting, and diarrhea ▪ Headache and low-grade fever may also occur
Rotavirus	▪ Vomiting, watery diarrhea, stomach cramps, fever
Protozoa	
Cryptosporidium	▪ Diarrhea, loose or watery stool, stomach cramps, upset stomach, and fever ▪ Usually causes mild illness, but can be serious or fatal for people with weakened immune systems

DEPARTMENT OF HEALTH AND HUMAN SERVICES
CENTERS FOR DISEASE CONTROL AND PREVENTION
SAFER • HEALTHIER • PEOPLE™

Contaminants in Well Water
(continued from previous page)

Giardia	▪ Diarrhea, loose or watery stool, stomach cramps ▪ Usually causes mild illness, but can be serious or fatal for people with weakened immune systems

Chemicals	**Health Effects****
	** These health effects are caused by consuming large doses of chemicals.
Atrazine	▪ Short-term: congestion of heart, lungs, and kidneys; low blood pressure; muscle spasms; weight loss; damage to adrenal glands ▪ Long-term: weight loss, cardiovascular damage, eye and muscle degeneration; cancer
Arsenic	▪ Stomach pain, nausea, vomiting, diarrhea, numbness in hands and feet, partial paralysis, and blindness ▪ Can also cause skin damage, circulatory system problems, and increased risk of cancer
Copper	▪ An essential nutrient at very low levels ▪ High level exposure causes upset stomach, vomiting, diarrhea, and stomach cramps ▪ Long-term exposure at high levels can also cause liver and kidney problems
Lead	▪ Delayed physical and mental development in babies ▪ Shortened attention span, hearing, and learning abilities of children ▪ Slightly increased blood pressures in adults ▪ Long-term exposure at high levels can include stroke, kidney disease, and cancer
Mercury	▪ Kidney damage
Nitrate	▪ Methemoglobinemia – a blood disorder that causes shortness of breath and blueness of skin, and can lead to serious illness or death ▪ Methmoglobinemia mainly affects infants and pregnant women ▪ Long-term effects include increased urination and bleeding of the spleen
Radium	▪ Increases risk of cancer
Volatile Organic Compounds (VOCs)	▪ Drowsiness and decreased responsiveness ▪ Skin irritation ▪ Some cause cancer after long-term exposure

For more information, visit www.cdc.gov/ncidod/healthywater

DEPARTMENT OF HEALTH AND HUMAN SERVICES
CENTERS FOR DISEASE CONTROL AND PREVENTION
SAFER • HEALTHIER • PEOPLE™

EPA National Primary Drinking Water Standards

	Contaminant	MCL or TT[1] (mg/L)[2]	Potential health effects from exposure above the MCL	Common sources of contaminant in drinking water	Public Health Goal
OC	Acrylamide	TT[8]	Nervous system or blood problems;	Added to water during sewage/wastewater increased risk of cancer treatment	zero
OC	Alachlor	0.002	Eye, liver, kidney or spleen problems; anemia; increased risk of cancer	Runoff from herbicide used on row crops	zero
R	Alpha particles	15 picocuries per Liter (pCi/L)	Increased risk of cancer	Erosion of natural deposits of certain minerals that are radioactive and may emit a form of radiation known as alpha radiation	zero
IOC	Antimony	0.006	Increase in blood cholesterol; decrease in blood sugar	Discharge from petroleum refineries; fire retardants; ceramics; electronics; solder	0.006
IOC	Arsenic	0.010 as of 1/23/06	Skin damage or problems with circulatory systems, and may have increased risk of getting cancer	Erosion of natural deposits; runoff from orchards, runoff from glass & electronics production wastes	0
IOC	Asbestos (fibers >10 micrometers)	7 million fibers per Liter (MFL)	Increased risk of developing benign intestinal polyps	Decay of asbestos cement in water mains; erosion of natural deposits	7 MFL
OC	Atrazine	0.003	Cardiovascular system or reproductive problems	Runoff from herbicide used on row crops	0.003
IOC	Barium	2	Increase in blood pressure	Discharge of drilling wastes; discharge from metal refineries; erosion of natural deposits	2
OC	Benzene	0.005	Anemia; decrease in blood platelets; increased risk of cancer	Discharge from factories; leaching from gas storage tanks and landfills	zero
OC	Benzo(a)pyrene (PAHs)	0.0002	Reproductive difficulties; increased risk of cancer	Leaching from linings of water storage tanks and distribution lines	zero
IOC	Beryllium	0.004	Intestinal lesions	Discharge from metal refineries and coal-burning factories; discharge from electrical, aerospace, and defense industries	0.004
R	Beta particles and photon emitters	4 millirems per year	Increased risk of cancer	Decay of natural and man-made deposits of certain minerals that are radioactive and may emit forms of radiation known as photons and beta radiation	zero
DBP	Bromate	0.010	Increased risk of cancer	Byproduct of drinking water disinfection	zero
IOC	Cadmium	0.005	Kidney damage	Corrosion of galvanized pipes; erosion of natural deposits; discharge from metal refineries; runoff from waste batteries and paints	0.005
OC	Carbofuran	0.04	Problems with blood, nervous system, or reproductive system	Leaching of soil fumigant used on rice and alfalfa	0.04
OC	Carbon tetrachloride	0.005	Liver problems; increased risk of cancer	Discharge from chemical plants and other industrial activities	zero
D	Chloramines (as Cl_2)	MRDL=4.0[1]	Eye/nose irritation; stomach discomfort, anemia	Water additive used to control microbes	MRDLG=4[1]

LEGEND

D Dinsinfectant

DBP Disinfection Byproduct

IOC Inorganic Chemical

M Microorganism

OC Organic Chemical

R Radionuclides

	Contaminant	MCL or TT[1] (mg/L)[2]	Potential health effects from exposure above the MCL	Common sources of contaminant in drinking water	Public Health Goal
OC	Chlordane	0.002	Liver or nervous system problems; increased risk of cancer	Residue of banned termiticide	zero
D	Chlorine (as Cl_2)	MRDL=4.0[1]	Eye/nose irritation; stomach discomfort	Water additive used to control microbes	MRDLG=4[1]
D	Chlorine dioxide (as ClO_2)	MRDL=0.8[1]	Anemia; infants & young children: nervous system effects	Water additive used to control microbes	MRDLG=0.8[1]
DBP	Chlorite	1.0	Anemia; infants & young children: nervous system effects	Byproduct of drinking water disinfection	0.8
OC	Chlorobenzene	0.1	Liver or kidney problems	Discharge from chemical and agricultural chemical factories	0.1
IOC	Chromium (total)	0.1	Allergic dermatitis	Discharge from steel and pulp mills; erosion of natural deposits	0.1
IOC	Copper	TT[7]; Action Level = 1.3	Short term exposure: Gastrointestinal distress. Long term exposure: Liver or kidney damage. People with Wilson's Disease should consult their personal doctor if the amount of copper in their water exceeds the action level	Corrosion of household plumbing systems; erosion of natural deposits	1.3
M	*Cryptosporidium*	TT[3]	Gastrointestinal illness (e.g., diarrhea, vomiting, cramps)	Human and animal fecal waste	zero
IOC	Cyanide (as free cyanide)	0.2	Nerve damage or thyroid problems	Discharge from steel/metal factories; discharge from plastic and fertilizer factories	0.2
OC	2,4-D	0.07	Kidney, liver, or adrenal gland problems	Runoff from herbicide used on row crops	0.07
OC	Dalapon	0.2	Minor kidney changes	Runoff from herbicide used on rights of way	0.2
OC	1,2-Dibromo-3-chloropropane (DBCP)	0.0002	Reproductive difficulties; increased risk of cancer	Runoff/leaching from soil fumigant used on soybeans, cotton, pineapples, and orchards	zero
OC	o-Dichlorobenzene	0.6	Liver, kidney, or circulatory system problems	Discharge from industrial chemical factories	0.6
OC	p-Dichlorobenzene	0.075	Anemia; liver, kidney or spleen damage; changes in blood	Discharge from industrial chemical factories	0.075
OC	1,2-Dichloroethane	0.005	Increased risk of cancer	Discharge from industrial chemical factories	zero
OC	1,1-Dichloroethylene	0.007	Liver problems	Discharge from industrial chemical factories	0.007
OC	cis-1,2-Dichloroethylene	0.07	Liver problems	Discharge from industrial chemical factories	0.07
OC	trans-1,2-Dichloroethylene	0.1	Liver problems	Discharge from industrial chemical factories	0.1
OC	Dichloromethane	0.005	Liver problems; increased risk of cancer	Discharge from drug and chemical factories	zero
OC	1,2-Dichloropropane	0.005	Increased risk of cancer	Discharge from industrial chemical factories	zero
OC	Di(2-ethylhexyl) adipate	0.4	Weight loss, live problems, or possible reproductive difficulties	Discharge from chemical factories	0.4
OC	Di(2-ethylhexyl) phthalate	0.006	Reproductive difficulties; liver problems; increased risk of cancer	Discharge from rubber and chemical factories	zero
OC	Dinoseb	0.007	Reproductive difficulties	Runoff from herbicide used on soybeans and vegetables	0.007
OC	Dioxin (2,3,7,8-TCDD)	0.00000003	Reproductive difficulties; increased risk of cancer	Emissions from waste incineration and other combustion; discharge from chemical factories	zero
OC	Diquat	0.02	Cataracts	Runoff from herbicide use	0.02
OC	Endothall	0.1	Stomach and intestinal problems	Runoff from herbicide use	0.1

LEGEND

D Dinsinfectant

DBP Disinfection Byproduct

IOC Inorganic Chemical

M Microorganism

OC Organic Chemical

R Radionuclides

	Contaminant	MCL or TT[1] (mg/L)[2]	Potential health effects from exposure above the MCL	Common sources of contaminant in drinking water	Public Health Goal
OC	Endrin	0.002	Liver problems	Residue of banned insecticide	0.002
OC	Epichlorohydrin	TT[8]	Increased cancer risk, and over a long period of time, stomach problems	Discharge from industrial chemical factories; an impurity of some water treatment chemicals	zero
OC	Ethylbenzene	0.7	Liver or kidneys problems	Discharge from petroleum refineries	0.7
OC	Ethylene dibromide	0.00005	Problems with liver, stomach, reproductive system, or kidneys; increased risk of cancer	Discharge from petroleum refineries	zero
IOC	Fluoride	4.0	Bone disease (pain and tenderness of the bones); Children may get mottled teeth	Water additive which promotes strong teeth; erosion of natural deposits; discharge from fertilizer and aluminum factories	4.0
M	*Giardia lamblia*	TT[3]	Gastrointestinal illness (e.g., diarrhea, vomiting, cramps)	Human and animal fecal waste	zero
OC	Glyphosate	0.7	Kidney problems; reproductive difficulties	Runoff from herbicide use	0.7
DBP	Haloacetic acids (HAA5)	0.060	Increased risk of cancer	Byproduct of drinking water disinfection	n/a[6]
OC	Heptachlor	0.0004	Liver damage; increased risk of cancer	Residue of banned termiticide	zero
OC	Heptachlor epoxide	0.0002	Liver damage; increased risk of cancer	Breakdown of heptachlor	zero
M	Heterotrophic plate count (HPC)	TT[3]	HPC has no health effects; it is an analytic method used to measure the variety of bacteria that are common in water. The lower the concentration of bacteria in drinking water, the better maintained the water system is.	HPC measures a range of bacteria that are naturally present in the environment	n/a
OC	Hexachlorobenzene	0.001	Liver or kidney problems; reproductive difficulties; increased risk of cancer	Discharge from metal refineries and agricultural chemical factories	zero
OC	Hexachlorocyclopentadiene	0.05	Kidney or stomach problems	Discharge from chemical factories	0.05
IOC	Lead	TT[7]; Action Level = 0.015	Infants and children: Delays in physical or mental development; children could show slight deficits in attention span and learning abilities; Adults: Kidney problems; high blood pressure	Corrosion of household plumbing systems; erosion of natural deposits	zero
M	*Legionella*	TT[3]	Legionnaire's Disease, a type of pneumonia	Found naturally in water; multiplies in heating systems	zero
OC	Lindane	0.0002	Liver or kidney problems	Runoff/leaching from insecticide used on cattle, lumber, gardens	0.0002
IOC	Mercury (inorganic)	0.002	Kidney damage	Erosion of natural deposits; discharge from refineries and factories; runoff from landfills and croplands	0.002
OC	Methoxychlor	0.04	Reproductive difficulties	Runoff/leaching from insecticide used on fruits, vegetables, alfalfa, livestock	0.04
IOC	Nitrate (measured as Nitrogen)	10	Infants below the age of six months who drink water containing nitrate in excess of the MCL could become seriously ill and, if untreated, may die. Symptoms include shortness of breath and blue-baby syndrome.	Runoff from fertilizer use; leaching from septic tanks, sewage; erosion of natural deposits	10
IOC	Nitrite (measured as Nitrogen)	1	Infants below the age of six months who drink water containing nitrite in excess of the MCL could become seriously ill and, if untreated, may die. Symptoms include shortness of breath and blue-baby syndrome.	Runoff from fertilizer use; leaching from septic tanks, sewage; erosion of natural deposits	1

LEGEND

D Dinsinfectant
IOC Inorganic Chemical
OC Organic Chemical
DBP Disinfection Byproduct
M Microorganism
R Radionuclides

	Contaminant	MCL or TT[1] (mg/L)[2]	Potential health effects from exposure above the MCL	Common sources of contaminant in drinking water	Public Health Goal
OC	Oxamyl (Vydate)	0.2	Slight nervous system effects	Runoff/leaching from insecticide used on apples, potatoes, and tomatoes	0.2
OC	Pentachlorophenol	0.001	Liver or kidney problems; increased cancer risk	Discharge from wood preserving factories	zero
OC	Picloram	0.5	Liver problems	Herbicide runoff	0.5
OC	Polychlorinated biphenyls (PCBs)	0.0005	Skin changes; thymus gland problems; immune deficiencies; reproductive or nervous system difficulties; increased risk of cancer	Runoff from landfills; discharge of waste chemicals	zero
R	Radium 226 and Radium 228 (combined)	5 pCi/L	Increased risk of cancer	Erosion of natural deposits	zero
IOC	Selenium	0.05	Hair or fingernail loss; numbness in fingers or toes; circulatory problems	Discharge from petroleum refineries; erosion of natural deposits; discharge from mines	0.05
OC	Simazine	0.004	Problems with blood	Herbicide runoff	0.004
OC	Styrene	0.1	Liver, kidney, or circulatory system problems	Discharge from rubber and plastic factories; leaching from landfills	0.1
OC	Tetrachloroethylene	0.005	Liver problems; increased risk of cancer	Discharge from factories and dry cleaners	zero
IOC	Thallium	0.002	Hair loss; changes in blood; kidney, intestine, or liver problems	Leaching from ore-processing sites; discharge from electronics, glass, and drug factories	0.0005
OC	Toluene	1	Nervous system, kidney, or liver problems	Discharge from petroleum factories	1
M	Total Coliforms (including fecal coliform and *E. coli*)	5.0%[4]	Not a health threat in itself; it is used to indicate whether other potentially harmful bacteria may be present[5]	Coliforms are naturally present in the environment as well as feces; fecal coliforms and *E. coli* only come from human and animal fecal waste.	zero
DBP	Total Trihalomethanes (TTHMs)	0.10 0.080 after 12/31/03	Liver, kidney or central nervous system problems; increased risk of cancer	Byproduct of drinking water disinfection	n/a[6]
OC	Toxaphene	0.003	Kidney, liver, or thyroid problems; increased risk of cancer	Runoff/leaching from insecticide used on cotton and cattle	zero
OC	2,4,5-TP (Silvex)	0.05	Liver problems	Residue of banned herbicide	0.05
OC	1,2,4-Trichlorobenzene	0.07	Changes in adrenal glands	Discharge from textile finishing factories	0.07
OC	1,1,1-Trichloroethane	0.2	Liver, nervous system, or circulatory problems	Discharge from metal degreasing sites and other factories	0.20
OC	1,1,2-Trichloroethane	0.005	Liver, kidney, or immune system problems	Discharge from industrial chemical factories	0.003
OC	Trichloroethylene	0.005	Liver problems; increased risk of cancer	Discharge from metal degreasing sites and other factories	zero
M	Turbidity	TT[3]	Turbidity is a measure of the cloudiness of water. It is used to indicate water quality and filtration effectiveness (e.g., whether disease-causing organisms are present). Higher turbidity levels are often associated with higher levels of disease-causing micro-organisms such as viruses, parasites and some bacteria. These organisms can cause symptoms such as nausea, cramps, diarrhea, and associated headaches.	Soil runoff	n/a
R	Uranium	30 ug/L as of 12/08/03	Increased risk of cancer, kidney toxicity	Erosion of natural deposits	zero

LEGEND

D	Dinsinfectant	IOC	Inorganic Chemical	OC	Organic Chemical
DBP	Disinfection Byproduct	M	Microorganism	R	Radionuclides

	Contaminant	MCL or TT[1] (mg/L)[2]	Potential health effects from exposure above the MCL	Common sources of contaminant in drinking water	Public Health Goal
OC	Vinyl chloride	0.002	Increased risk of cancer	Leaching from PVC pipes; discharge from plastic factories	zero
M	Viruses (enteric)	TT[3]	Gastrointestinal illness (e.g., diarrhea, vomiting, cramps)	Human and animal fecal waste	zero
OC	Xylenes (total)	10	Nervous system damage	Discharge from petroleum factories; discharge from chemical factories	10

NOTES

1 Definitions

- Maximum Contaminant Level Goal (MCLG)—The level of a contaminant in drinking water below which there is no known or expected risk to health. MCLGs allow for a margin of safety and are non-enforceable public health goals.
- Maximum Contaminant Level (MCL)—The highest level of a contaminant that is allowed in drinking water. MCLs are set as close to MCLGs as feasible using the best available treatment technology and taking cost into consideration. MCLs are enforceable standards.
- Maximum Residual Disinfectant Level Goal (MRDLG)—The level of a drinking water disinfectant below which there is no known or expected risk to health. MRDLGs do not reflect the benefits of the use of disinfectants to control microbial contaminants.
- Maximum Residual Disinfectant Level (MRDL)—The highest level of a disinfectant allowed in drinking water. There is convincing evidence that addition of a disinfectant is necessary for control of microbial contaminants.
- Treatment Technique (TT)—A required process intended to reduce the level of a contaminant in drinking water.

2 Units are in milligrams per liter (mg/L) unless otherwise noted. Milligrams per liter are equivalent to parts per million (ppm).

3 EPA's surface water treatment rules require systems using surface water or ground water under the direct influence of surface water to (1) disinfect their water, and (2) filter their water or meet criteria for avoiding filtration so that the following contaminants are controlled at the following levels:

- *Cryptosporidium* (as of 1/1/02 for systems serving >10,000 and 1/14/05 for systems serving <10,000) 99% removal.
- *Giardia lamblia*: 99.9% removal/inactivation
- Viruses: 99.99% removal/inactivation
- *Legionella:* No limit, but EPA believes that if *Giardia* and viruses are removed/inactivated, *Legionella* will also be controlled.
- Turbidity: At no time can turbidity (cloudiness of water) go above 5 nephelolometric turbidity units (NTU); systems that filter must ensure that the turbidity go no higher than 1 NTU (0.5 NTU for conventional or direct filtration) in at least 95% of the daily samples in any month. As of January 1, 2002, for systems servicing >10,000, and January 14, 2005, for systems servicing <10,000, turbidity may never exceed 1 NTU, and must not exceed 0.3 NTU in 95% of daily samples in any month.
- HPC: No more than 500 bacterial colonies per milliliter
- Long Term 1 Enhanced Surface Water Treatment (Effective Date: January 14, 2005); Surface water systems or (GWUDI) systems serving fewer than 10,000 people must comply with the applicable Long Term 1 Enhanced Surface Water Treatment Rule provisions (e.g. turbidity standards, individual filter monitoring, *Cryptosporidium* removal requirements, updated watershed control requirements for unfiltered systems).
- Filter Backwash Recycling: The Filter Backwash Recycling Rule requires systems that recycle to return specific recycle flows through all processes of the system's existing conventional or direct filtration system or at an alternate location approved by the state.

4 No more than 5.0% samples total coliform-positive in a month. (For water systems that collect fewer than 40 routine samples per month, no more than one sample can be total coliform-positive per month.) Every sample that has total coliform must be analyzed for either fecal coliforms or *E. coli* if two consecutive TC-positive samples, and one is also positive for *E. coli* fecal coliforms, system has an acute MCL violation.

5 Fecal coliform and *E. coli* are bacteria whose presence indicates that the water may be contaminated with human or animal wastes. Disease-causing microbes (pathogens) in these wastes can cause diarrhea, cramps, nausea, headaches, or other symptoms. These pathogens may pose a special health risk for infants, young children, and people with severely compromised immune systems.

6 Although there is no collective MCLG for this contaminant group, there are individual MCLGs for some of the individual contaminants:

- Haloacetic acids: dichloroacetic acid (zero); trichloroacetic acid (0.3 mg/L)
- Trihalomethanes: bromodichloromethane (zero); bromoform (zero); dibromochloromethane (0.06 mg/L)

7 Lead and copper are regulated by a Treatment Technique that requires systems to control the corrosiveness of their water. If more than 10% of tap water samples exceed the action level, water systems must take additional steps. For copper, the action level is 1.3 mg/L, and for lead is 0.015 mg/L.

8 Each water system must certify, in writing, to the state (using third-party or manufacturers certification) that when it uses acrylamide and/or epichlorohydrin to treat water, the combination (or product) of dose and monomer level does not exceed the levels specified, as follows: Acrylamide = 0.05% dosed at 1 mg/L (or equivalent); Epichlorohydrin = 0.01% dosed at 20 mg/L (or equivalent).

LEGEND

D	Dinsinfectant	IOC	Inorganic Chemical	OC	Organic Chemical
DBP	Disinfection Byproduct	M	Microorganism	R	Radionuclides

National Secondary Drinking Water Standards

National Secondary Drinking Water Standards are non-enforceable guidelines regulating contaminants that may cause cosmetic effects (such as skin or tooth discoloration) or aesthetic effects (such as taste, odor, or color) in drinking water. EPA recommends secondary standards to water systems but does not require systems to comply. However, states may choose to adopt them as enforceable standards.

Contaminant	Secondary Standard
Aluminum	0.05 to 0.2 mg/L
Chloride	250 mg/L
Color	15 (color units)
Copper	1.0 mg/L
Corrosivity	noncorrosive
Fluoride	2.0 mg/L
Foaming Agents	0.5 mg/L
Iron	0.3 mg/L
Manganese	0.05 mg/L
Odor	3 threshold odor number
pH	6.5-8.5
Silver	0.10 mg/L
Sulfate	250 mg/L
Total Dissolved Solids	500 mg/L
Zinc	5 mg/L

Office of Water (4606M)
EPA 816-F-03-016
www.epa.gov/safewater
June 2003