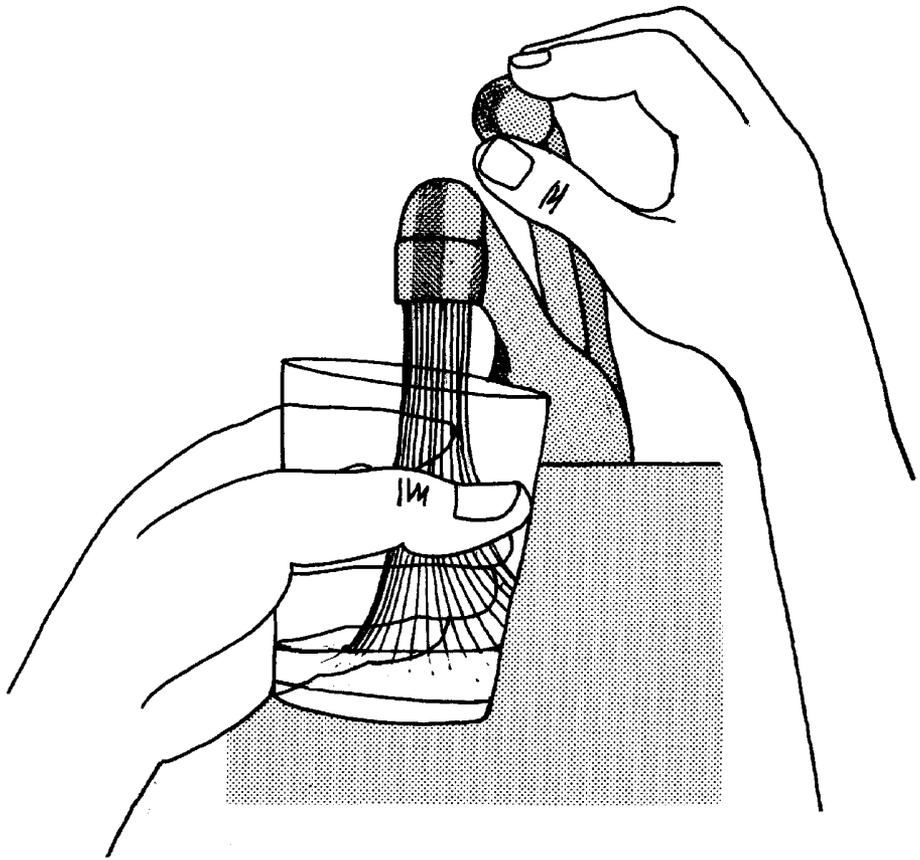


# Interpreting Drinking Water Quality Analysis What Do the Numbers Mean?

5<sup>th</sup> Edition\*

Theodore B. Shelton, Ph.D.



**\* PLEASE NOTE: This reflects changes in the Safe Drinking Water Act effective 11/96. Previous editions are no longer accurate.**

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**5<sup>th</sup> Edition**

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# **INTERPRETING DRINKING WATER QUALITY ANALYSIS**

## **WHAT DO THE NUMBERS MEAN?**

### **INTRODUCTION**

This publication summarizes the information necessary for interpreting drinking water quality analyses performed by water testing laboratories. It focuses on testing results obtained from drinking water supplies from public water systems and nonpublic water systems (home wells). It is intended primarily for homeowners, but environmental organizations, health departments, and commercial water testing laboratories and others should find this material of interest and value.

For readers who are not familiar with the terms and chemical expressions used in the text, a brief list of definitions follows the main text.

### **WHAT IS PURE WATER?**

We know that all life is dependent on water and that water exists in nature in many forms - clouds, rain, snow, ice, and fog; however, strictly speaking, chemically pure water does not exist for any appreciable length of time in nature. Even while falling as rain, water picks up small amounts of gases, ions, dust, and particulate matter from the atmosphere. Then, as it flows over or through the surface layers of the earth, it dissolves and carries with it some of almost everything it touches, including that which is dumped into it by man.

These added substances may be arbitrarily classified as biological, chemical (both inorganic and organic), physical, and radiological impurities. They include industrial and commercial solvents, metal and acid salts, sediments, pesticides, herbicides, plant nutrients, radioactive materials, road salts, decaying animal and vegetable matter, and living microorganisms, such as algae, bacteria, and viruses. These impurities may give water a bad taste, color, odor, or cloudy appearance (turbidity), and cause hardness, corrosiveness, staining, or frothing. They may damage growing plants and transmit disease. Many of these impurities are removed or rendered harmless, however, in municipal drinking water treatment plants.

Pure water means different things to different people. Homeowners are primarily concerned with domestic water problems related to color, odor, taste, and safety to family health, as well as the cost of soap, detergents, "softening," or other treatments required for improving the water quality. Chemists and engineers working for industry are concerned with the purity of water as it relates to scale deposition and pipe corrosion. Regulatory agencies are concerned with setting standards to protect public health. Farmers are interested in the effects of irrigation waters on the chemical, physical, and osmotic properties of soils, particularly as they influence crop production; hence, they are concerned with the water's total mineral content, proportion of sodium, or content of ions "toxic" to plant growth.

One means of establishing and assuring the purity and safety of water is to set a standard for various contaminants. A standard is a definite rule, principle, or measurement which is established by governmental authority. The fact that it has been

established by authority makes a standard rigid, official, and legal; but this fact does not necessarily mean that the standard is fair or based on sound scientific knowledge. Where human health data or other scientific data are sparse, standards have sometimes been established on an interim basis until better information becomes available.

The Safe Drinking Water Act sets minimum standards to be met by all public water systems. New Jersey and most other states have established their own drinking water regulations using federal regulations as a basis. State regulations may be more stringent than the federal regulations.

## **INTRODUCTION TO THE SAFE DRINKING WATER ACT**

The Federal Safe Drinking Water Act (SDWA) (P.L. 93-523) was signed into law in 1974 and amended several times thereafter. The act authorized the U.S. Environmental Protection Agency (USEPA) to establish a cooperative program among local, state, and federal agencies for drinking water. Under the SDWA, the primary role of the federal government was to develop national drinking water regulations that protect public health and welfare. The states could request the responsibility of implementing the regulations and monitoring the performance of public water systems. The public water systems themselves were responsible for treating and testing their own drinking water to ensure that the quality consistently met the standards set by the regulations.

As directed by the SDWA, the USEPA developed primary and secondary drinking water regulations designed to protect public health and welfare. These regulations establish several important definitions. They include the following: Public Water System means a system for the provision to the public of water for human consumption through pipes or other constructed conveyances if the system has at least 15 service connections or regularly serves at least 25 individuals daily at least 60 days out of the year. A public water system is either a community water system or a noncommunity water system. Basically, a community system serves water to a residential population, whereas a noncommunity system serves water to a nonresidential population. A Community Water System means a public water system which serves at least 15 service connections used by permanent residents or regularly serves 25 permanent residents. A Noncommunity Water System means a public water system that is not a community water system. Examples include separate water systems which serve motels, restaurants, campgrounds, churches, lodges, rest stops along interstate highways, and roadside service stations. A Nontransient Noncommunity Water System regularly serves the same population at least six months of a year. Examples include separate water systems which serve schools, workplaces, and hospitals. A Public Transient Noncommunity Water System is a public water system that is not a public community water system and serves a transient population at least 60 days out of the year.

Please note that if the establishments mentioned above are served by a community water system they are considered to be a part of that system and therefore are not subject to separate regulation. For example, a campground may serve hundreds of people daily, but they are probably different people each day so no individual drinks very much of the campground's water. Since certain contaminants have adverse

health effects only when consumed regularly over a long period, the distinctions between public community, noncommunity and nontransient noncommunity systems are important in determining which contaminants must be monitored to protect public health.

## **A-280 AMENDMENTS TO THE NJ SAFE DRINKING WATER ACT**

The New Jersey Safe Drinking Water Act became law in September 1977. New Jersey Department of Environmental Protection (DEP) is the primary agency for implementing the SDWA in New Jersey. All regulations promulgated by USEPA are automatically adopted as New Jersey regulations. In January, 1984, the governor of New Jersey signed into law amendments to the New Jersey Safe Drinking Water Act. These amendments (P.L. 1983, c.443), commonly called A-280, required all public community water supplies to be periodically tested for a specified list of organic chemicals. The amendments also required the development of standards for these contaminants. These additional standards were needed because these chemicals were being detected in ground and/or surface waters, and were known to be potentially harmful to human health. Many of these chemicals are present in water supplies throughout the nation because of their widespread industrial and domestic use. New Jersey was one of the first states to require monitoring for these chemicals, and now is a leading state in the development of additional drinking water standards. Regulations establishing New Jersey Maximum Contaminant Levels (MCLs) for 17 organic contaminants were published on January 3, 1989, N.J.A.C. 7:10-16 and updated in November 1996.

The A-280 amendments state that the MCLs for carcinogens shall permit cancer in no more than one in a million persons ingesting that chemical for a lifetime. The MCLs for non-carcinogens shall eliminate, within the limits of practicality and feasibility, all adverse physiological effects which may result from ingestion. The N.J. Drinking Water Quality Institute was established to review scientific studies of the effects of chemicals detected in drinking water and recommend limits (MCLs) for each chemical. The Institute is comprised of representatives from the water suppliers, the general public, the academic science community, the DEP, and the New Jersey Department of Health and Senior Services. This new regulation should lead to a reduction of risk and improvement of drinking water statewide.

## **HEALTH EFFECTS OF DRINKING WATER CONTAMINANTS**

Chemicals in drinking water which are toxic may cause either acute or chronic health effects. An acute effect usually follows a large dose of a chemical and occurs almost immediately. Examples of acute health effects are nausea, lung irritation, skin rash, vomiting, dizziness, and, in the extreme, death.

The levels of chemicals in drinking water, however, are seldom high enough to cause acute health effects. They are more likely to cause chronic health effects, effects that occur after exposure to small amounts of a chemical over a long period. Examples of chronic health effects include cancer, birth defects, organ damage, disorders of the nervous system, and damage to the immune system.

Evidence relating chronic human health effects to specific drinking water contaminants is very limited. In the absence of exact scientific information, scientists predict the likely adverse effects of chemicals in drinking water using laboratory animal studies and, when available, human data from clinical reports and epidemiological studies.

USEPA classifies compounds for carcinogenicity potential according to the “weight of evidence” approach as stated in the Agency’s Guidelines for Carcinogen Risk Assessment. These Guidelines specify five carcinogenicity classifications:

- Group A - Human carcinogen (sufficient evidence from epidemiological studies).
- Group B - Probable human carcinogen.
  - Group B1 - At least limited evidence of carcinogenicity in humans.
  - Group B2 - Usually a combination of sufficient evidence in animals and inadequate data in humans.
- Group C - Possible human carcinogen (limited evidence of carcinogenicity in the absence of human data).
- Group D - Not classifiable (inadequate human and animal evidence of carcinogenicity).
- Group E - Evidence of noncarcinogenicity for humans (no evidence of carcinogenicity in at least two adequate animal tests in different species or in both epidemiological and animal studies).

The possible health effects of a contaminant in drinking water differ widely, depending on whether a person consumes the water over a long period, briefly, or intermittently. Thus, MCLs and monitoring requirements for systems serving permanent populations (Public Community Water Systems and Nontransient Non-community Water Systems) may be more stringent than those regulations for systems serving transient or intermittent users (Public Noncommunity Water Systems).

Maximum contaminant levels are based, directly or indirectly, on an assumed drinking water rate of two liters per person per day. MCLs for organic and inorganic contaminants (except nitrate) are based on the potential health effects of long-term exposure, and they provide substantial protection to virtually all consumers. The uncertainty in this process is due in part to the variations in the knowledge of and the nature of the health risks of the various contaminants.

## **SETTING STANDARDS - MAXIMUM CONTAMINANT LEVELS (MCLs)**

Standards set under authority of the SDWA are called Maximum Contaminant Levels (MCLs). An MCL is the highest amount of a specific contaminant allowed in the water delivered to any customer of a public water system. An MCL may be expressed in milligrams per liter (mg/l), which is the same for the purposes of water quality analysis as parts per million (ppm). The MCLs can also be expressed as micrograms/liter (ug/l) which is equivalent to parts per billion (ppb). One thousand micrograms per liter (1000 ug/l) is equivalent to one milligram per liter (1 mg/l). MCLs have been set by the USEPA and the DEP to provide a margin of safety to protect the public health.

Impurities in drinking water that are regulated and have an adverse health impact are grouped into five categories: inorganic chemical contaminants, organic chemical contaminants, microbiological contaminants, radiological contaminants, and turbidity.

The process of setting primary standards (MCLs) for drinking water contaminants is based on three criteria: (1) the contaminant causes adverse health effects; (2) instruments are available to detect it in drinking water; and (3) it is known to occur in drinking water.

The regulatory agency first looks at all the toxicological data on a contaminant, usually obtained from chronic and subchronic animal studies. Occasionally human clinical or epidemiological data are also available. Experts use this information to estimate the concentration of a drinking water contaminant that may be toxic and the concentrations, if any, that may cause no adverse effects.

For chemicals which do not cause cancer, officials set standards using a figure calculated from animal studies called the Reference Dose (Rfd), formerly called the Acceptable Daily Intake or ADI. The Rfd is the estimate of the daily dose of a substance that a person can ingest over a lifetime without suffering any adverse health effects and it includes a conservative safety margin.

Regulators use the Rfd to establish a Maximum Contaminant Level Goal (MCLG) for a contaminant. The MCLG is the concentration of a contaminant that experts believe a person can drink safely over a lifetime. It is based entirely on health considerations and, as a health goal, is set at a level where no adverse health effects should occur. The MCLG, which is not enforced by the USEPA, is used to set enforceable drinking water standards.

The MCL, the primary standard enforced by the USEPA, is set as close as possible to the MCLG. In setting an MCL, USEPA professionals consider, in addition to health effects, the feasibility and the combined cost of analyzing water for a contaminant and for treating water to remove the contaminant. Therefore, the MCL is often less stringent than the MCLG; however, by statute, the MCL must be set as close as is feasible to the MCLG.

In setting MCLs for chemicals believed to cause cancer, a different risk assessment is used, and USEPA regulators assume that no concentration is safe. Consequently, the MCLG is set at zero. But, a zero level is not always possible to achieve, nor is it possible to measure because of the sensitivity of the analytical equipment. USEPA incorporates cost and treatability considerations into the MCLs for carcinogens as with the noncarcinogenic MCLs; these MCLs must be set as close as is feasible to the MCLG.

The state was required to set drinking water standards for 22 contaminants listed in the A-280 amendments. There were no USEPA MCLs for these chemicals when New Jersey began this standard-setting process in 1984. The standard-setting process was specified in the A-280 amendments to the N.J. Safe Drinking Water Act and is in some ways different from the federal process for these chemicals. The

carcinogenic MCLs had to be calculated such that no more than one in one million persons ingesting that chemical in drinking water over a lifetime would develop cancer (one in one million risk). The noncarcinogenic MCLs were calculated in the same manner as for the federal MCLs. In 1987, USEPA published MCLs for eight volatile organic chemicals that are also on the A-280 list. In nearly all cases, the MCLs developed by New Jersey for the same compounds were more stringent than the federal government's.

Setting drinking water standards is an imperfect process, rarely based on conclusive human evidence. Data relating human health effects to chemicals in drinking water are limited, and scientists have to rely on mathematical modeling for predicting the effects of drinking small amounts of chemicals for many years. In addition, regulatory decisions frequently incorporate economic, political, and social considerations. Therefore, it is important to understand that primary standards or MCLs for drinking water contaminants do not guarantee that water with a contaminant level below the standard is risk-free; nor do they mean that water with a higher level is unsafe.

Specific limits have not yet been set for every toxic, carcinogenic, or undesirable contaminant that might enter a public water supply. While the need for continued attention to chemical contaminants in water is recognized, the regulations are limited by available scientific and engineering data on which those judgments of safety can be made.

Table 1 lists the MCLs for public drinking water supplies in New Jersey (as of 11/96). The table combines both the federal and N.J. Safe Drinking Water Act regulations. These regulations will be subject to continuous change. You should contact the NJDEP - Bureau of Safe Drinking Water, PO Box 426, Trenton, NJ 08625-0426, if you need more current information.

Table 2 lists proposed MCLs for radionuclides. These contaminants are the last group that needs final MCLs (except for Arsenic and Sulfate, whose final MCL is still under review) out of the 83 contaminants referenced in the Federal Safe Drinking Water Act. Table 3 lists the chemicals for which new MCLs were set effective 11/96. Table 4 lists unregulated contaminants for which USEPA has set monitoring requirements.

For a detailed explanation of the Safe Drinking Water Program, refer to the Federal Safe Drinking Water Act regulations [40 CFR Parts 141, 142, 143] and the New Jersey Safe Drinking Water Act regulations [N.J.A.C. 7:10-1 et seq.].

**TABLE 1. MAXIMUM CONTAMINANT LEVELS (MCLs) FOR PUBLIC DRINKING WATER SUPPLIES IN NEW JERSEY (as of 11/96)**

<u>VOLATILE ORGANIC COMPOUNDS</u>	<u>MCL (in ppb or ug/l)</u>
Benzene	1*
Carbon Tetrachloride	2*
meta-Dichlorobenzene	600*
ortho-Dichlorobenzene	600
para-Dichlorobenzene	75
1,1-Dichloroethane	50*
1,2-Dichloroethane	2*
1,1-Dichloroethylene	2*
cis-1,2-Dichloroethylene	70
trans-1,2-Dichloroethylene	100
1,2-Dichloropropane	5
Ethylbenzene	700
Methyl tertiary butyl ether (MTBE)	70*
Methylene Chloride (Dichloromethane)	3*
Monochlorobenzene	50*
Naphthalene	300*
Styrene	100
1,1,1,2-Tetrachloroethane	1*
Tetrachloroethylene	1*
Toluene	1000
1,2,4-Trichlorobenzene	9*
1,1,1-Trichloroethane	30*
1,1,2-Trichloroethane	3*
Trichloroethylene	1*
Vinyl Chloride	2
Xylenes (Total)	1000*

<u>SYNTHETIC ORGANIC COMPOUNDS</u>	<u>MCL (in ppb or ug/l)</u>
Alachlor	2
Aldicarb	No MCL, Monitoring Required
Aldicarb Sulfone	No MCL, Monitoring Required
Aldicarb Sulfoxide	No MCL, Monitoring Required
Atrazine	3
Benzo(a)pyrene	0.2
Carbofuran	40
Chlordane	0.5*
Dalapon	200
Dibromochloropropane(DBCP)	0.2
Di(2-ethylhexyl)adipate	400
Di(2-ethylhexyl)phthalate	6
Dinoseb	7
Diquat	20
Endothall	100
Endrin	2
Ethylene dibromide (EDB)	0.05
Glyphosate	700
Heptachlor	0.4

\*A NJ MCL (A-280 Legislation)

<u>SYNTHETIC ORGANIC COMPOUNDS(cont.)</u>	<u>MCL (in ppb or ug/l)</u>
Heptachlor Epoxide	0.2
Hexachlorobenzene	1
Hexachlorocyclopentadiene	50
Lindane	0.2
Methoxychlor	40
Oxamyl	200
PCBs (polychlorinated biphenyls)	0.5
Pentachlorophenol	1
Picloram	500
Simazine	4
Toxaphene	3
2,3,7,8-TCDD (Dioxin)	0.00003
2,4-D (2,4-Dichlorophenoxyacetic acid)	70
2,4,5-TP (Silvex)	50
Trihalomethanes, (Total TTHMs)	100 (annual average)
Chloroform, Bromodichloromethane, Bromoform, Dibromochloromethane	

<u>INORGANIC COMPOUNDS</u>	<u>MCL (in ppb or ug/l)</u>
Antimony	6
Arsenic	50
Asbestos	7 million fibers/liter (longer than 10 µm)
Barium	2000
Beryllium	4
Cadmium	5
Chromium	100
Copper <sup>1</sup>	1500 (Action Level)
Cyanide	200
Fluoride (naturally occurring)	4000
Lead <sup>1</sup>	15 (Action Level)
Mercury	2
Nickel	No MCL, Monitoring Required
Nitrate	10000 (as N)
Nitrite	1000 (as N)
Total nitrate and nitrite	10000 (as N)
Selenium	50
Thallium	2

MICROBIOLOGICAL CONTAMINANTS (see page 29)

Coliform bacteria

For private home wells Absence of Coliform bacteria/100 ml  
 For public water systems<sup>2</sup> Coliform bacteria standards are based on the presence or absence of coliform in a sample. The number of samples collected by a public water system is determined by the size of the population served. A system collecting at least 40 samples/month can have coliform in no more than 5% of the samples. A system collecting fewer than 40 samples/month can have no more than one coliform positive. Any number exceeding these amounts triggers an MCL exceedence.

TURBIDITY

Turbidity No more than 5% of the samples may exceed 0.5 Nephelometric Turbidity Unit

**RADIOLOGICAL CONTAMINANTS**

Gross alpha activity (including Radium 226, but excluding radon and uranium)	15 picoCuries/l
Radium 226/228	5 picoCuries/l
Beta particle and photon radioactivity	4 millirem/year

<sup>1</sup> An (AL) action level is not an MCL. It is a trigger point at which remedial action is to take place.

<sup>2</sup> See 40 CFR (Code of Federal Regulations) Parts 141 and 142 for details.

**TABLE 2. PROPOSED MAXIMUM CONTAMINANT LEVELS (MCLs) FOR PUBLIC DRINKING WATER SUPPLIES IN NEW JERSEY (PENDING USEPA FINAL REGULATIONS)<sup>3</sup>**

<u>RADIONUCLIDES</u>	<u>MCLs</u>
Radium-226 <sup>4</sup>	20 pCi/l
Radium-228 <sup>4</sup>	20 pCi/l
Uranium	30 pCi/l
Beta and photon emitters	4 mrem ede/yr <sup>5</sup>
Adjusted gross alpha emitters	15 pCi/l

<sup>3</sup> These MCLs are pending final adoption by the USEPA. When they are adopted they automatically become NJ regulations.

<sup>4</sup> An MCL currently exists for this contaminant.

<sup>5</sup> ede/yr - effective dose equivalent per year.

**TABLE 3. LIST OF CHEMICALS FOR WHICH NEW MCLs WERE SET BY NJDEP EFFECTIVE 11/18/96**

<u>A-280</u>	
1,1-Dichloroethane	Naphthalene
Methyl tertiary butyl ether (MTBE)	1,1,2,2-Tetrachloroethane
1,1,2-Trichloroethane	

**TABLE 4. LIST OF UNREGULATED CONTAMINANTS FOR WHICH USEPA HAS SET MONITORING REQUIREMENTS**

ORGANIC CHEMICALS

Volatile Organic Chemicals

Bromobenzene	p-Chlorotoluene
Bromodichloromethane	Dichlorobenzene
Bromoform	Bromomethane
Chlorobenzene	1,3-Dichloropropane
Chlorodibromomethane	2,2-Dichloropropane
Chloroform	1,3-Dichloropropene
Chloroethane	1,1-Dichloropropene
Chloromethane	1,1,1,2-Tetrachloroethane
o-Chlorotoluene	1,2,3-Trichloropropane

Synthetic Organic Chemicals

Aldrin	3-Hydroxycarbofuran
Butachlor	Methomyl

Carbaryl  
Dieldrin  
Dicamba

Metolachlor  
Metribuzin  
Propachlor

### INORGANIC CHEMICALS

Nickel  
Sulfate  
Sodium

## WHAT DO THE MAXIMUM CONTAMINANT LEVEL NUMBERS MEAN?

### ORGANIC CHEMICAL MAXIMUM CONTAMINANT LEVELS

#### VOLATILE ORGANIC COMPOUNDS

##### **BENZENE**

**MCL 1 ug/l**

Benzene is a natural component of crude oil and natural gas. Industry uses benzene in the production of rubber, styrene, and pesticides. Benzene's volatility and water solubility provide the potential for environmental migration. Benzene production by the petrochemical and petroleum refining industries ranks 16th on the list of the top 50 chemicals produced in the United States. At present there is no known intentional use of benzene in consumer products for home use. Gasoline in the United States contains an average of 0.8 percent benzene. Exposure to benzene has been associated with aplastic anemia and acute myelogenous leukemia; benzene is listed as a human carcinogen (USEPA Group A).

##### **CARBON TETRACHLORIDE**

**MCL 2 ug/l**

Carbon tetrachloride is manufactured by the chlorination of methane, propane, ethane, propylene, or carbon disulfide and as a by-product of vinyl chloride and perchloroethylene production. The major use of carbon tetrachloride is in the manufacture of chlorofluorocarbons, which are used as refrigerants, foam-blowing agents, and solvents. Carbon tetrachloride is classified as a probable human carcinogen (USEPA Group B2) and has been shown to induce liver neoplasms in hamsters, mice, and rats.

##### ***meta*-DICHLOROBENZENE**

**MCL 600 ug/l**

##### ***ortho*-DICHLOROBENZENE**

**MCL 600 ug/l**

##### ***para*-DICHLOROBENZENE**

**MCL 75 ug/l**

Chlorinated benzenes are used as intermediates in the production of organic chemicals, including other chlorinated benzenes, and in herbicides, pesticides, fungicides, dyes, rubber, process solvents, and deodorizing agents. In humans the DCBs produce acute effects on the respiratory, hematologic, urinary, and central nervous systems. Chronic exposures can result in liver injury and other toxic effects. DCBs are not highly acutely toxic to animals. Chronically exposed animals may develop central nervous system, liver, and kidney damage.

**1,1-DICHLOROETHANE****MCL 50 ug/l**

1,1-Dichloroethane is a chlorinated aliphatic hydrocarbon which has been detected in drinking water supplies. This compound is one of the less toxic chlorinated aliphatics. 1,1-Dichloroethane has been used as a chemical intermediate and as a solvent for extraction and degreasing. Exposure of cats to 1,1-dichloroethane by inhalation was found to produce kidney damage. A Maximum Contaminant Level of 50 ug/l was derived to protect against renal damage.

**1,2-DICHLOROETHANE****MCL 2 ug/l**

1,2-Dichloroethane (ethylene dichloride) is produced in greater amounts than any other hydrocarbon. Its major use is in the production of vinyl chloride; additionally, it is used as a solvent, in consumer products, as a lead scavenger in gasoline, and as a grain fumigant. Humans are exposed via the air and water, primarily near industrial sites. The odor threshold in water is 20 mg/l. 1,2-Dichloroethane is a mutagen and has been shown to cause cancer in rats and mice.

**1,1-DICHLOROETHYLENE****MCL 2 ug/l****1,2-DICHLOROETHYLENE (*cis*)****MCL 70 ug/l****1,2-DICHLOROETHYLENE (*trans*)****MCL 100 ug/l**

1,1-Dichloroethylene (1,1-DCE) is a chemical intermediate of polyvinylidene chloride copolymers, used in barrier coatings by the packaging industry. 1,2-Dichloroethylenes have a limited use as solvents and preservatives. No estimates of current production levels are available; however use is not widespread. The instability of dichloroethylenes and their limited solubility in water diminish the potential for human exposure in drinking water. Dichloroethylenes at high exposure concentrations can depress the central nervous system and produce narcosis that may result in death. Although toxic effects from chronic exposure to 1,2-dichloroethylenes are not known, 1,1-dichloroethylene has been shown to cause liver and kidney injury in animal studies. Limited evidence from animal studies indicates that 1,1-DCE may be carcinogenic, but epidemiological studies of exposed human populations do not provide direct evidence of carcinogenicity.

**1,2-DICHLOROPROPANE****MCL 5 ug/l**

This organic chemical is used as a solvent and a pesticide. When soil and climactic conditions are favorable, 1,2-dichloropropane may get into drinking water by runoff into surface water or by leaching into groundwater. It may also get into drinking water through improper waste disposal. This chemical has been shown to damage the nervous and reproductive system of laboratory animals such as rats and mice exposed at high levels over their lifetimes. Chemicals that cause cancer in laboratory animals also may increase the risk of cancer in humans who are exposed over long periods. USEPA has set the drinking water standard for 1,2-dichloropropane at 5 ug/l to protect against the risk of these adverse health effects. Drinking water that meets the USEPA standard is associated with little to none of this risk and is considered safe with respect to dichloropropane.

**ETHYLBENZENE****MCL 700 ug/l**

This organic chemical is a major component of gasoline. It generally gets into water by improper waste disposal or leaking gas tanks. This chemical has been shown to damage kidneys, livers, and nervous systems of such laboratory animals as rats exposed to high levels during their lifetimes. USEPA has set the drinking water

standard for ethylbenzene at 700 ug/l to protect against the risk of these adverse health effects. Drinking water that meets the USEPA standard is associated with little to none of this risk and is considered safe with respect to ethylbenzene.

### **METHYL TERTIARY BUTYL ETHER (MTBE)**

**MCL 70 ug/l**

MTBE is used to increase the octane rating of gasoline, and more recently has been added to gasoline to meet the requirements of the Clean Air Act, which require increased oxygen content of gasoline in both CO and ozone non-attainment areas. Typical concentrations of MTBE in gasoline are 2 to 8 percent by volume for increased octane rating. A MCL of 70 ug/l for MTBE has been derived based on increased kidney weight seen in subchronic gavage studies and its classification as a possible human carcinogen.

### **METHYLENE CHLORIDE (DICHLOROMETHANE)**

**MCL 3 ug/l**

This organic chemical is a widely used solvent. It is used in the manufacture of paint remover, as a metal degreaser and as an aerosol propellant. It generally gets into drinking water after improper discharge of waste disposal. This chemical has been shown to cause cancer in laboratory animals such as rats and mice when the animals are exposed at high levels over their lifetimes. Chemicals that cause cancer in laboratory animals also may increase the risk of cancer in humans who are exposed over long periods of time. NJDEP has set the drinking water standard for methylene chloride at 3 ppb to reduce the risk of cancer or other adverse health effects which have been observed in laboratory animals. Drinking water which meets the NJDEP standard is associated with little to none of this risk and should be considered safe with respect to dichloromethane.

### **MONOCHLOROBENZENE**

**MCL 50 ug/l**

Monochlorobenzene is an intermediate in chemical and pesticide production and a process solvent for various organic compounds. It is also a process solvent for methylene diisocyanate, various adhesives, polishes, waxes, pharmaceuticals, and natural rubber. Human exposure has been occupationally related or accidental. Acute exposure to this chemical results in central nervous system depression and hepatic and renal disorders. Effects of chronic exposure involve depression of both the central nervous system and peripheral nervous system, and respiratory tract irritation. In animals, chronic exposure causes hepatic and kidney changes and increased liver weights. The classification of *para*-dichlorobenzene as a probable human carcinogen (USEPA Group B2) or possible human carcinogen (USEPA Group C) is a controversial one. USEPA will reassess its Group C classification as new information becomes available.

### **NAPHTHALENE**

**MCL 300 ug/l**

Napthalene is a white crystalline solid recovered during the processing of petroleum or coal tar. It is released into the water by industrial processes. Individuals are exposed to naphthalene primarily by inhalation through the use of mothballs. Overexposure to naphthalene in humans has been associated with increase in cataract formation and the occurrence of hemolytic anemia. Napthalene does not appear to be mutagenic and there is no evidence of carcinogenic potential on the basis of limited studies. As a result, an MCL of 300 ug/l was obtained which should be protective of possible human health effects incurred from ingestion of naphthalene in drinking water.

**STYRENE****MCL 100 ug/l**

This organic chemical is commonly used to make plastics and is sometimes a component of resins used for drinking water treatment. Styrene may get into drinking water from improper waste disposal. This chemical has been shown to damage the livers and nervous systems of laboratory animals when exposed to high levels during their lifetimes. USEPA has set the drinking water standard for styrene at 100 ug/l to protect against the risk of these adverse health effects. Drinking water that meets the USEPA standard is associated with little to none of this risk and is considered safe with respect to styrene.

**1,1,2,2-TETRACHLOROETHANE****MCL 1 ug/l**

1,1,2,2-Tetrachloroethane was once used extensively as an industrial solvent and intermediate but it presently has limited since less toxic substitutes are available. The compound has been detected in New Jersey surface water and groundwater supplies. 1,1,2,2-Tetrachloroethane is a known toxicant to the liver, kidney, and central nervous system in both humans and laboratory animals. It is classified by EPA as a possible human carcinogen (Group C) since there is limited animal and no human evidence for carcinogenicity. A MCL of 1 ug/l was derived for 1,1,2,2-tetrachloroethane to protect from liver damage and possible carcinogenicity.

**TETRACHLOROETHYLENE****MCL 1 ug/l**

Tetrachloroethylene is a colorless liquid used primarily as a solvent in the dry cleaning of fabrics. To a lesser extent it is used as a degreasing solvent in metal industries and as a chemical intermediate in the synthesis of other compounds. It is not frequently detected in surface waters because of its volatility, but is found most often in groundwaters. The odor threshold for tetrachloroethylene in water is 300 ug/l. Tetrachloroethylene is classified as a probable human carcinogen (USEPA Group B2) by NJDEP.

**TOLUENE****MCL 1000 ug/l**

This organic chemical is used as a solvent and in the manufacture of gasoline for airplanes. It generally gets into water by improper waste disposal or leaking underground storage tanks. This chemical has been shown to damage kidneys, livers, and nervous systems of such laboratory animals as rats and mice exposed to high levels during their lifetimes. Some industrial workers who were exposed to relatively large amounts of this chemical during working careers also suffered damage to the liver, kidney, and nervous system. USEPA has set the drinking water standard for toluene at 1000 ug/l to protect against the risk of these adverse health effects. Drinking water that meets the USEPA standard is associated with little to none of this risk and is considered safe with respect to toluene.

**1,2,4-TRICHLOROBENZENE****MCL 9 ug/l**

This organic chemical is used as a dye carrier and as a precursor in herbicide manufacture. It generally gets into drinking water by discharges from industrial activities. This chemical has been shown to cause damage to several organs, including the adrenal glands. NJDEP has set the drinking water standard for 1,2,4-trichlorobenzene at 8 ppb to protect against the risk of these adverse health effects. Drinking water which meets the NJDEP standard is associated with little to none of this risk and should be considered safe with respect to 1,2,4-trichlorobenzene.

**1,1,1-TRICHLOROETHANE****MCL 30 ug/l**

1,1,1-Trichloroethane is a commonly used industrial solvent which has gained widespread use largely because of its low toxicity compared with other chlorinated hydrocarbons. Cold cleaning and vapor degreasing are its major commercial applications. Additionally, it is used as a spot remover and as a component of adhesives, coatings, and aerosols. Long-term exposure of experimental animals to 1,1,1-trichloroethane has been associated with liver damage. The odor threshold for 1,1,1-trichloroethane in water is 50 mg/l.

**1,1,2-TRICHLOROETHANE****MCL 3 ug/l**

This organic chemical is an intermediate in the production of 1,1,2-trichloroethylene. It generally gets into water by industrial discharge of wastes. This chemical has been shown to damage the kidney and liver of laboratory animals such as rats exposed to high levels during their lifetimes. EPA has set the drinking water standard for 1,1,2-trichloroethane at 0.005 ppm to protect against the risk of these adverse health effects. Drinking water which meets the EPA standard is associated with little to none of this risk and should be considered safe with respect to 1,1,2-trichloroethylene.

**TRICHLOROETHYLENE****MCL 1 ug/l**

Trichloroethylene is a colorless liquid used extensively as a solvent in the vapor degreasing of fabricated metal parts. It may be found in printing inks, varnishes, paints, lacquers, adhesives, spot removers, rug cleaners, and disinfectants. It is no longer used in food, drugs, or cosmetics. The major source of it in the environment is volatilization during production and use. The odor threshold of trichloroethylene in water is 0.5 mg/l. The USEPA classifies trichloroethylene as a probable human carcinogen (Group B2).

**VINYL CHLORIDE****MCL 2 ug/l**

Vinyl chloride is a synthetic chemical with no natural sources. In the United States, vinyl chloride has been synthesized commercially for over 50 years, reaching a production level of 7.5 billion pounds in 1984. Vinyl chloride is used in the production of polymer (polyvinyl chloride), the most widely used plastic in the world, in the manufacture of piping, and conduit, electrical wire insulation and cables, food packaging materials, floor coverings, and a variety of other industrial products. It is classified as a human carcinogen (USEPA Group A) and has been shown to induce liver cancer in rats, mice, hamsters, and humans.

**XYLENE(S) (Total)****MCL 1000 ug/l**

The xylenes are widely used as solvents for inks, rubber, gums, resins, adhesives, and lacquers; as thinners and paint removers; in the paper coating industry; as a component of paint, varnishes, dyes, cements, cleaning fluids, and aviation fuels; as solvents and emulsifiers for agricultural products; in perfumes, insect repellents, pharmaceuticals, and in the leather industry. Its use is increasing as a "safe" replacement for benzene, and in gasoline as part of the benzene-toluene-xylene (BTX) component. Releases of xylene into the environment are estimated to be nearly 410 million kilograms annually. Levels in New Jersey drinking water have been found to range from 0.2 to 3.0 ug/l. In general, xylenes are acutely toxic to animals and humans only at higher concentrations, the liver and central nervous system being most notably affected by chronic exposure. Embryotoxic and developmental effects

have been demonstrated in animals exposed to xylene at low doses either orally or by inhalation. Pregnant women and their fetuses should therefore be considered high-risk subpopulations.

## **SYNTHETIC ORGANIC COMPOUNDS**

The chlorinated hydrocarbons are one of the most important groups of synthetic organic pesticides because of their wide use, great stability in the environment, and toxicity to mammals and insects. The symptoms of poisoning, regardless of the compound involved or the route of entry, are similar but may vary in severity. Mild cases of poisoning are characterized by headache, dizziness, gastrointestinal disturbances, numbness and weakness of the extremities, apprehension, and hyperirritability. When absorbed into the body, some of the chlorinated hydrocarbons are not metabolized rapidly and are stored in the fat. Based on these and other facts, limits in drinking water have been calculated primarily on the basis of the extrapolated intake that would cause minimal toxic effects in mammals (rats and dogs).

### **ALACHLOR**

**MCL 2 ug/l**

This organic chemical is widely used as a pesticide. When soil and climatic conditions are favorable, alachlor may get into drinking water by runoff into surface water or by leaching into groundwater. This chemical has been shown to cause cancer in such laboratory animals as rats and mice when the animals are exposed at high levels over their lifetimes. Chemicals that cause cancer in laboratory animals also may increase the risk of cancer in humans who are exposed over long periods. USEPA has set the drinking water standard for alachlor at 2 ug/l to reduce the risk of cancer or other adverse health effects which have been observed in animals. Drinking water that meets this standard is associated with little to none of this risk and is considered safe with respect to alachlor.

### **ATRAZINE**

**MCL 3 ug/l**

This organic chemical is an herbicide. When soil and climatic conditions are favorable, atrazine may get into drinking water by runoff into surface water or by leaching into groundwater. This chemical has been shown to affect offspring of rats and the heart of dogs. USEPA has set the drinking water standard for atrazine at 3 ug/l to protect against the risk of these adverse health effects. Drinking water that meets the USEPA standard is associated with little to none of this risk and is considered safe with respect to atrazine.

### **BENZO[A]PYRENE**

**MCL 0.2 ug/l**

The major source of benzo[a]pyrene in drinking water is the leaching from coal tar lining and sealants in water storage tanks. Cigarette smoke and charbroiled meats are a common source of general exposure. This organic chemical has been shown to cause cancer in animals such as rats and mice when the animals are exposed at high levels. EPA has set the drinking water standard for benzo[a]pyrene at 0.2 ppb to protect against the risk of cancer. Drinking water which meets the EPA standard is associated with little to none of this risk and should be considered safe with respect to benzo[a]pyrene.

**CARBOFURAN****MCL 40 ug/l**

This organic chemical is a pesticide. When soil and climatic conditions are favorable, carbofuran may get into drinking water by runoff into surface water or by leaching into groundwater. This chemical has been shown to damage the nervous and reproductive systems of such laboratory animals as rats and mice exposed at high levels over their lifetimes. Some humans who were exposed to relatively large amounts of this chemical during their working careers also suffered damage to the nervous system. Effects on the nervous system are generally rapidly reversible. USEPA has set the drinking water standard for carbofuran at 40 ug/l to protect against the risk of these adverse health effects. Drinking water that meets the USEPA standard is associated with little to none of this risk and is considered safe with respect to carbofuran.

**CHLORDANE****MCL 0.5 ug/l**

Chlordane is a wide-spectrum insecticide. Production has been reduced within the last 10 years due to USEPA cancellation proceedings and a settlement that determined a schedule to phase out legal chlordane use. Until April 1976, chlordane was used on agricultural crops, such as corn, potatoes, and tomatoes, as well as home garden crops, to control soil insects and ants. In 1980, 10 million pounds of chlordane were used to treat soil for termites by subsurface injection. The only approved use of chlordane since July 1, 1983, is for underground termite control. Human exposure to chlordane has occurred by occupational and accidental means. Toxic effects following acute exposure to this chemical include central nervous system sensitization and gastrointestinal disorders. Toxic effects of chronic exposure include skin irritation, blurred vision, exhaustion, liver damage, anorexia and weight loss, severe gastroenteritis, and death. Chlordane has been classified as a probable human carcinogen (USEPA Group B2) based on positive results in mice and female rats.

**DALAPON****MCL 200 ug/l**

This organic chemical is a widely used herbicide. It may get into drinking water after application to control grasses in crops, drainage ditches and along railroads. This chemical has been shown to cause damage to the kidney and liver in laboratory animals when the animals are exposed to high levels over their lifetimes. EPA has set the drinking water standard for dalapon at 200 ppb to protect against the risk of these adverse health effects. Drinking water which meets the EPA standard is associated with little to none of this risk and should be considered safe with respect to dalapon.

**DIBROMOCHLOROPROPANE (DBCP)****MCL 0.2 ug/l**

This organic chemical was once a popular pesticide. When soil and climatic conditions are favorable, DBCP may get into drinking water by runoff into surface water or by leaching into groundwater. This chemical has been shown to damage the nervous and reproductive systems of such laboratory animals as rats and mice exposed at high levels over their lifetimes. Chemicals that cause cancer in laboratory animals also may increase the risk of cancer in humans who are exposed over long periods. USEPA has set the drinking water standard for DBCP at 0.2 ug/l to protect against the risk of these adverse health effects. Drinking water that meets the USEPA standard is associated with little to none of this risk and is considered safe with respect to DBCP.

**DI(2-ETHYLHEXYL)ADIPATE****MCL 400 ug/l**

Di(2-ethylhexyl)adipate is a widely used plasticizer in a variety of products, including synthetic rubber, food packaging materials and cosmetics. It may get into drinking water after improper waste disposal. EPA has set the drinking water standard for di(2-ethylhexyl)adipate at 400 ppb to protect against the risk of adverse health effects. Drinking water which meets the EPA standard is associated with little to none of this risk and should be considered safe with respect to di(2-ethylhexyl)adipate.

**DI(2-ETHYLHEXYL)PHTHALATE****MCL 6 ug/l**

Di(2-ethylhexyl)phthalate is widely used in the production of polyvinyl chloride (PVC) resins. It may get into drinking water after improper waste disposal. This chemical has been shown to cause cancer in laboratory animals such as rats and mice exposed to high levels over their lifetimes. EPA has set the drinking water standard for di(2-ethylhexyl)phthalate at 6 ppb to protect against the risk of cancer or other adverse health effects which have been observed in laboratory animals. Drinking water which meets the EPA standard is associated with little to none of this risk and should be considered safe with respect to di(2-ethylhexyl)phthalate.

**DINOSEB****MCL 7 ug/l**

Dinoseb is a widely used pesticide and generally gets into drinking water after application on orchards, vineyards and other crops. This chemical has been shown to damage the thyroid and reproductive organs in laboratory animals such as rats exposed to high levels. EPA has set the drinking water standard for dinoseb at 7 ppb to protect against the risk of adverse health effects. Drinking water which meets the EPA standard is associated with little to none of this risk and should be considered safe with respect to dinoseb.

**DIQUAT****MCL 20 ug/l**

This organic chemical is a herbicide used to control terrestrial and aquatic weeds. It may get into drinking water by runoff into surface water. This chemical has been shown to damage the liver, kidney, and gastrointestinal tract and causes cataract formation in laboratory animals such as dogs and rats exposed at high levels over their lifetimes. EPA has set the drinking water standard for diquat at 20 ppb to protect against the risk of these adverse health effects. Drinking water which meets the EPA standard is associated with little to none of this risk and should be considered safe with respect to diquat.

**ENDOTHALL****MCL 100 ug/l**

This organic chemical is a herbicide used to control terrestrial and aquatic weeds. It may get into water by runoff into surface water. This chemical has been shown to damage the liver, kidney, gastrointestinal tract and reproductive system of laboratory animals such as rats and mice exposed at high levels over their lifetimes. EPA has set the drinking water standard for endothall at 100 ppb to protect against the risk of these adverse health effects. Drinking water which meets the EPA standard is associated with little to none of this risk and should be considered safe with respect to endothall.

**ENDRIN****MCL 2 ug/l**

This organic chemical is a pesticide no longer registered for use in the United States. However, this chemical is persistent in treated soils and accumulates in sediments and aquatic and terrestrial biota. This chemical has been shown to cause damage to the liver, kidney and heart in laboratory animals such as rats and mice when the animals are exposed at high levels over their lifetimes. EPA has set the drinking water standard for endrin at 2 ppb to protect against the risk of these adverse health effects which have been observed in laboratory animals. Drinking water that meets the EPA standard is associated with little to none of this risk and should be considered safe with respect to endrin.

**ETHYLENE DIBROMIDE (EDB)****MCL 0.05 ug/l**

This organic chemical was once a popular pesticide. When soil and climactic conditions are favorable, EDB may get into drinking water by runoff into surface water or by leaching into groundwater. This chemical has been shown to damage the nervous and reproductive systems of such laboratory animals as rats and mice exposed at high levels over their lifetimes. Chemicals that cause cancer in laboratory animals also may increase the risk of cancer in humans who are exposed over long periods. USEPA has set the drinking water standard for EDB at 0.05 ug/l to protect against the risk of these adverse health effects. Drinking water that meets the USEPA standard is associated with little to none of this risk and is considered safe with respect to EDB.

**GLYPHOSATE****MCL 700 ug/l**

This organic chemical is a herbicide used to control grasses and weeds. It may get into drinking water by runoff into surface water. This chemical has been shown to damage liver and kidneys in laboratory animals such as rats and mice exposed to high levels over their lifetimes. EPA has set the drinking water standard for glyphosate at 700 ppb to protect against the risk of adverse health effects. Drinking water which meets the EPA standard is associated with little to none of this risk and should be considered safe with respect to glyphosate.

**HEPTACHLOR****MCL 0.4 ug/l**

This organic chemical was once a popular pesticide. When soil and climatic conditions are favorable, heptachlor may get into drinking water by runoff into surface water or by leaching into groundwater. This chemical has been shown to damage the nervous and reproductive systems of such laboratory animals as rats and mice exposed at high levels over their lifetimes. Chemicals that cause cancer in laboratory animals also may increase the risk of cancer in humans who are exposed over long periods. USEPA has set the drinking water standard for heptachlor at 0.4 ug/l to protect against the risk of these adverse health effects. Drinking water that meets the USEPA standard is associated with little to none of this risk and is considered safe with respect to heptachlor.

**HEPTACHLOR EPOXIDE****MCL 0.2 ug/l**

This organic chemical was once a popular pesticide. When soil and climatic conditions are favorable, heptachlor epoxide may get into drinking water by runoff into surface water or by leaching into groundwater. This chemical has been shown to damage the nervous and reproductive systems of such laboratory animals as rats and mice exposed at high levels over their lifetimes. Chemicals that cause cancer in

laboratory animals also may increase the risk of cancer in humans who are exposed over long periods. USEPA has set the drinking water standard for heptachlor epoxide at 0.2 ug/l to protect against the risk of these adverse health effects. Drinking water that meets the USEPA standard is associated with little to none of this risk and is considered safe with respect to heptachlor epoxide.

### **HEXACHLOROBENZENE**

**MCL 1 ug/l**

This organic chemical is produced as an impurity in the manufacture of certain solvents and pesticides. This chemical has been shown to cause cancer in laboratory animals such as rats and mice when the animals are exposed to high levels during their lifetimes. Chemicals that cause cancer in laboratory animals also may increase the risk of cancer in humans who are exposed over long periods of time. EPA has set the drinking water standard for hexachlorobenzene at 1 ppb to protect against the risk of cancer and other adverse health effects. Drinking water which meets the EPA standard is associated with little to none of this risk and should be considered safe with respect to hexachlorobenzene.

### **HEXACHLOROCYCLOPENTADIENE**

**MCL 50 ug/l**

This organic chemical is used as an intermediate in the manufacture of pesticides and flame retardants. It may get into water by discharge from production facilities. This chemical has been shown to damage the kidney and the stomach of laboratory animals when exposed to high levels over their lifetimes. EPA has set the drinking water standard for hexachlorocyclopentadiene at 50 ppb to protect against the risk of these adverse health effects. Drinking water which meets the EPA standard is associated with little to none of this risk and should be considered safe with respect to hexachlorocyclopentadiene.

### **LINDANE**

**MCL 0.2 ug/l**

Lindane (gamma isomer of 1,2,3,4,5,6-hexachlorocyclohexane) is an insecticide registered for commercial and home use. Lindane is the active ingredient in several prescribed shampoos used for the elimination of head lice. Lindane is slightly soluble in water and will volatilize to the atmosphere from soil or water. It is persistent in soils (half-life greater than 100 days), though it does undergo rapid biotransformation under anaerobic conditions. Acute exposure of animals to lindane results in neurological and behavioral effects. The liver and the kidney appear to be the primary target organs for lindane toxicity. Lindane is classified as "B2-C" (i.e., in between the lower half of the "B" category of 'probable' and the "C" category of 'possible' carcinogen classifications) based upon evidence that lindane gives rise to malignant liver tumors in two strains of mice, plus supportive evidence of pre-cancerous liver lesions in shorter term studies. Lindane, because of the potential adverse effects and occurrence in drinking water, is regulated.

### **METHOXYCHLOR**

**MCL 40 ug/l**

Methoxychlor, a chemical closely related to DDT, has been used as an insecticide for approximately 40 years. Methoxychlor has been widely used in home and garden applications, as well as on domestic animals, trees, and in waters. The half-life for methoxychlor in water is estimated to be 46 days, and thus it is not considered to be persistent. Methoxychlor exhibits a wide range of toxicity when administered at high dose levels to animals. Central nervous system effects were observed in dogs, and kidney and liver changes in swine and rats. Methoxychlor has been classified in

EPA's Group D (not classifiable), based upon inconclusive results in animal tests. Methoxychlor has been shown to exhibit chronic toxic effects at high dose levels and has been detected in drinking water; for these reasons it is regulated.

### **OXAMYL**

**MCL 200 ug/l**

This organic chemical is used as a pesticide for the control of insects and other pests. It may get into drinking water by runoff into surface water or leaching into ground water. This chemical has been shown to damage the kidneys of laboratory animals such as rats when exposed at high levels over their lifetimes. EPA has set the drinking standard for oxamyl at 200 ppb to protect against these adverse health effects. Drinking water which meets the EPA standard is associated with little to none of this risk and should be considered safe with respect to oxamyl.

### **PCBs (POLYCHLORINATED BIPHENYLS)**

**MCL 0.5 ug/l**

Polychlorinated biphenyls (PCBs) have been used commercially for over 50 years primarily as dielectrics. Their chemical inertness has led to their wide dissemination and persistence in the environment. As many as 209 different compounds of PCBs are possible; they exist in varying proportions in commercial mixtures called aroclor. Commercial PCB mixtures are distinguished by a number, e.g., aroclor 1254, which is based on the average percentage of chlorine in the mixture. Human exposure to PCBs has resulted largely from consumption of contaminated food and from the work environment. Production is banned; however there are a few exceptions for closed electrical systems. PCBs accumulate in the fatty tissues and skin of man and other animals. The major sites of pathology caused by PCBs are the skin and liver. Several studies in rodents suggest strongly that PCBs are carcinogenic and may also enhance the carcinogenicity of other compounds.

### **PENTACHLOROPHENOL**

**MCL 1 ug/l**

Pentachlorophenol is an organic chemical used as a wood preservative, herbicide, disinfectant, and defoliant. It generally gets into drinking water by runoff into surface water or leaching into groundwater. This chemical has been shown to produce adverse effects and to damage the liver and kidneys of laboratory animals such as rats exposed to high levels during their lifetimes. Some humans who were exposed to relatively large amounts of this chemical also suffered damage to the liver and kidneys. USEPA has set the drinking water standard for pentachlorophenol at 1 part per billion (ug/l) to protect against the risk of cancer or other health effects.

### **PICLORAM**

**MCL 500 ug/l**

This organic chemical is used as a pesticide for broadleaf weed control. It may get into drinking water by runoff into surface water or leaching into groundwater as a result of pesticide application and improper waste disposal. This chemical has been shown to cause damage to the kidneys and liver in laboratory animals such as rats when the animals are exposed at high levels over their lifetimes. EPA has set the drinking water standard for picloram at 500 ppb to protect against the risk of these adverse health effects. Drinking water which meets the EPA standard is associated with little to none this risk and should be considered safe with respect to picloram.

**SIMAZINE****MCL 4 ug/l**

This organic chemical is a herbicide used to control annual grasses and broadleaf weeds. It may leach into groundwater or runs off into surface water application. This chemical may cause cancer in laboratory animals and mice exposed at high levels during their lifetimes. Chemicals that cause cancer in laboratory animals increase the risk of cancer in humans who are exposed over long of time. EPA has set the drinking water standard for simazine at 4 ppb to reduce the risk of cancer or other adverse health effects. Drinking water which meets the EPA standard is associated with little to none of this risk and should be considered safe with respect to simazine.

**TOXAPHENE****MCL 3 ug/l**

Toxaphene (a mixture of C<sub>10</sub> chlorinated camphenes with an approximate overall empirical formula of C<sub>10</sub>H<sub>10</sub>Cl<sub>5</sub>) is a persistent, broad-spectrum insecticide. This product was used extensively on food and fiber crops for many years, but current registered uses are limited. The USEPA Toxaphene Work Group reported that toxaphene is highly persistent and accumulates in the environment. Acute exposure to toxaphene results in a variety of central nervous system effects, including salivation, hyperexcitability, behavioral changes, and convulsions. The kidney, liver, and testes are also affected by acute exposure to toxaphene. Toxaphene has been classified in EPA's Group B2 (probable human carcinogen), based upon the positive results in studies in rats and mice. The available data indicate that toxaphene is a potent carcinogen in animals. For this reason and because there is some occurrence in drinking water, it is regulated.

**2,3,7,8-TCDD (Dioxin)****MCL 0.00003 ug/l**

This organic chemical is an impurity in the production of some pesticides. It may get into drinking water by industrial discharge of wastes. This chemical has been shown to cause cancer in laboratory animals such as rats and mice when the animals are exposed at high levels over their lifetimes. Chemicals that cause cancer in laboratory animals also may increase the risk of cancer in humans who are exposed over long periods of time. EPA has set the drinking water standard for dioxin at 0.00003 ppb to reduce the risk of cancer or other adverse health effects which have been observed in laboratory animals. Drinking water which meets this standard is associated with little to none of this risk and should be considered safe with respect to dioxin.

**2,4-D (2,4-DICHLOROPHENOXYACETIC ACID)****MCL 70 ug/l**

2,4-D (2,4-dichlorophenoxyacetic acid) is a systemic herbicide used to control broadleaf weeds. 2,4-D is sold as a variety of salts, esters, and other derivatives which are very soluble in water. 2,4-D and its derivatives undergo both chemical and biological degradation when released to the environment. Soil residues break down in approximately six weeks and repeated application usually does not lead to accumulation. Nearly 60 percent of the domestically available 2,4-D is used on agricultural crop sites. The remainder is used on range and pasture land, industrial and commercial sites, lawns and turf, forests, and in water. 2,4-D is currently registered for aquatic weed control in ponds, lakes, reservoirs, marshes, bayous, drainage ditches, canals, rivers, and streams. 2,4-D has been detected in many surface and groundwaters. The compound has been detected in waste waters and hazardous wastes; it is mobile and widely used on many crops. Short-term exposure to 2,4-D at high doses by the oral route or by other routes results in progressive symptoms of

muscular incoordination, hindquarter paralysis, stupor, coma, and death in animals. 2,4-D has been classified in EPA's Group D (not classifiable), based upon inadequate data from animal studies. Exposure to 2,4-D at high dose levels results in kidney damage and skeletal muscle changes; thus it is regulated.

### **2,4,5-TP (SILVEX)**

**MCL 50 ug/l**

2,4,5-TP [2-(2,4,5-trichlorophenoxy) propionic acid], or silvex, is an herbicide that has been used for weed and brush control on rangeland and rights of way, pastures, commercial or ornamental turf, home weed control, and weed control in and along canals and other waterways. 2,4,5-TP is soluble in water, and its environmental persistence is expected to be relatively short. 2,4,5-TP is contaminated to varying extents with 2,3,7,8-TCDD, a highly toxic polychlorinated dibenzo-p-dioxin. Substantial differences in the toxicity of 2,4,5-TP have been reported, probably based upon the degree of contamination of the compound. Single, oral exposure to 2,4,5-TP at high doses causes a variety of physiological and biochemical effects including depression, posterior quarter muscle weakness, irritation of the stomach, and minor liver and kidney damage in mammals. It has been classified in EPA's Group D (not classifiable), based upon inadequate data from animal studies. Exposure to 2,4,5-TP at high dose levels results in a variety of chronic adverse health effects. Because this contaminant also has been detected in several drinking water systems, it is regulated.

### **TRIHALOMETHANES (TOTAL THMs)**

**MCL 100 ug/l**

Trihalomethanes are members of a group of organic chemicals that contain one carbon atom, one hydrogen atom, and three halogen atoms. The halogen atoms important in the formation of trihalomethanes in water are chlorine, bromine, and iodine. At most locations, only 4 of the 10 possible trihalomethanes can occur in significant concentrations in chlorinated drinking water. They are trichloromethane (chloroform), bromodichloromethane, dibromochloromethane, and tribromomethane (Bromoform).

Chloroform, usually the trihalomethane found in the highest concentrations, is formed by the reaction of free chlorine with certain natural organic compounds in the water. Formation occurs during chlorination and can continue to occur as long as free chlorine is available. Other trihalomethanes are formed by the reaction of bromine or iodine with the same group of organic compounds.

The effects of chloroform on the human body are still under study, but one test has found that high doses of chloroform can be carcinogenic to rats and mice. Therefore, the USEPA considers chloroform a potential human carcinogen. The USEPA also believes that the other trihalomethanes are implicated, by association, as potential carcinogens.

The primary drinking water regulations provide an MCL of 0.10 mg/l for total trihalomethanes (TTHMs) along with associated monitoring and reporting requirements. This MCL applies to community water systems which serve more than 10,000 people and add a disinfectant (oxidant) to the water in any part of the drinking water treatment process. This MCL may be extended in time to community water systems serving fewer than 10,000 people as well as to noncommunity systems.

## **INORGANIC CHEMICAL MAXIMUM CONTAMINANT LEVELS**

### **ANTIMONY**

**MCL 6 ug/l**

Antimony occurs naturally in soils, groundwater and surface waters and is often used in the flame retardant industry. It is also used in ceramics, glass, batteries, fireworks and explosives. It may get into drinking water through natural weathering of rock, industrial production, municipal waste disposal or manufacturing processes. This element has been shown to decrease longevity, and altered blood levels of cholesterol and glucose in laboratory animals such as rats exposed to high levels during their lifetimes. EPA has set the drinking water standard for antimony at 0.006 ppm to protect against the risk of these adverse health effects. Drinking water which meets the EPA standard is associated with little to none of this risk and should be considered safe with respect to antimony.

### **ARSENIC**

**MCL 50 ug/l**

Areas with elevated levels of arsenic in geologic materials are found throughout the United States. Most of the arsenic produced is a by-product of the smelting of copper, lead, and zinc ores. Arsenic has been found in both groundwater and surface waters from both natural processes and industrial activities, including smelting operations, use of arsenical pesticides, and industrial waste disposal. Arsenic compounds have been shown to produce acute and chronic toxic effects which include systemic irreversible damage. The trivalent (+3) compounds are the most toxic and tend to accumulate in the body. Chronic animal studies have shown body weight changes, decreased blood hemoglobin, liver damage, and kidney damage. Arsenic has been classified in EPA's Group A (human carcinogen), based upon evidence of human carcinogenicity through inhalation and ingestion exposure. Arsenic is regulated because of its potential adverse health effects and its widespread occurrence.

### **ASBESTOS**

**7 million fibers/l (longer than 10 μm)**

Asbestos is a naturally occurring mineral. Most asbestos fibers in drinking water are less than 10 micrometers (μm) ( $1\mu\text{m} = 10^{-7}$  meters) in length and occur in drinking water from natural sources and from corroded asbestos-cement pipes in the distribution system. The major uses of asbestos were in the production of textiles, plastics, cements, floor tiles, paper products, paint, and caulking; and in transportation-related applications. Asbestos was once a popular insulating and fire-retarding material. Inhalation studies have shown that various forms of asbestos have produced lung tumors in laboratory animals. The available information on the risk of developing gastrointestinal tract cancer associated with the ingestion of asbestos from drinking water is limited. Ingestion of intermediate-range chrysotile asbestos fibers greater than 10 micrometers in length is associated with causing benign tumors in male rats. Chemicals that cause cancer in laboratory animals also may increase the risk of cancer in humans who are exposed over long periods. USEPA has set the drinking water standard for asbestos at 7 million long fibers to reduce the potential risk of cancer or other adverse health effects which have been observed in laboratory animals. Drinking water which meets the USEPA standard is associated with little to none of this risk and should be considered safe with respect to asbestos.

**BARIUM****MCL 2000 ug/l**

Barium is a naturally occurring metal found in many types of rock, such as limestones and sandstones, and soils in the eastern United States. Certain geologic formations in California, Arkansas, Missouri, and Illinois are known to contain barium levels about 1,000 times higher than those found in other portions of the United States. Areas associated with deposits of coal, petroleum, natural gas, oil shale, black shale, and peat may also contain high levels of barium. Principal areas where high levels of barium have been found in drinking water include parts of Iowa, Illinois, Kentucky, and Georgia. Acute exposure to barium in animals and humans results in a variety of cardiac, gastrointestinal, and neuromuscular effects. Barium has been classified in EPA's Group D (not classifiable), based upon inadequate data from animal studies. Barium exposure has been associated with hypertension and cardiotoxicity in animals. For this reason and because of the widespread occurrence of barium in drinking water, it is regulated.

**BERYLLIUM****MCL 4 ug/l**

Beryllium occurs naturally in soils, ground water and surface waters and is often used in electrical equipment and electrical components. It generally gets into water from runoff from mining operations, discharge from processing plants and improper waste disposal. Beryllium compounds have been associated with damage to the bones and lungs and induction of cancer in laboratory animals such as rats and mice when the animals are exposed at high levels over their lifetimes. There is limited evidence to suggest that beryllium may pose a cancer risk via drinking water exposure. Therefore, EPA based the health assessment on noncancer effects with an extra uncertainty factor to account for possible carcinogenicity. Chemicals that cause cancer in laboratory animals also may increase the risk of cancer in humans who are exposed over long periods of time. EPA has set the drinking water standard for beryllium at 0.004 ppm to protect against the risk of these adverse health effects. Drinking water which meets the EPA standard is associated with little to none of this risk and should be considered safe with respect to beryllium.

**CADMIUM****MCL 5 ug/l**

Cadmium is found in very low concentrations in most rocks, as well as in coal and petroleum and often in combination with zinc. Geologic deposits of cadmium can serve as sources to groundwater and surface water, especially when in contact with soft, acidic waters. Cadmium uses include electroplating, nickel-cadmium batteries, paint and pigments, and plastic stabilizers. It is introduced into the environment from mining and smelting operations and industrial operations, including electroplating, reprocessing cadmium scrap, and incineration of cadmium-containing plastics. The remaining cadmium emissions are from fossil fuel use, fertilizer application, and sewage sludge disposal. Cadmium may enter drinking water as a result of corrosion of galvanized pipe. Landfill leachates are also an important source of cadmium in the environment. Acute and chronic exposure to cadmium in animals and humans results in kidney dysfunction, hypertension, anemia, and liver damage. The kidney is considered to be the critical target organ in humans chronically exposed to cadmium by ingestion. Cadmium has been classified in EPA's Group B1 (probable human carcinogen), based upon evidence of carcinogenicity in humans through inhalation exposure. However, since cadmium has not been shown to be carcinogenic through

ingestion exposure, the compound is regulated based upon chronic toxicity data. Because of cadmium's potential adverse health effects and widespread occurrence in raw waters, it is regulated.

## **CHROMIUM**

**MCL 100 ug/l**

Chromium is a naturally occurring metal that in drinking water forms compounds with valences of +3 and +6, with the trivalent state being the more common. Although chromium is not currently mined in the United States, wastes from old mining operations may enter surface and groundwater through runoff and leaching. Chromate wastes from plating operations may also be a source of water contamination. Fossil fuel combustion, waste incineration, cement plant emissions, chrome plating, and other metallurgical and chemical operations may result in releases of chromium to the atmosphere. Chromium III and chromium VI have greatly differing toxicity characteristics. Chromium III is a nutritionally essential element. Chromium VI is much more toxic than Chromium III and has been shown to produce liver and kidney damage, internal hemorrhage, and respiratory disorders. Also, subchronic and chronic exposure to Chromium VI in the form of chromic acid can cause dermatitis and ulceration of the skin. Chromium has been classified in EPA's Group A (human carcinogen), based upon positive inhalation data for Chromium VI in humans and animals. However, since chromium has not been shown to be carcinogenic through ingestion exposure, the compound is regulated based upon chronic toxicity data. Chromium exposure at high levels has been shown to result in chronic toxic effects in animals and humans by ingestion; thus it is regulated.

## **COPPER**

**1500 ug/l (Action Level)**

Copper, a reddish-brown metal, is often used to plumb residential and commercial structures that are connected to water distribution systems. Copper contaminating drinking water as a corrosion by-product occurs as the result of the corrosion of copper pipes that remain in contact with water for a prolonged period. Copper is an essential nutrient, but at high doses it has been shown to cause stomach and intestinal distress, liver and kidney damage, and anemia. Persons with Wilson's disease may be at higher risk of health effects due to copper contamination resulting from the corrosion of plumbing materials. Public water systems serving over 50,000 people or fewer that have copper concentrations below 1300 parts per billion in more than 90 percent of tapwater samples (the USEPA action level) are not required to install or improve their treatment. Any water system that exceeds the action level must also monitor its source water to determine whether treatment to remove copper in source water is needed.

## **CYANIDE**

**MCL 200 ug/l**

Cyanide is used in electroplating, steel processing, plastics, synthetic fabrics and fertilizer products. It usually gets into water as a result of improper waste disposal. Cyanide compounds have been shown to damage the spleen, brain and liver of humans fatally poisoned with cyanide. EPA has set the drinking water standard for cyanide at 0.2 ppm to protect against the risk of these adverse health effects. Drinking water which meets the EPA standard is associated with little to none of this risk and should be considered safe with respect to cyanide.

## **FLUORIDE**

**MCL 4000 ug/l**

Federal regulations require that fluoride, which occurs naturally in your water supply, not exceed a concentration of 4.0 mg/l in drinking water. This MCL has been established to protect public health. Exposure to drinking water levels above 4.0 mg/l for many years may result in some cases of crippling skeletal fluorosis, which is a serious bone disorder.

Fluoride in children's drinking water at levels of approximately 1 mg/l reduces the number of dental cavities 60-65 percent below rates in communities with little or no fluoride. However, some children exposed to levels of fluoride greater than about 2.0 mg/l may develop dental fluorosis. Dental fluorosis, in its moderate and severe forms, is a brown staining and/or pitting of the permanent teeth. Because dental fluorosis occurs only when developing teeth (before they erupt from the gums) are exposed to elevated fluoride levels, households without children are not expected to be affected by this level of fluoride. Federal law also requires that notification take place when monitoring indicates that the fluoride exceeds 2.0 mg/l. This is intended to alert families about dental problems that might affect children under nine years of age. Families with children under the age of nine with fluoride exceeding 2.0 mg/l are encouraged to seek other sources of drinking water for their children to avoid the possibility of staining and pitting.

## **LEAD**

**15 ug/l (Action Level)**

Materials that contain lead have frequently been used in the construction of water supply distribution systems and plumbing systems in private homes and other buildings. The most commonly found materials include service lines, pipes, brass and bronze fixtures, and solders and fluxes. Lead in these materials can contaminate drinking water as a result of the corrosion that takes place when water comes into contact with those materials. Lead can cause a variety of adverse health effects in humans. At relatively low levels of exposure, these effects may include interference in red blood cell chemistry, delays in normal physical and mental development in babies and young children, slight deficits in the attention span, hearing, and learning abilities of children, and slight increases in blood pressure of some adults. EPA's national primary drinking water regulation requires all public water systems to optimize corrosion control to minimize lead contamination resulting from the corrosion of plumbing materials. Public water systems serving 50,000 people or fewer that have lead concentrations below 15 parts per billion (ppb) in more than 90 percent of tap water samples (the USEPA action level) have optimized their corrosion control treatment. Any water system that exceeds the action level must also monitor its source water to determine whether treatment to remove lead in source water is needed. Any water system that continues to exceed the action level after installation of corrosion control and/or source water treatment must eventually replace all lead service lines contributing in excess of 15 ppb of lead to drinking water. Any water system that exceeds the action level must also undertake a public education program to inform consumers of ways they can reduce their exposure to potentially high levels of lead in drinking water.

The following steps can be taken to minimize your exposure to lead:

1. Flush your plumbing to counteract the effects of “contact time.” Flushing involves allowing the cold faucet to run until a change in temperature occurs (minimum of one minute). Water drawn during flushing doesn’t have to be wasted. It can be saved for other uses such as washing dishes or clothes and watering plants.
2. Do not consume hot tap water. Hot water tends to aggravate lead leaching when brought in contact with lead plumbing materials.
3. For private wells steps can be taken to make water noncorrosive. Water-treatment devices for individual households include calcite filters and other devices to lessen acidity.
4. Insist on lead-free materials for use in repairs and newly installed plumbing.
5. Lead can be removed from your tap water by installing point-of-use treatment devices now commercially available, which include: ion-exchange filters, reverse osmosis devices, and distillation units. (For more information call (609) 984-5862.)
6. Bottled water can be purchased for drinking and cooking purposes. (For more information call (609) 588-3123.)

Lead has been classified in EPA’s Group B2 (probable human carcinogen), based upon evidence of kidney tumors in rats by the oral route.

## **MERCURY**

**MCL 2 ug/l**

Mercury exists in two basic forms; the inorganic salt and organic mercury compounds (methyl mercury). Mercury levels in coal range from 10-46,000 ppb. The major use of mercury is in electrical equipment (batteries, lamps, switches, and rectifiers). Mercury may also enter the environment from mining, smelting, and fossil fuel combustion. Inorganic mercury is poorly absorbed through the gastro-intestinal tract. The principal target organ of inorganic mercury is the kidney. Exposure to inorganic mercury compounds at high levels results in renal effects. Because inorganic mercury is the form of mercury detected in drinking water, has widespread occurrence, and may have adverse health effects, it is regulated.

## **NITRATE (NO<sub>3</sub><sup>-</sup>)**

**MCL 10000 ug/l**

Nitrate is the more stable oxidized form of combined nitrogen in most environmental media. Most nitrogenous materials in natural waters tend to be converted to nitrate, and, therefore, all sources of combined nitrogen (particularly organic nitrogen and ammonia) should be considered as potential nitrate sources. Nitrates occur naturally in mineral deposits (generally sodium or potassium nitrate), in soils, seawater, freshwater systems, the atmosphere, and in biota. Lakes and other static water bodies usually have less than 1.0 ug/l of nitrate/nitrogen. Groundwater levels of nitrate/nitrogen may range up to 20 ug/l or more, with higher levels characteristically occurring in shallow aquifers beneath areas of extensive development. Major sources of nitrates or nitrite in drinking water include fertilizer, sewage, and feedlots. The toxicity of nitrate in humans is due to the body’s reduction of nitrate to nitrite. This reaction takes place in saliva of humans at all ages and in the gastrointestinal tract of infants during the first three months of life. The toxicity of nitrite is demonstrated by vasodilatory/cardiovascular effects at high dose levels and methemoglobinemia at

lower dose levels. Methemoglobinemia, “Blue-Baby Disease,” is an effect in which hemoglobin is oxidized to methemoglobin, resulting in asphyxia. Infants up to three months of age are the most susceptible subpopulation with regard to nitrate. This is due to the fact that in the adult and child, about 10 percent of ingested nitrate is transformed to nitrite, while 100 percent of ingested nitrate can be transformed to nitrite in the infant. The effects of methemoglobinemia are rapidly reversible, and there are, therefore, no accumulative effects. Nitrate/nitrite have been classified in EPA’s Group D (not classifiable), based upon inadequate data in animals and humans. Nitrate compounds have demonstrated adverse toxic effects in infants. Due to potential toxicity and widespread occurrence in water, it is regulated.

**NITRITE (NO<sub>2</sub>-)**

**MCL 1000 ug/l**

Nitrite is used in fertilizers and is found in sewage and wastes from humans and/or farm animals and may get into drinking water by runoff into surface water or by leaching into groundwater. While excessive amounts of nitrite in drinking water have not been observed, other sources of nitrite have caused serious illness and sometimes death in infants under six months of age. The serious illness in infants is caused because nitrite interferes with the oxygen-carrying capacity of the child’s blood. This is an acute disease in that symptoms can develop rapidly. However, in most cases, health deteriorates over a period of days. Symptoms include shortness of breath and blueness of the skin. Clearly, expert medical advice should be sought immediately if these symptoms occur. The purpose of this notice is to encourage parents and other responsible parties to provide an alternate source of drinking water. Local and state health authorities are the best source of information concerning alternate sources of drinking water for infants. USEPA has set the drinking water standard at 1 mg/l for nitrite to protect against the risk of adverse effects. USEPA has also set a drinking water standard for nitrate (converted to nitrite in humans) at 10 mg/l and for the sum of nitrate and nitrite at 10 mg/l. Drinking water that meets the USEPA standard is associated with little to none of this risk and is considered safe with respect to nitrite.

**SELENIUM**

**MCL 50 ug/l**

Selenium occurs in U.S. soils in the western states. The more alkaline soil tends to make selenium more water-soluble, and increased plant uptake and accumulation occur. Most of the commercial selenium has toxic effects at high dose levels and is nutritionally essential at low levels. Acute and chronic toxic effects have been observed in animals. In humans, few data exist on acute toxicity. In animals, selenium deficiency results in congenital white muscle disease and other diseases. Selenium has been classified in EPA’s Group D (not classifiable), based upon inadequate data in animals and humans. Selenium exposure at high levels results in chronic adverse health effects, and thus it is regulated.

**THALLIUM**

**MCL 2 ug/l**

Thallium is found naturally in soils and is used in electronics, pharmaceuticals, and the manufacture of glass and alloys. Thallium compounds have been shown to damage the kidney, liver, brain and intestines of laboratory animals when the animals are exposed at high levels over their lifetimes. EPA has set the drinking water standard for thallium at 0.002 ppm to protect against the risk of these adverse health effects. Drinking water which meets the EPA standard is associated with little to none of this risk and should be considered safe with respect to thallium.

## **MICROBIOLOGICAL MAXIMUM CONTAMINANT LEVELS - THE COLIFORM TEST**

The fact that a water supply has been used for a long time without any adverse effects is no guarantee of its safety. Residents of a community may develop a tolerance for certain bacteria to which they are regularly exposed, but strangers often become ill from drinking the same water. For this reason it is important that drinking water be tested regularly for bacteriological quality.

The standard bacteriological method for judging the suitability of water for domestic use is the coliform test. This method of analysis detects the presence of coliform bacteria, which are found in the natural environment (soils and plants) and in the intestines of humans and other warmblooded animals. They are discharged in the bowel movement; hence, any food or water sample in which this group of bacteria is found is to be suspected of having come into contact with domestic sewage, animal manure, or with soil or plant materials. It follows that such a water supply may contain pathogenic bacteria and viruses which cause such serious human illnesses as typhoid fever, dysentery, hepatitis, etc.

The present regulations require water systems to take a minimum number of microbiological samples each month based upon the number of persons being served. The larger the population served, the more microbiological samples required per month.

The two standard methods for determining the numbers of coliform bacteria in a water sample are the multiple tube fermentation technique and the membrane filter technique. In the multiple tube fermentation technique, a series of fermentation tubes containing special nutrients is inoculated with appropriate quantities of water to be tested and incubated. After 24 hours, the presence or absence of gas formation in the tubes is noted. This is considered a presumptive test for the presence of coliform organisms. A confirming test performed for drinking water samples involves a similar technique using the culture from the positive presumptive test in a different nutrient medium.

In the membrane filter technique, which is less time consuming, an appropriate quantity of water to be tested is filtered through a specially designed membrane filter which traps bacteria. The filter is removed and placed in a special dish with nutrients and incubated for 24 hours. The typical coliform colony has a metallic surface sheen. The results are usually expressed as number of coliform colonies per 100 ml of water sample.

### **TOTAL COLIFORM RULE (effective January 1, 1991)**

The new rule does not change the monitoring frequency for any system unless the population served by the system is over 10,000. The number of routine samples is based on population size. The way the laboratories process the samples will remain similar, as explained below.

The major changes in the new rule will occur in the evaluation stage. All the results of the analytical testing will be reported as either the PRESENCE or ABSENCE of coliforms. If all samples show absence, then your system is in compliance. If the sample shows the presence of coliforms, three things happen:

1. The lab will automatically test the sample for fecal coliform.
2. You must collect either 4 REPEAT samples (for systems equal to or less than 1,000 population) or 3 REPEAT samples (for systems greater than 1,000 population) within the next 24 hours. The repeat samples must be taken at the original sample point, one immediately upstream of the original site, and one immediately downstream of the original site. The fourth sample can be taken from any sample point. If any of the repeat samples come back indicating a presence of coliform, you will need to take another set of repeat samples.
3. The following month you will need to take a total of at least 5 ROUTINE samples. If your system normally takes less than five routine samples per month, you will need to take whatever number of penalty samples to bring the total up to 5 routine for that month.

For systems collecting less than 40 samples per month, you may have no more than 1 Total Coliform positive sample per month. For systems collecting over 40 routine samples per month, you may have no more than 5 percent of your samples total coliform positive per month. In either case, if any sample (routine or repeat) is fecal coliform positive, then your system is automatically in violation of the MCL for total coliforms.

There are three different violations:

1. Monitoring Violation: if you did not take the required number of routine samples per month.
2. Nonacute Quality Violation: when the total coliform has been detected in excess of the MCL, but no pathogens (fecal coliforms) have been detected.
3. Acute Quality Violation: both total coliform and pathogens have been detected.

Public notice is dependent on the type of violation that has occurred. The violation must be reported to the state by the end of the working day.

## **MAXIMUM CONTAMINANT LEVELS FOR TURBIDITY**

Turbidity in water is caused by the presence of suspended matter, such as clay, silt, fine particles of organic and inorganic matter, and plankton and other microscopic organisms. The standard measure of turbidity, the turbidity unit (TU), is an expression of the optical property of a water sample which causes light to be scattered and absorbed rather than transmitted in straight lines through the sample. As the number of particles increases, more light is scattered, and higher turbidity readings are obtained. The measuring instrument is called a nephelometer, and the readings are expressed as nephelometric turbidity units (NTU) or turbidity units.

Turbidities in excess of 5 TUs are easily detectable in a glass of water and are usually objectionable for aesthetic reasons. Clay or other inert suspended particles in drinking water may not adversely affect health, but water containing such particles may require treatment to make it suitable for its intended use. Following a rainfall, variations in groundwater turbidity may be an indication of surface pollution.

## **TURBIDITY**

### **MCL No more than 5% of samples may exceed 0.5 Nephelometric Turbidity Unit (NTU)**

For water systems using conventional filtration or direct filtration, the turbidity level of representative samples of a system's filtered water must be less than or equal to 0.5 NTU in at least 95 percent of the measurements taken each month, measured as specified in Code of Federal Regulations [CFR 141.74 (a)(4) and (c)(1)], except that if the State determines that the system is capable of achieving at least 99.9 percent removal and/or inactivation of *Giardia lamblia* cysts at some turbidity level higher than 0.5 NTU in at least 95 percent of the measurements taken each month, the State may substitute this higher turbidity limit for that system. However, in no case may the State approve a turbidity limit that allows more than 1 NTU in more than 5 percent of the samples taken each month. The turbidity level of representative samples of a systems' filtered water must at no time exceed 5 NTU.

## **RADIOLOGICAL CONTAMINANTS**

The use of atomic energy as a power source for industrial needs, and for medical diagnosis and treatment, the mining of radioactive materials, and naturally occurring radioactive geological formations have made it necessary to establish limiting concentrations for the intake into the body of radioactive substances. These limits apply to food as well as drinking water.

There are adverse health effects from radiation, and unnecessary exposure should be avoided. The MCLs for radioactivity (radionuclides) in the current regulations are intended to limit the human intake of these substances so that the total radiation exposure of any individual will not exceed those defined in the Radiation Protection Guides recommended by the Federal Radiation Council. Man has always been exposed to natural radiation from water, food, and air, and the quantity of radiation a person is exposed to varies with the background radioactivity. Water of high radioactivity is unusual; nevertheless, it is known to exist in certain areas, from either natural or man-made sources.

Radiological data are available for certain areas in publications of the U.S. Environmental Protection Agency, U.S. Public Health Service, U.S. Geological Survey, and from federal, state, or local agencies. For information or recommendations on specific problems, the appropriate agency should be contacted.

The NJ Department of Environmental Protection is in the process of identifying elevated levels of naturally occurring radioactivity in drinking water obtained from certain locations in southern New Jersey. The natural radioactivity is present in drinking water being drawn from the Cohansey aquifer. The aquifer is the predominant source of drinking water in the New Jersey Coastal Plain for both municipal and private wells in southern New Jersey. The Cohansey aquifer is present in all or parts of Atlantic, Burlington, Camden, Cape May, Cumberland, Gloucester, Monmouth, Ocean, and Salem. The highest levels of radioactivity were found to be related to the

acidity of the water, agricultural land use, and the presence of elevated concentrations of nitrate and magnesium in the water. NJDEP recommends water testing and treatment if the MCL is exceeded for private well owners in the affected area.

## **RADIOACTIVITY (RADIONUCLIDES)**

**MCLs (see below)\***

Gross Alpha Particle Activity, Radium - 226 and Radium - 228

Combined Radium - 226 and Radium - 228

**5pCi/l**

Gross alpha particle activity (including Radium - 226 but excluding radon and uranium)

**15pCi/l**

### **Man-made Radioactivity**

The average annual concentration of beta particle and photon radioactivity from man-made radionuclides in drinking water shall not produce an annual dose equivalent to the total body or any internal organ greater than 4 millirem/year. Tritium must be less than 20,000 pCi/l, and strontium must be less than 8 pCi/l, provided that if both of the latter are present the sum of their annual dose equivalent to bone marrow shall not exceed 4 millirem/year.

If gross beta particle activity exceeds 50pCi/l, major radioactive constituents must be identified, and appropriate organ and total body doses must be calculated.

\*These MCLs are summarized. Consult the Code of Federal Regulations 141.15 for complete requirements.

## **TREATMENT TECHNIQUE REQUIREMENTS FOR LEAD AND COPPER ACTION LEVELS**

The U.S. Environmental Protection Agency has established action levels for lead and copper. The action level for lead is exceeded if the concentration of lead in more than 10 percent of tap water samples collected during any monitoring period is greater than 0.015 mg/l. The action level for copper is exceeded if the concentration of copper in more than 10 percent of the of tap water samples collected during any monitoring period is greater than 1.3 mg/l.

## **CORROSION CONTROL TREATMENT**

Systems must collect tap water samples for lead and copper from high-risk homes.

### Corrosion Control Studies

1. Systems triggered into the corrosion control treatment requirements may first have to conduct studies to compare the effectiveness of:

- pH and alkalinity adjustment (reduces the acidity of the water);
- calcium adjustment (promotes the formation of protective coating inside pipes and plumbing); and
- addition of phosphate or silica-based corrosion inhibitor (forms protective coating inside pipes and plumbing).

2. All large water systems (serving >50,000 people) are required to conduct such studies.

3. Small and medium-size water systems (serving <50,000 people) that exceed the lead or copper action level are required to first submit a recommendation for optimal corrosion control treatment to the state.

4. The state will either approve the recommended treatment or require the installation of an alternative treatment. The state may, as an alternative, require small and medium-size water systems to conduct the corrosion control treatment studies described above.

5. Any system that conducts corrosion control studies must recommend an optimal corrosion control treatment to the state on the basis of study results and monitoring data.

6. States will either approve a system's recommendation or designate an alternative treatment as optimal.

### Corrosion Control Treatment

1. Once treatment is specified by the state, systems will have 24 months to install optimal corrosion control treatment and 12 months to collect follow-up samples.

2. States will assign values for a set of water quality parameters that constitute optimal corrosion control treatment:

- pH;
- alkalinity;
- calcium, when carbonate stabilization is used;
- orthophosphate, when an inhibitor with a phosphate compound is used; and
- silica, when an inhibitor with a silicate compound is used.

3. A system must continue to operate within the water quality parameters established by the state.

### **SOURCE WATER TREATMENT**

1. All public water systems that exceed the tap water lead or copper action level must collect source water samples and submit the data with a treatment recommendation to the state.

2. States may specify one of the following treatments, or an alternative treatment at least as effective, for the system to install: a) ion exchange, b) reverse osmosis, c) lime softening, or d) coagulation/filtration.

3. Once treatment is specified by the state, systems will have 24 months to install source water treatment and 12 months to collect follow-up source water samples.

4. States will review follow-up source water monitoring results and assign maximum permissible lead and copper concentrations in source water entering the distribution system.

5. Systems must continue to deliver water to all entry points in the distribution system that does not exceed the maximum permissible lead and copper concentrations established by the state.

6. Source water monitoring will be standardized to 3/6/9 year cycles after treatment or the state determines no treatment is necessary.

## **PUBLIC EDUCATION**

1. Informs the public about the adverse health effects of lead and explains the steps people can take in their homes to reduce their exposure to lead in drinking water (i.e., flushing the tap; cooking with cold water rather than hot; checking for lead solder in new plumbing; and testing their water for lead).

2. All public water systems exceeding the lead action level must deliver the USEPA-developed public education program to their customers within 60 days.

3. Every 12 months, systems must deliver:

- bill stuffers to their customers and brochures to all institutions in the community frequented by women and children (i.e., health departments, hospitals, clinics, etc.), and
- the public education material to the editorial departments of major newspapers serving the community.

4. Every 6 months, systems must submit a public service announcement on lead in drinking water to major television and radio stations serving the community.

5. Every 12 months, nontransient noncommunity water systems must post information notices in each building served by the system and deliver brochures to all of the system's customers.

6. The public education program must be delivered by a water system for as long as the system exceeds the lead action level.

## **LEAD SERVICE LINE REPLACEMENT**

1. All public water systems that continue to exceed the lead action level after installing optimal corrosion control treatment and source water treatment must replace lead service lines that contribute in excess of 15 parts per billion (ppb) to total tap water lead levels.

2. A system must replace 7 percent of its lead lines each year or demonstrate that the lines not replaced contribute less than 15 ppb of lead to drinking water at the tap.

3. A system must replace the entire lead service line unless it can demonstrate that it does not control the entire line. Water systems must offer to replace the owner's portion of the service line.

4. A system that exceeds the lead action level after installing optimal corrosion control treatment and source water treatment has 15 years to replace all lead service lines.

## WHAT DO THE SECONDARY MAXIMUM CONTAMINANT LEVELS (SMCLs) MEAN?

**TABLE 5. NEW JERSEY SECONDARY DRINKING WATER REGULATIONS — SECONDARY MAXIMUM CONTAMINANT LEVEL (SMCLs) (effective November 1996)**

<u>Contaminant</u>	<u>SMCL</u>
ABS/LAS (Foaming Agents) <sup>1</sup>	0.5 mg/l (upper limit)
ALUMINUM	0.2 mg/l (upper limit)
CHLORIDE	250 mg/l (upper limit)
COLOR	10 color units (Standard Cobalt Scale)
CORROSIVITY	Within + or -1.0 of the optimum pH as determined by the Langelier Index; or by another method acceptable to the NJDEP
FLUORIDE <sup>2</sup>	2 mg/l upper limit
HARDNESS (as CaCO <sub>3</sub> )	250 mg/l upper limit 50 mg/l lower limit
IRON <sup>3</sup>	0.3 mg/l
MANGANESE <sup>3</sup>	0.05 mg/l
ODOR	3 Threshold odor number (TON)
pH	6.5 - 8.5 (optimum range)
SILVER	0.1 mg/l
SODIUM <sup>4</sup>	50 mg/l
SULFATE	250 mg/l (upper limit)
TASTE	No objectionable taste
TOTAL DISSOLVED SOLIDS (TDS)	500 mg/l (upper limit)
ZINC	5 mg/l (upper limit)

<sup>1</sup> Alkyl-Benzene-Sulfonate and Linear-Alkyl-Sulfonate or similar Methylene Blue Reactive Substances contained in synthetic detergents.

<sup>2</sup> A range of 0.8 to 1.2 mg/l fluoride is recommended for those water supplies in which the fluoride concentration is artificially adjusted.

<sup>3</sup> The limits for iron and manganese may be raised to 0.6 mg/l and to 0.1 mg/l, respectively, if a sequestering treatment is provided. However, when either of these higher limits is exceeded in the raw water of a public community water system, the water shall be treated so as to reduce the iron concentration to below 0.3 mg/l and/or the manganese concentration to below 0.05 mg/l.

<sup>4</sup> Significant only for consumers requiring a low-sodium diet.

## Microbiological and Biological Characteristics

1. Drinking water shall be free from visible organisms such as algae, algal diatoms, arachnids, and larvae.

The contaminants covered by these regulations are those which may adversely affect the aesthetic quality of drinking water, such as taste, odor, color, and appearance, and which thereby may deter public acceptance of drinking water provided by public water systems.

Secondary levels represent reasonable goals for drinking water quality but are not enforceable. Rather, they are intended as guidelines. Odor, color, taste, and other aesthetic qualities are important factors in the public's acceptance and confidence in the public water system; thus, states have encouraged the implementation of these SMCLs so that the public will not be driven to obtain drinking water from potentially lower quality, higher risk sources.

Table 5, New Jersey Secondary Drinking Water Regulations -- Secondary Maximum Contaminant Levels (SMCLs) (effective November, 1996), lists the regulations currently in effect. New Jersey requires periodic monitoring for secondary contaminants in public community water systems. The regulations define upper and lower limits for these substances in drinking water to protect the public welfare. Failure of test results to fall within these limits may constitute grounds for unacceptability of the water supply.

### **ABS/LAS FOAMING AGENTS**

**SMCL 0.5 mg/l**

The 0.5 mg/l limit for foaming agents is based upon the fact that, at higher concentration levels, the water may exhibit undesirable taste and foaming properties. Also, concentrations above the limit may be indicative of undesirable contaminants or pollutants from questionable sources, such as infiltration by sewage. Because no standardized "foamability test" exists, this property is determined indirectly by measuring the anionic surfactant concentration in the water utilizing the Methylene Blue Test. Many substances other than detergents, however, will cause foaming, and their presence will be detected by the Methylene Blue Test.

### **ALUMINUM**

**SMCL 0.05 - 0.2 mg/l**

USEPA believes that in some waters post-precipitation of aluminum may take place after treatment. This could cause increased turbidity and aluminum water quality slugs under certain treatment and distribution changes. USEPA also agrees with the World Health Organization (WHO, 1984) that "discoloration of drinking water in distribution systems may occur when the aluminum level exceeds 0.1 mg/l in the finished water." WHO further adopts a guidance level of 0.2 mg/l in recognition of difficulty in meeting the lower level in some situations. While USEPA encourages utilities to meet a level of 0.05 mg/l where possible, it still believes that varying water quality and treatment situations necessitate a flexible approach to establish the SMCL. What may be appropriate in one case may not be appropriate in another. Hence, a range for the standard is appropriate. The definition of "secondary drinking water regulation" in the SDWA provides that variations may be allowed according to "other circumstances." The state primacy agency may make a decision on the

appropriate level for each utility on a case-by-case basis. Consequently, for the reasons given above, the final SMCL for aluminum will be a range of 0.05 mg/l to 0.2 mg/l, with the precise level then being determined by the state for each system.

## **CHLORIDE**

**SMCL 250 mg/l**

The SMCL of 250 mg/l for chloride is the level above which the taste of the water may become objectionable to the consumer. In addition to the adverse taste effects, high chloride concentration levels in the water contribute to the deterioration of domestic plumbing, water heaters, and municipal waterworks equipment. High chloride concentrations in the water may also be associated with the presence of sodium in drinking water. Elevated concentration levels of sodium may have an adverse health effect on normal, healthy persons. In addition, a small segment of the population may be on severely restricted diets requiring limitation of their sodium intake. For the preceding reasons, the SMCL for chloride represents a desirable and reasonable level for protection of the public welfare.

## **COLOR**

**SMCL 10 CU**

In some instances, color may be objectionable to some people at as low as 5 CU. Color may be indicative of large quantities of organic chemicals, inadequate treatment, high disinfectant demand, and the potential for production of excess amounts of disinfectants' by-products such as trihalomethanes. Natural color may be caused by decaying leaves, plants, and soil organic matter. It may also result from the presence of such metals as copper, iron, and manganese (which also have SMCLs), as well as color from industrial sources. While color itself is not usually objectionable changes in color levels lead to greater consumer complaints, as opposed to a relatively constant color level. From the standpoint of health, its presence is aesthetically objectionable and suggests that the water may need additional treatment. Experience has shown that rapid

## **CORROSIVITY**

**SMCL Within + or -1 of the optimum pH as determined by the Langelier Index**

Corrosion is a complex phenomenon and the occurrence of corrosion-related contamination is not uniform in all water supply systems. Problems of corrosive waters are unique to the circumstances in each public water system because the quality of the raw water varies, treatment systems can impact the corrosive nature of the water, and distribution systems vary in types of pipe used.

In 1936, Professor Langelier's work dealing with the conditions at which a given water is in equilibrium with calcium carbonate was published. The use of the equation developed by Langelier made it possible to predict the tendency of natural or conditioned water either to deposit calcium carbonate or to dissolve calcium carbonate. This is useful in predicting the scaling or corrosive tendencies of a water. If the water dissolves calcium carbonate, the water is corrosive and has a negative value; if the water deposits calcium carbonate, it has a scaling tendency and a positive value.

In recognition of the importance of the role of various parameters affecting the corrosivity of the water, USEPA regulations include specific requirements for monitoring and reporting the pH, alkalinity, hardness, and TDS of the water.

The Aggressive Index (AI), established as a criterion for determining the quality of the water that can be transported through asbestos cement pipe without adverse effects, is calculated from the pH, calcium hardness in mg/l as  $\text{CaCO}_3^-$  (H), and the total alkalinity in mg/l as  $\text{CaCO}_3^-$  (A) of the water by the formula  $\text{AI} = \text{pH} + \log(\text{AH})$ . Aggressive index values less than 10.0 indicate highly aggressive water, values between 10.0 and 12.0 indicate moderately aggressive water, and values greater than 12.0 indicate nonaggressive waters.

## **FLUORIDE**

### **SMCL 1.0 mg/l (lower limit) (artificially adjusted water supplies)**

The examination of the teeth of many thousands of children, and the fluoride analysis of hundreds of water supplies showed a remarkable relationship between the concentration of waterborne fluoride and the incidence of dental caries. The relationship, or actually three distinct relationships, are as follows:

1. When the fluoride level exceeds about 1.5 ppm, any further increase does not significantly decrease the incidence of decayed, missing, or filled teeth, but does increase the occurrence and severity of mottling.
2. At a fluoride level of approximately 1.0 ppm, the optimum occurs - maximum reduction in caries with no aesthetically significant mottling.
3. At fluoride levels below 1.0 ppm some benefits occur, but caries reduction is not so great and gradually decreases as the fluoride levels decrease until, as zero fluoride is approached, no observable improvement occurs.

For these reasons, NJDEP regulations set a lower limit of 1.0 mg/l for drinking water supplies which artificially adjust the level of fluoride. The levels are adjusted by the addition of a variety of fluoride containing compounds, such as fluosilicic acid, sodium silicofluoride, etc. The optimum fluoride level for a given community depends on climatic conditions because the amount of water (and consequently the amount of fluoride) ingested by children is primarily influenced by air temperature. This relationship was first studied and reported by Galagan and Associates in the 1950s, but has been further investigated and supported by Richards, et al in 1967. It should be noted that when fluoride is artificially adjusted, it is particularly advantageous to maintain fluoride concentration at or near the optimum. The reduction in dental caries experienced at optimum fluoride concentrations will diminish by as much as 50% when fluoride concentration is 0.2 mg/l below the optimum. For these reasons, NJDEP intends to recommend a range of 0.8 - 1.2 mg/l for artificially adjusted water supplies when it promulgates new regulations.

## **FLUORIDE**

### **SMCL 2.0 mg/l (upper limit) (naturally occurring fluoride)**

USEPA has also set a SMCL of 2.0 mg/l (upper limit) for fluoride in drinking water supplies which have naturally occurring fluoride to protect against objectionable dental fluorosis (ie., a staining and/or pitting of the teeth). While community water systems are not required to reduce the level of fluoride if it exceeds 2.0 mg/l, they are required to distribute a public notice which advises that children are likely to develop objectionable dental fluorosis. USEPA concludes that dental fluorosis is a cosmetic effect and not an adverse health effect. In 1986, USEPA promulgated an MCL of 4.0 mg/l for fluoride. This level protects humans from crippling skeletal fluorosis, an adverse health effect.

## HARDNESS (WATER HARDNESS)

SMCL 250 mg/l

Water hardness is caused by the polyvalent metallic ions dissolved in water. Hardness commonly is reported as an equivalent concentration of calcium carbonate ( $\text{CaCO}_3$ ).

The concept of hardness comes from water supply practice. It is measured by soap requirements for adequate lather formation and as an indicator of the rate of scale formation in hot water heaters and low-pressure boilers. A commonly used classification is given below:

### Classification of Water by Hardness Content

<u>Concentration</u> <u><math>\text{CaCO}_3</math> (mg/l)</u>	<u>Concentration</u> <u><math>\text{CaCO}_3</math> (gpg)</u>	<u>Hardness Description</u>
0-75	0-5	soft
75-150	5-9	moderately hard
150-300	9-18	hard
300 and up	18 and up	very hard

Hardness is sometimes expressed as grains per gallon (gpg). To convert milligrams per liter (mg/l) or parts per million (ppm) to grains per gallon (gpg), use the formula below:

$$\frac{(\text{mg/l}) \text{ or } (\text{ppm})}{17.1} = \text{gpg}$$

Natural sources of hardness principally are limestones which are dissolved by percolating rainwater made acidic by dissolved carbon dioxide. Industrial sources include discharges from operating and abandoned mines.

Hardness in fresh water frequently is distinguished as carbonate and noncarbonate fractions. The carbonate fraction is chemically equivalent to the bicarbonates present in water. Since bicarbonates generally are measured as alkalinity, the carbonate hardness usually is considered equal to the alkalinity. When water containing bicarbonate or "temporary" hardness is heated, carbon dioxide is driven off, converting the bicarbonate into carbonates which precipitate to form the hard scale found in cooking utensils, pipes, hot water tanks, and boilers. This scale reduces the capacity of pipes to carry water and does not transmit heat well. Detergents minimize the adverse effects of hard water in washing and other processes, and proper water softening entirely eliminates the hard water problem.

When hardness exceeds 180mg/l, it generally causes problems, and a water softener should be considered. Water softened to zero hardness is corrosive. It is therefore desirable to blend a proportion of nonsoftened water with extremely soft water.

**IRON****SMCL 0.3 mg/l**

At 1.0 mg/l a substantial number of people will note the bitter astringent taste of iron. Also at this concentration, it imparts a brownish color to laundered clothing and stains plumbing fixtures with a characteristic rust color. Staining can result at levels of 0.05 mg/l, lower than those that are detectable to taste buds (0.1-1.0 mg/l). Therefore, the SMCL of 0.3 mg/l represents a reasonable compromise, as adverse aesthetic effects are minimized at this level.

**MANGANESE****SMCL 0.05 mg/l**

The SMCL was set to prevent aesthetic and economic damage. Excess manganese produces a brownish color in laundered goods and impairs the taste of tea, coffee, and other beverages. Concentrations may cause a dark brown or black stain on porcelain plumbing fixtures. As with iron, manganese may form a coating on distribution pipes. These may slough off, causing brown blotches on laundered clothing or black particles in the water.

**ODOR****SMCL 3 Threshold Odor Number (T.O.N.)**

Odor is an important quality factor affecting the drinkability of water. Odors for certain substances in water may be detected at extremely low concentrations. This may be indicative of the presence of organic and inorganic pollutants that may originate from municipal and industrial waste discharges or from natural sources. The Threshold Odor Number (T.O.N.) of water is the dilution factor required before the odor is minimally perceptible. A (T.O.N.) of 1 indicates that the water has characteristics comparable to odor-free water, while a (T.O.N.) of 4 indicates that a volume of the test water would have to be diluted to four times its volume before the odor became minimally perceptible. For precise work, a panel of five or more testers is required, and the (T.O.N.) is based on the greatest amount of dilution which elicits a positive odor response from one of the testers. The (T.O.N.) level of 3 was determined to be appropriate because most consumers find the water at this limit acceptable. Determination of odor below this level is difficult because of possible interferences from other sources and variability of the sensing capabilities of the personnel performing the test. Therefore, the SMCL of 3 (T.O.N.) has been set.

**pH****SMCL 6.5-8.5**

This is a numerical expression that indicates the degree to which a water is acidic or alkaline. These various degrees are represented on a scale of 0 to 14, with 0 being most highly acidic, 14 most alkaline, and 7 neutral.

High pH levels are undesirable since they may impart a bitter taste to the water. Furthermore, the high degree of mineralization associated with alkaline waters will result in the encrustation of water pipes and water-using appliances. The combination of high alkalinity and calcium with low pH levels may be less corrosive than water with a combination of high pH, low alkalinity, and calcium content. High pH levels also depress the effectiveness of disinfection by chlorination, thereby requiring the use of additional chlorine or longer contact times. A range of 6.5 - 8.5 was determined as that which would achieve the maximum environmental and aesthetic benefits.

**SILVER****SMCL 0.01 mg/l**

Silver is a relatively rare metal. Its major commercial uses are in photography, electric/electronic components, sterling and electroplate, and alloys and solder. Environmental releases can occur during ore mining and processing, product fabrication, and disposal. However, because of the great economic value of silver, recovery practices are typically used to minimize losses. The only adverse effect resulting from chronic exposure to low levels of silver in animals and humans is argyria, a blue-gray discoloration of the skin and internal organs. Argyria is markedly disfiguring and is a permanent, nonreversible effect. Argyria is the result of silver deposition in the dermis and at basement membranes of the skin and other internal organs. There is no evidence that exposure to silver results in mutagenic or carcinogenic effects. Silver has been classified in EPA's Group D (not classifiable), based upon inadequate data in animals and humans. The current SMCL for silver is based upon 1 gram of silver resulting in argyria.

**SODIUM****SMCL 50 mg/l**

Sodium is the principal cation in the hydrosphere. It is derived geologically from the leaching of surface and underground deposits of salts (e.g., sodium chloride) and from the decomposition of sodium aluminum silicates and similar minerals. The sodium ion is a major constituent of natural waters. Human activities also contribute sodium to water supplies, primarily through the use of sodium chloride as a deicing agent, and the use of washing products. Based on the available studies, it appears that insufficient evidence is available to conclude whether or not sodium in drinking water causes an elevation of blood pressure in the general population. It has been estimated that food accounts for approximately 90 percent of the daily intake of sodium, whereas drinking water contributes up to the remaining 10 percent. In order to afford protection to a segment of the U.S. population on a sodium-restricted diet, in 1968, the American Heart Association (AHA) recommended a level of 5 mg of sodium per 8 ounces of water or 20 mg/l. USEPA is suggesting a guidance level for sodium of 20 mg/l in drinking water for the high-risk population as recommended by the AHA. When it is necessary to know the precise amount of sodium present in a water supply, a laboratory analysis should be made. When home water softeners utilizing the ion-exchange method are used, the amount of sodium will be increased. For this reason, water that has been softened should be analyzed for sodium when a precise record of individual sodium intake is needed. For healthy persons, the sodium content of water is unimportant because the intake from salt is so much greater, but for persons placed on a low-sodium diet because of heart, kidney, circulatory ailments, or complications in pregnancy, sodium in water must be considered.

**SULFATE****SMCL 250 mg/l**

High concentrations of sulfate in drinking waters have three effects: (1) water containing appreciable amounts of sulfate ( $\text{SO}_4$ ) tends to form hard scales in boilers and heat exchangers; (2) sulfates cause taste effects; and (3) sulfates can cause laxative effects with excessive intake.

The laxative effect of sulfates is usually noted in transient users of a water supply because people who are accustomed to high sulfate levels in drinking water have no adverse response. Diarrhea can be induced at sulfate levels greater than 500 mg/l but typically near 750 mg/l.

While sulfate imparts a slightly milder taste to drinking water than chloride, no significant taste effects are detected below 300 mg/l.

Sulfate cannot readily be removed from drinking water, except by distillation, reverse osmosis, or electro dialysis, but these are expensive. As with water having high levels of chloride, it is recommended that either an alternative source be used or that the high sulfate water be diluted with a lower sulfate containing water.

## **TASTE**

## **SMCL No Objectionable Taste**

Taste, like odor, depends on contact of a stimulating substance with the appropriate human receptor cell in the body. The stimuli are chemical in nature and the term “chemical senses” often is applied to odor and taste. Water is a neutral medium, always present on or at the membranes that perceive sensory response. In its pure form, water cannot produce odor or taste sensations. No satisfactory theory of olfaction ever has been devised, although many have been formulated. Humans and animals can avoid many potentially toxic foods and waters because of adverse sensory response. Without this form of primitive sensory protection many species would not have survived. Today, these same senses often continue to provide the first warning of potential hazards in the environment.

Some substances, such as certain inorganic salts, produce taste without odor and can be evaluated by the taste test. Many other sensations ascribed to the sense of taste actually are odors, even though the sensation is not noticed until the material is taken into the mouth.

Standard Methods for the Examination of Water and Wastewater, 15th edition, describes a Taste Rating Test. The purpose of the test is to estimate the taste acceptability of the drinking water. Briefly, up to 10 samples are given to selected panel members who have been selected at trial orientation sessions. Rating involves a series of steps where the panel members take water into their mouths and form an initial judgment on a rating scale. The rating scale ranges from 1 to 9 with 1 being “I would be very happy to accept this water as my everyday drinking water” to 9 “I can’t stand this water in my mouth and I could never drink it.” Averages are determined of all ratings given each sample with a mean and standard deviation reported. This number can then be used to determine whether or not the water has any objectionable taste to the majority of consumers.

## **TOTAL DISSOLVED SOLIDS (TDS)**

## **SMCL 500 mg/l**

Total Dissolved Solids (TDS) may have an influence on the acceptability of the water in general and, in addition, high TDS value may be an indication of the presence of excessive concentration of some specific substance, not included in the Safe Drinking Water Act, which would make the water aesthetically objectionable to the consumer. The life of home hot water heaters decreases by approximately one year for each additional 200 mg/l of TDS in water above the typical household level of 220 mg/l. The SMCL of 500 mg/l for TDS is reasonable because it represents an optimum value commensurate with the aesthetic level to be set as a desired water- quality goal.

## **ZINC**

**SMCL 5 mg/l**

Zinc is found in some natural waters, most frequently in areas where it is mined. It is not considered detrimental to health unless it occurs in very high concentrations. It imparts an undesirable taste to drinking water. For this reason, the SMCL of 5.0 mg/l was set.

## **BIOLOGICAL CHARACTERISTICS**

Certain forms of aquatic vegetation and microscopic animal life in natural waters may be either stimulated or retarded in their growth by water-quality factors. The growth of algae and other microscopic plants found floating on the surface of the water is stimulated by light, temperature, nutrients such as nitrogen and phosphorus, and pH conditions. Their growth may in turn be retarded by changes in pH, temperature, the presence of inorganic impurities, excessive cloudiness or darkness, or the presence of certain species of bacteria.

Cycles of growth and decay of the cellular material of these microorganisms may result in the production of by-products which may adversely affect the quality of the water supply. The same general statements may be made regarding the growth cycles of other nonpathogenic bacteria and harmless microorganisms.

Thus, to prevent problems, a water source should be as free from biological activity as possible. In order to achieve this: (a) water sources should be selected that support a minimum of plant and animal life; (b) the supply should be protected from contamination by biological agents; (c) the introduction of nutrients, organic chemicals, and fertilizing materials should be avoided; and (d) treatment for the destruction of biologic life or its by-products should be instituted as needed.

## **WHAT TESTS DO I NEED? PUBLIC WATER SYSTEMS**

Under the Safe Drinking Water Act (SDWA), all public water systems are required to sample and test their water supplies according to a fixed schedule for all contaminants for which MCLs have been set. For example, transient noncommunity water systems serving ground water sample for microbiological contaminants quarterly. A community water system, on the other hand, must monitor at a minimum monthly for bacteria based on population served. As an example, a water system servicing up to 4,900 people must take five microbiological samples from the water distribution system per month, whereas a system serving 500,000 people must take 210 samples a month. Larger systems are required to take even more samples.

The sampling location is the point-of-entry for nearly every contaminant. Most community water systems have multiple points of entry. Tests for inorganic contaminants, for example, must be taken at each point-of-entry to the water distribution system and repeated each year for community systems utilizing surface sources and every 3 years for those utilizing groundwater sources.

Table 6 (Community and Nontransient Noncommunity Compliance Monitoring Requirements) provides a summary of the base monitoring requirements for the major contaminant groups regulated by the Safe Drinking Water Act. Federal regulations provide a mechanism for both increasing monitoring and decreasing monitoring for the

contaminant groups listed on Table 6. If a test exceeds a "trigger" value, increased monitoring is required until the test results from that point-of-entry are determined to be "reliably and consistently" less than the MCL. (For most organics the trigger value is greater than the Method Detection Level and less than the MCL. For inorganics, the trigger value is the MCL. Refer to Table 6 for more detail.) Waivers to reduce or eliminate sampling for asbestos, inorganics, synthetic organics and volatile organic chemicals are issued to water systems for individual points-of-entry based on contaminant use in the vicinity of the well head and susceptibility of the water sources to contamination. Prior sampling results can be used to decrease monitoring, through waiver-by-rule provisions, for some contaminant groups.

**TABLE 6. COMMUNITY AND NONTRANSIENT NONCOMMUNITY COMPLIANCE MONITORING REQUIREMENTS**

Contaminant	Base Requirement		Trigger that Increases Sampling	Waivers for Base Requirements *
	Ground water	Surface water		
Asbestos	1 Sample every 9 years		> MCL	YES Based on Vulnerability Assessment
Nitrate	Annual After 1 year <50% of MCL, surface water system may reduce to an annual sample	Quarterly	> 50% MCL	NO
Nitrite	1 Sample: If <50% of MCL, state discretion		> 50% MCL	NO
Inorganics	1 Sample every 3 years	Annual sample	> MCL	YES Based on analytical results of 3 rounds
VOCs	4 Quarterly samples every 3 years Annual after 1 year of no detects		> 0.0005 mg/l	YES Based on Vulnerability Assessment
Pesticides and PCBs	4 Quarterly samples every 3 years After 1 round of no detects: systems >3300 reduce to 2 samples per year every 3 years; systems < 3300 reduce to 1 sample every 3 years		Method Detection Limit (MDL)	YES Based on Vulnerability Assessment
Unregulated -6 IOCs -24 SOCs	1 Sample 4 Consecutive quarterly samples		N.A.	YES Based on Vulnerability Assessment

\* Two types of waivers are available: waivers by rule and vulnerability waivers. Waivers by rule are based on prior monitoring results. They reduce but do not eliminate monitoring. Vulnerability waivers eliminate monitoring but must be renewed, usually every three years.

If your public water system fails to comply with certain aspects of the Safe Drinking Water Act, public notification is required. The exact type and frequency of notification depend on the seriousness of any potential adverse health effects which may be involved. Tier 1 notification for community water systems, which includes failure to comply with an established maximum contaminant level or treatment technique or a compliance schedule for a variance or exemption, requires newspaper notification, mail notification, and notification of electronic media. Tier 2 notification for community water systems, including failure to monitor or utilize the proper testing methodology or when a variance or exemption is granted, requires newspaper notification only. This emphasis on public notification and involvement is designed to bring about voluntary compliance as quickly as possible without costly, time-consuming legal battles.

Those served by a public water system and concerned about the water quality should be able to obtain the complete water test results required under the SDWA directly from the local water utility. In addition, the

NJ Department of Environmental Protection  
Bureau of Safe Drinking Water  
PO Box 426  
Trenton, NJ 08625-0426  
(609) 292-5550

has copies of limited water analyses performed by the state.

Additional information on drinking water may be obtained by writing:

U.S. Environmental Protection Agency  
Office of Drinking Water  
401 M Street, S.W.  
Washington, DC 20240  
(800) 426-4791 (Drinking Water Hotline)

The USEPA regional office for New Jersey is located at:

U.S. Environmental Protection Agency - Region II  
Office of Drinking Water  
290 Broadway  
New York, NY 10007  
(212) 637-5000

Local watershed associations or environmental groups may also have collected drinking water quality information.

## **WHAT TESTS DO I NEED? NEW PUBLIC NONCOMMUNITY WATER SYSTEMS**

Under New Jersey regulations and under local authority, a sample of raw water from every proposed public noncommunity water system must be tested for:

### **TABLE 7. NEW PUBLIC NONCOMMUNITY WATER SYSTEMS - INITIAL TESTING REQUIRED FOR CERTIFICATION (N.J.A.C. 7:10-12.30)**

BACTERIA (TOTAL COLIFORM)	RADIONUCLIDES
INORGANICS	SECONDARY CONTAMINANTS
VOLATILE ORGANIC CHEMICALS (VOCs)	

Additional testing may be required by the local board of health having jurisdiction. New Jersey regulations mention that local authorities may want to require testing of surface water for pesticides. The local board of health may also require additional treatment of the water.

### **WHAT TESTS DO I NEED? NEW WELLS (NONPUBLIC WATER SYSTEMS)**

Under New Jersey regulations and under local authority, a sample of raw water from every proposed nonpublic water system must be tested for:

#### **TABLE 8. TESTS REQUIRED FOR NEW WELLS (N.J.A.C. 7:10-12.30)**

BACTERIA (TOTAL COLIFORM)  
NITRATES  
IRON  
MANGANESE  
pH

It may also be advisable to include all the tests listed in Table 9, next section.

Additional testing may be required by the local board of health having jurisdiction. New Jersey regulations mention that local authorities may want to require testing for VOCs and/or radon. The local board of health may also require additional treatment of the water.

### **WHAT TESTS DO I NEED? EXISTING HOME WELLS**

When buying an existing home with a well, it is advisable to insist that the seller provide for water testing before closing on the house. Many buyers have discovered water-quality problems too late and are burdened with the expense of having to treat their well water or drilling a completely new well. The Farmers Home Administration, Veterans Administration, and Federal Housing Administration all require water testing on home wells before mortgages are issued. Some realtors are also requiring the seller to provide a certificate of water potability for their listings.

Residents of Ocean County should be aware of a County Board of Health regulation which requires additional testing before final certification of new wells and upon sale or transfer of ownership of real property upon which a well is located. Testing is required for the following 26 parameters: Turbidity, Bacteria (Total Coliform), Nitrates, Iron, Manganese, pH, Arsenic, Cadmium, Chromium, Lead, Mercury, Benzene, Carbon Tetrachloride, Chlorobenzene, Dichlorobenzene(s), 1,2-Dichloroethane, 1,1-Dichloroethylene, *trans*-1,2-Dichloroethylene, Methylene Chloride, Tetrachloroethylene, 1,1,1-Trichloroethane, Trichloroethylene, Vinyl Chloride, Xylene(s), Sodium, Chlordane (resales only). Other counties may have similar regulations. Testing must be done in a laboratory certified by DEP.

Table 9 is a list of water tests which have been compiled through discussions with state officials and water-quality experts. The list of tests is designed to ensure maximum safety of the water supply while keeping testing costs to a minimum.

**TABLE 9. RECOMMENDED WATER TESTS FOR EXISTING HOME WELLS (NONPUBLIC WATER SYSTEMS)**

<u>Test Name</u>	<u>MCL or SMCL or Action Level</u>
<u>Recommended:</u>	
BACTERIA (Total Coliform) <sup>1</sup>	none detected
NITRATE <sup>1</sup>	10 mg/l NO <sub>3</sub> <sup>-</sup>
LEAD <sup>1</sup>	0.015 mg/l/ Action Level
<u>Consider:</u>	
VOLATILE ORGANIC <sup>1</sup> CHEMICAL SCAN	If positive retest for specific chemicals
HARDNESS (Total)	50-250 mg/l (lower-upper limit)
IRON	0.3 mg/l
MANGANESE	0.05 mg/l
SODIUM	50 mg/l
pH	6.5-8.5
CORROSIVITY	Langelier Index +/-1.0
RADIOACTIVITY (Gross Alpha) <sup>1</sup>	15 pCi/l
MERCURY <sup>2</sup>	0.002 mg/l
RADON-222 <sup>3</sup>	300 pCi/l

<sup>1</sup> Denotes an MCL based on health effects. If these levels are exceeded consult with the local health department for interpretation and guidance.

<sup>2</sup> In wells between 50-150 feet deep in South Jersey, the DEP also recommends that the homeowner consider these tests. Consult with your local health officer for the applicability of these tests to your municipality.

<sup>3</sup> Denotes a proposed MCL based on health effects. If these levels are exceeded consult with the local health department for interpretation and guidance.

The absolute minimum testing should include the coliform test for bacteriological safety. This test should be done at least annually during different seasons each year. If there is a history of previous positive samples, more frequent testing is recommended. Other reasons for testing more frequently include an open or dug well (not permitted by current New Jersey regulations) and unusual episodes of diarrhea, especially among visitors to the home.

If taste, odor, color, or turbidity is a problem or if any of the drinking water quality problems listed in Table 10 exist, additional testing is probably necessary.

Additional chemical testing is also warranted if the home is located in a heavily industrialized area; near service stations, machine shops, dry cleaners; near a hazardous waste source or a landfill; if nearby houses have reported problems; or if you feel your water has some unusual chemical taste, odor, or color. Consult with local health officials who can advise you on what specific tests to have performed. They may have a record of water-quality problems in each area and can offer information and advice.

**TABLE 10. ADDITIONAL WATER TESTING RECOMMENDATIONS FOR COMMON PROBLEMS OR SPECIAL SITUATIONS**

<u>PROBLEM</u>	<u>COMMON SIGNS/ SITUATIONS</u>	<u>CAUSES</u>	<u>TEST RECOMMENDED</u>
"Hard" water	Large amount of soap required to form suds. Insoluble soap curd on dishes and fabrics. Hard scaly deposit in pipes and water heaters.	Calcium, magnesium, manganese, and iron (may be in the form of bicarbonates, carbonates, sulfates or chlorides).	Hardness Test
Rusty colored water	Rust stains on clothing and porcelain plumbing fixtures. Metallic taste to water. Rust coating in toilet tank. Faucet water turns rust colored after exposure to air.	Iron or manganese, or iron bacteria.	Iron Test Manganese Test
"Rotten egg" odor	Iron, steel, or copper parts of pumps, pipes and fixtures corroded. Fine black particles in water (commonly called black water). Silverware turns black.	Hydrogen sulfide gas, sulfate-reducing bacteria, or sulfur bacteria.	Hydrogen Sulfide Test
"Acid" water	Metal parts on pump, piping, tank, and fixtures corroded. Red stains from corrosion of galvanized pipe; blue-green stains from corrosion of copper or brass.	Carbon dioxide. In rare instances, mineral acid, sulfuric, nitric, or hydrochloric.	pH Langelier Index
Cloudy turbid water	Dirty or muddy appearance.	Silt, sediment, microorganisms.	Check well construction with local well driller.
Chemical odor of gasoline, fuel oil	Well near abandoned fuel oil tank; gas station.	Leaking underground storage tank.	Volatile Organic Chemical Scan or specific fuel component
Unusual chemical odor	Well near dump, junkyard, landfill, industry or drycleaner.	Groundwater contamination, underground injection, or leaching waste site.	Check with Health Dept., Organic chemical scan, heavy metals.

No obvious problem	Well located in area of intensive agricultural use.	Long term use of pesticides and fertilizers.	Test for pesticides used in area, nitrate test.
Recurrent Gastro-intestinal illness	Recurrent gastro-intestinal illness in guests drinking the water.	Cracked well casing, cross connection with septic system.	Bacteria (Coliform Test), nitrate test.
Sodium restricted diet, salty brackish, or bitter taste	Well near seawater, road salt storage site or heavily salted roadway.	Saltwater intrusion, groundwater contamination.	Chloride, Sodium, Total Dissolved Solids (TDS).

Testing for specific trace organic chemicals is expensive and requires sophisticated equipment costing tens of thousands of dollars. For accurate and reliable results, tests should be done in a state-certified laboratory.

## **WATER TESTING - WHERE SHOULD I GET MY WATER ANALYZED?**

### **GENERAL INFORMATION ON WATER TESTING**

Amateurs should take water samples only under the direction of a certified state water quality laboratory.

There are two types of sampling locations depending on the contaminant of interest. For private homeowners and small water systems, these locations may be the same. The sampling locations are point-of-entry (POE) after treatment or in the water distribution system (consumers tap). The purpose of these two types of sampling locations is to differentiate between contamination derived from the source water or contamination derived from the distribution pipes.

The goal of drinking water sampling should be to collect a sample under the worst conditions; therefore, checking water a day after a heavy rainfall is a good idea. If corrosive water is suspected, a sample for lead or copper should be taken first thing in the morning, without letting the water run. For other tests wait until mid-morning after a good quantity of water has been used. Samples for bacteria (Total Coliforms) must be collected using sterile containers and under sterile conditions. In addition, keep a record of all your water test results; by observing any changes over time you may be able to discover any problems.

### **SERVICES FREE OF CHARGE**

Tests for total hardness, tastes, odors, and certain chemical impurities may be obtained from companies selling or renting water conditioning equipment. They will also make recommendations for equipment to correct the problems. However, as a precaution, any recommendations should be rechecked with an independent laboratory to ensure impartial analysis.

Look in the Yellow Pages of your telephone directory under “Water Softening” or “Water Conditioning” for the names of local dealers.

### **STATE-CERTIFIED PRIVATE LABORATORIES AND CONSULTING FIRMS**

Water testing should be done only at state-certified private laboratories or consulting firms. Important: Laboratories gain or lose state certification on an almost daily basis. To ensure that a laboratory is currently certified for testing in a particularly category (i.e., microbiological, limited chemical, atomic absorption, gas chromatography, or organic chemicals on A-280 List) call NJDEP-Office of Quality Assurance. Names, addresses, and telephone numbers of current state-certified laboratories can be obtained from the county offices of Rutgers Cooperative Extension (ask for Fact Sheet 343, “Where to Get Your Drinking Water Tested in New Jersey”) or your local health department, or:

NJDEP - Division of Environmental Safety, Health and  
Analytical Programs  
Office of Quality Assurance  
PO Box 424  
Trenton, NJ 08625  
(609) 292-3950

Private laboratories will collect samples and make tests for fees ranging from \$15 and up, depending on the type of test. Most local, county, and state health departments in New Jersey will not test water from private home wells unless there is public health concern.

A laboratory near one’s home is most likely to be familiar with problems in that area and can best advise as to which pollutants to test for.

Certain sanitary and environmental engineering consulting firms are available for hire for unusual or difficult water quality problems. Consult the telephone Yellow Pages under “Engineers - Sanitary.”

## **WHAT TO DO IF YOUR DRINKING WATER EXCEEDS AN MCL OR SMCL**

### **FACTS TO CONSIDER BEFORE TREATING YOUR WATER**

Many water supply problems can be controlled or eliminated by using a variety of drinking water treatment devices. Before proceeding with the selection process there are several facts you need to consider.

*If an MCL Is Exceeded, Consult Your Health Department.*

MCLs are health-based standards and you may be assuming additional risk if you continue to drink the water. Young children and infants are particularly susceptible. SMCLs are aesthetic standards.

*Always Retest To Ensure You Have A Problem.*

It is always good practice to have your water retested to ensure accuracy in sampling and in the laboratory. The second test should be done by a different laboratory to confirm results.

*Consult With A Water-Quality Expert And/Or Your Local Health Department.*

When you are certain you have a particular contamination problem, consult with a water-quality expert. These individuals may be familiar with the preferred treatment methods in your area. Recent and historical water data should be reviewed by an expert to determine which processes are appropriate. The local health official or DEP may also be consulted if uncertainties arise.

*Consider Alternatives*

Availability and cost of public water supplies or other alternatives including deeper private wells should be considered. If the home unit is preferred, then consider the use of either a whole-house, faucet, or line-bypass unit. Bottled water may also be an alternative.

When you have more than one water-quality problem, choosing a treatment device is more complex. Many times you cannot treat one problem without treating another first. Many times, two problems can be eliminated with one treatment or the treatment method itself causes a problem.

*Select Unit*

After choosing a treatment process, select a unit to install. Criteria for unit selection may include field experience, independent evaluations by the National Sanitation Foundation and the Water Quality Association, equipment safeguards, maintenance requirements, initial and ongoing costs, and warranties or performance guarantees by the dealer.

*Field Test*

Equipment reliability and performance can best be determined by field testing. Field data can help determine a monitoring program.

*Purchase and Install*

Using reputable dealers, licensed plumbers, and certified installers should ensure that the device will perform according to specifications and warranties.

*Monitor and Maintain*

Safe operation of a home treatment unit requires monitoring and maintenance by an independent third party. While the above approach costs money not typically included in the purchase and installation price, the consumer should receive a safer product if this approach is followed.

*For More Information*

If you need more information about home water treatment technologies and devices, consult the references in the Bibliography at the end of this publication, write your county office of Rutgers Cooperative Extension, or contact the NJDEP Bureau of Safe Drinking Water in Trenton.

# HOME DRINKING WATER TREATMENT TECHNOLOGIES AND DEVICES

## ACTIVATED CARBON FILTRATION

Effective for:

Some Organic Chemicals  
Taste  
Trihalomethanes

Some Pesticides  
Odor

This technology uses any of several carbonaceous materials such as bituminous coal, coconut shells, lignite, peat, or wood. Activation is the process whereby the carbonaceous material is fragmented under high heat by steam in the absence of oxygen. Granules and exposed pores are created. Certain contaminants in water such as organic chemicals will adhere to the exposed surfaces of the many pores, through a variety of sorption processes. Studies have shown that activated carbon is most effective in removing large (high molecular weight) impurities and those with comparatively low solubility in water. It is, therefore, most effective in removing pesticides, benzene, and halogenated organics such as trichloroethylene (TCE). Activated carbon filters will significantly improve taste and odor of drinking water and will effectively remove chlorine and specific adsorbable organics such as trihalomethanes (THMs), including chloroform.

Activated carbon filters work best when first put in service. With use, the adsorption capacity of the carbon becomes used up and the filter no longer removes as much of the contaminants and will do a poorer job on the most difficult ones. In fact, contaminants can leach off the filter at higher concentrations than the influent concentration when the filter becomes overloaded. Most manufacturers state or suggest a life for the filter media in gallons treated, but this generally presumes some unstated concentration, mix of contaminants, or contact time. Manufacturers frequently state guidelines for determining when the filter needs replacement: return of poor taste or odor, color change of the filter media, reduced flow through the filter, etc. This may be satisfactory if the contaminant is only an annoyance but not if it is a health hazard. Unfortunately, many hazardous contaminants do not cause off-tastes, odors, or color at the concentrations found in water supplies. The only way to determine if the filter has removed them to acceptable levels is by repeated testing of the treated water. When using the units to remove health-related contaminants it is preferable to install two units in series (one after the other) with a sample tap in between so that testing can be done to determine when one unit is used up and needs to be replaced without being exposed to the contaminant.

Some water treatment units contain silver, which manufacturers claim prevents the growth of bacteria and acts as a bacteriostatic agent. These units are registered with the Environmental Protection Agency (USEPA) as bacteriostatic units. The main requirement of the registration is that the units do not release excessive amounts of silver. Registration does not imply that USEPA has examined the effectiveness of the units. A few units are designed to be microbiological purifiers containing a chemical disinfectant; such units would be subject to registration by USEPA and would be required to prove the microbiological and other claims made. Manufacturers of water treatment units are required to obtain an establishment (Est.) registration

number to identify their plant. Some manufacturers seem to have used their establishment (Est.) number to make it appear that USEPA has endorsed or approved their product. This is not the case.

## **AIR STRIPPING**

Effective for:

Some Volatile Organic Chemicals  
Iron (with filtration)

Hydrogen Sulfide  
Radon Gas

Until recently this technology has been limited to large operations at water treatment plants, but a few manufacturers now have developed point-of-use (POU) aeration devices for home water treatment. In air stripping columns water flows downward by gravity while air is pumped upward from the bottom of the column by a mechanical blower. As the water flows down through the column it passes over a packing material which increases the area of the air-liquid interphase. Volatile organic compounds are transferred from the water to the air which is vented outside. The volatile organic chemicals (VOCs) which are most commonly detected in groundwater can be removed by air stripping. In POU applications, up to 90 percent removal of (VOCs) can be expected. Aeration is also effective in removing certain inorganic contaminants including hydrogen sulfide and iron. However, use of air stripping towers to remove iron requires post-treatment filtration. The rate at which VOCs are removed from water by aeration (or the mass transfer characteristics of the compound) depends on several factors: hydraulic loading rate (or water flow rate); air:water (A:W) ratio; type of packing material; height of packing material; temperature of the water and air; type of VOCs; and concentration of VOC. Air stripping does have several limitations. The removal efficiency of air stripping columns is largely dependent on the type of VOCs present in the water and the ease with which they are stripped from the water. Once the water passes through the column it is necessary to have storage and repumping facilities to distribute it through the house. The energy costs of pumping the water to and away from the tower, as well as running the blower, must also be considered. It is also a good idea to require a performance guarantee, or a period of pilot testing with frequent monitoring, to ensure adequate removal of contaminants.

## **BOTTLED WATER**

Effective for:

A temporary solution to  
many water-quality problems

Aesthetic problems  
Emergency situations

Bottled water may be an alternative when a home well is contaminated. In a household with an infant, bottled water could be substituted for a water source that has high nitrate levels. In some instances, families are forced to buy water by the caseload for years. Where the contamination cannot be traced or an alternative found, bottled water becomes a long-term solution. The question is often asked, "Are bottled waters safer or healthier than public water supplies?" The bottled water industry adheres to a plant inspection program established by the American Sanitation Institute (ASI). According to the International Bottled Water Association, "Industry products come from protected sources, are bottled in facilities regulated as food plants, and processed using good manufacturing practices approved by the federal government." The United States Food and Drug Administration (FDA)

regulates bottled waters on a national level, but New Jersey has promulgated its own standards which require that bottled waters meet all the MCLs under the N.J. Safe Drinking Water Act. The FDA has established standards of quality for bottled drinking water; however, it exempts mineral waters because, by their very nature, they exceed physical and chemical limits prescribed in the Bottled Drinking Water Standard. The FDA has established "Good Manufacturing Practice Regulations" for processing and bottling of all bottled waters. These outline in detail the sanitary conditions under which the water is to be obtained, processed, bottled, and tested. They require that waters be obtained from sources free from pollution and be "of good sanitary quality" when judged by the results of bacteriological and chemical analyses. Water bottlers must list the addition of salt and carbon dioxide on their labels, and they are prohibited from making "objectionable therapeutic claims." To answer the question, "Are bottled waters safer or healthier than public water supplies?" you must investigate your water supply to be sure it is as pure and risk-free as you want it to be. If you are on a public water system, find out where your water comes from, what contaminants it is tested for, and whether any are present in quantities which pose a health question or risk to you. If you decide that bottled water is for you, investigate the bottled water you select. After all, there is no need to spend a lot of money on bottled water if it is no better than your own tap water.

## **CHLORINATORS**

Effective for:

Bacteria (Coliforms)

Microbiological Contamination

Chlorinators can be used for noncommunity water supplies; however, this technology is not recommended by DEP for private homeowners since the chemicals used in this type of treatment can be dangerous.. Ultraviolet radiation or ceramic filters would be more appropriate for the homeowner with a microbiological problem.

Chlorination of an individual water system should be considered only as a last resort. Well disinfection or shock chlorination, as it is sometimes called, should always be attempted first before purchasing chlorination equipment. Shock chlorination can be accomplished by mixing a strong chlorine solution with the water in the well and letting it stand for a few hours. This will kill the coliform and most disease-causing organisms. As a general practice, a new well should be shock chlorinated before being put in use, and again whenever it is opened to pull the pump or to remove sand and sediment from the bottom of the hole. The procedure is explained in "Potable Water -- Directions for Disinfecting a Well -- Circular 598." A copy can be obtained from your county office of Rutgers Cooperative Extension.

The positive-displacement chlorinator, the most reliable type of device for this purpose, consists of a small electrical chemical-feed pump. The amount of chlorine fed can be increased or decreased with a simple adjustment of a control knob. Operation of an electric hypochlorinator can be synchronized with that of the well pump, so that both start and stop at the same time. Flow-actuated positive-displacement hypochlorinators (water-meter type) dispense the chlorine solution in proportion to the actual flow rate of the water. This type of equipment operates only if water is flowing in the pipe. The dosage of chlorine is more accurately attuned to the rate of flow than it is to the on-off cycle of the well pump. Aspirators or suction-type

chlorinators are not positive displacement and generally are not reliable, because the chlorine dosage varies with the pressure and flow rate in the pipeline to which it is attached. Minerals precipitating from the water and the chlorine solution will clog the small jets in the aspirator, and this will prevent the chlorine from being drawn into the system. It is important to inspect the chlorine solution storage tank and chlorinators frequently to be sure that a supply of chlorine solution is always available and that the equipment is working properly. Calcium hypochlorite, in powder or tablets, can be used as a concentrated source of chlorine to mix a stock solution. Mix according to directions on the label so as to obtain the proper concentration of chlorine in the mixture. After mixing, use only the clear solution; discard the bottom sediment because it may clog the hypochlorinator.

## **DISTILLATION**

Effective for:

All Inorganic Chemicals, i.e., Nitrates, Sodium Chloride  
Some Organic Chemicals

In this technology, water is heated until it turns to steam. The steam is circulated in coils and then encounters a cooling process, either circulation of cool water or a fan. The subsequent reduction in temperature causes the steam to condense as distilled and purified water, purged of most dissolved or suspended contaminants. Distillation is the only water purification process which removes with absolute certainty microorganisms such as bacteria and viruses which may cause diseases and may be contained in the feedwater. Distillation also removes trace amounts of heavy metals, all organic chemicals which are not carried over in the steam, nitrates, and other inorganic anions.

Distilled water, because it is essentially mineral-free, is very aggressive, in that it tends to dissolve substances with which it is in contact. Notably, carbon dioxide from the air is rapidly absorbed, making the water acidic and even more aggressive. Many metals are dissolved by distilled water. Because of the absence of minerals, distilled water may not be the ideal drinking water. It has been described as tasteless and flat. It is recommended that you try some before purchasing a unit.

The distillation process is an effective means of removing most contaminants, but it has several drawbacks. It is very slow, although somewhat more rapid than reverse osmosis, and energy cost (electricity) is high. A problem with some distillation units is that they allow certain organic contaminants with a lower boiling point than water (some pesticides, for example) to vaporize with the water, recondense, and end up with the processed water. A type of unit called a "fractional distiller" avoids this problem, but not all distillers are of this type. Maintenance can be a problem, depending on the design of the units. The minerals and other contaminants left behind in the boiling chamber can build up, interfering with the operation of the unit. Hard water can quickly clog a distiller. Some units are easy to clean by hand; others are difficult or require a strong acid. Many models have reset switches and timers which make automatic operation possible. These features may be desirable when distilled water is continuously used. If water is the coolant medium, waste of water may be even higher than reverse osmosis. All distillers should be Underwriters Laboratories (UL) listed. The warranty may be limited or full. Frequency of cleaning the distiller varies with the quantity of impurities in the water.. Some manufacturers recommend

cleaning the machine after every third distillation. White vinegar may be used by leaving it in the boiling tank overnight, or a special cleaner made by the appliance manufacturer may be used.

## **ION EXCHANGE**

Effective for:

Hard Water (Water Softening)	Calcium
Manganese	Iron
Some Heavy Metals	

Ion exchange is a combined physical and chemical process in which ions that are dissolved in water are transferred to, and held by a solid material or exchange resin. The system used for water softening contains a cation exchange resin. Positively charged sodium ions are used to coat most common cation exchange resins. When water containing dissolved cations contacts the resin, the cations are “exchanged” for, or trade places with, the loosely held sodium ions on the resin. In this way the calcium and magnesium ions responsible for hardness are removed from the water and placed on the exchange resin, a process that makes the water “soft.”

In this process, however, sodium ions are added to the water. Eventually a point is reached when very few sodium ions remain on the resin, thus no more calcium or magnesium ions can be removed from the incoming water. The resin at this point is said to be “exhausted,” or “spent,” and cannot accomplish further water treatment until it is “recharged” or “regenerated.” Most whole-house systems have a bypass to allow for large volume use on the yard, or to fill up pools, etc. While softeners are used primarily to reduce the damage of scale and other deposits, and to enhance water for cleaning purposes, cation exchangers have an added benefit of reducing toxic metals such as lead and barium, as well as radium, a radioactive material. (Anion exchange units operate on the same principle, but they are used primarily to treat well water supplies containing relatively high levels of nitrates.)

Once an analysis of water is available, selection of a water softening unit depends on the hardness of the raw water and the amount of water to be softened. You may also choose between manual, automatic, semiautomatic, and fully automatic units, which differ in the degree to which the consumer must participate in the regeneration of exhausted resins. As mentioned previously, if a manual unit is selected, you should also consider the frequency of regeneration. The newest equipment is available with digital controls and many programmable options.

## **MECHANICAL FILTRATION**

Effective for:

Turbidity	Sediment
Dirt	Particulates (Loose Scale)

Mechanical filtration, often referred to as particulate or turbidity filtration, removes dirt, sediment, and loose scale from the incoming water. This technology employs sand, filter paper, or compressed glass wool or other straining material and operates as a fine sieve would, clearing the water of dirt, sediment, and coarse and fine particulates including rust particles. The result is physically cleaner, clearer, and

aesthetically more pleasing water, but with little removal of harmful dissolved organic or inorganic chemical contaminants. These filters will not remove nitrates, heavy metals, pesticides, or trihalomethanes.

## **REVERSE OSMOSIS**

Effective for:

Certain Inorganic Chemicals  
Nitrates

Dissolved Solids

Reverse osmosis (RO) treatment decreases the dissolved impurities in water. It successfully treats water with high salt content, cloudiness, and dissolved minerals, such as sulfate, calcium, magnesium, sodium, potassium, manganese, chloride, nitrate, fluoride, boron, and orthophosphate. RO also is effective with some detergents, some taste-, color-, and odor-producing chemicals, certain organic contaminants, and specific pesticides.

RO units work by passing water under normal pressure at the tap through cellulose or noncellulosic (polyamide) membranes. A cellulose acetate membrane will not be degraded by chlorine present in municipal water systems. A polyamide membrane will be degraded and, therefore, must be preceded by an activated carbon filter for chlorine removal when chlorinated water is to be treated. Normal pressure at the tap will force filtered water through the membrane and leave behind dissolved solids. Reverse osmosis will remove 90-95 percent of most dissolved contaminants. Membrane density in the sub-micron range will also reject many types of bacteria. Reverse osmosis under-sink installations are costly and require space not ordinarily available in small homes. The usual installation requires three separate cartridges: one for particulates, one for activated carbon, and the reverse osmosis membrane. This results in a costly cartridge replacement program because the useful lives of the separate cartridges vary.

Whatever the installation, countertop or under the sink, reverse osmosis is slow and wasteful of water. For every gallon of potable water obtained, between 4 and 6 gallons of water will go down the drain. It may be necessary to process 30 gallons of water in order to obtain 5 gallons of drinking water. The system may be in operation up to 33 hours intermittently to produce 5 gallons of filtered water, but as the tank is being filled drinking water is available on demand. Although reverse osmosis has been used by industry for many years, its introduction to the home market is fairly recent. Manufacturers are attempting to increase membrane life and water recovery rates. You should be sure that the water-quality problem you are treating warrants a treatment method that is relatively expensive and uses large quantities of water.

## **ULTRAVIOLET RADIATION**

Effective for:

Bacteria (coliforms)

Microbiological contamination

This technology uses a special light bulb which produces ultraviolet light. The ultraviolet (or U.V.) radiation must pass through every particle of water with a minimum dose to be effective in water purification. In clear water this is not difficult to achieve. However, turbid water may permit disease-causing organisms to "hide behind" particles, shielding them from contact with the killing radiation. There are

several effective U.V. water purifiers on the market. They are used in whole-house treatment applications, and are effective at destroying all disease-causing organisms if the radiation is at the proper wavelength and of sufficient intensity. When operating properly, U.V. systems can produce bacteria-free and virus-free water (most claim a 99.9 percent killing rate). The process leaves no residue, taste, or odor. This factor can be a drawback, however, as there is no way to measure if the system is doing its job except by performing a bacteria test on the water. Some systems incorporate a meter which measures the U.V. radiation being transmitted through the water. A quartz window through the side of the irradiating chamber allows the ultraviolet rays to activate a photoelectric cell which measures the intensity of the U.V. If insufficient radiation is present, it is set to turn off the water pump and/or actuate an alarm. The major problem with most U.V. systems is the collection of sediment and growth of algae inside the irradiation chamber. New designs are available which may help to eliminate this problem. In one new U.V. system, water flows through Teflon tubes surrounded by irradiating U.V. lights. This eliminates the fouling on the quartz tubes and appears to be an effective and relatively maintenance-free method.

## DEFINITIONS OF TERMS

**ADMINISTRATIVE AUTHORITY** - the board of health having jurisdiction.

**CARCINOGENIC** - producing or tending to produce cancer.

**CONTAMINANT** - any physical, chemical, biological, or radiological substance or matter in the water.

**DISTILLED WATER** - water which has been purified by passing through an evaporation-condensation cycle. It contains minute amounts of dissolved solids. Multiple distilling will further lower the dissolved solids.

**GRAINS PER GALLON (gpg)** - an obsolete expression needed to denote water hardness. To convert gpg to ppm, multiply the hardness in grains per gallon by 17.1.

**ION** - an electrically charged atom or group of atoms which results when one or more electrons are gained or lost; resulting in either a positive (+) or negative (-) charge. It can be made up of one element or a group of elements; for example, the calcium ( $\text{Ca}^{++}$ ) or bicarbonate ( $\text{HCO}_3^-$ ) ions.

**MICROGRAM/LITER (ug/l)** - a metric unit used to denote concentration of chemicals or other substances, in water; ug/l is equivalent to parts per billion (ppb) or  $10^{-6}$  grams/liter.

**MILLIGRAMS PER LITER (mg/l)** - a unit used to denote concentration of chemicals or other substances, in water. Mg/l and ppm are equivalent expressions of concentration ( $10^{-3}$  grams/liter).

**MILLILITER (ml)** - a unit of volume denoting one-thousandth of a liter; 3,785 ml equal 1 gallon.

**MILLIMHO (mmho)** - a unit of conductance reciprocal to ohm. It is useful in determining total concentration of dissolved salts or minerals in water.

**MUTAGENIC** - capable of inducing a mutation, a relatively permanent change in genes (hereditary material).

**PARTS PER BILLION (ppb or ug/l)** - a unit used to denote concentration of chemicals or other substances. The unit implies a part of something in one billion parts of water or other substances. The following comparisons help in putting this concentration in perspective; one inch in 16,000 miles, one cent in \$10,000,000, one drop in 60,000 quarts of liquid or 1 second in 32 years. **ppb** and **ug/l** are equivalent expressions of concentration.

**PARTS PER MILLION (ppm or mg/l)** - a unit used to denote concentration of chemicals or other substances. The unit implies a part of something in one million parts of water or other substances. The following comparisons help in putting this concentration in perspective; one inch in 16 miles, one cent in \$10,000, one drop in 60 quarts or 1 second in 12 days. **ppm** and **mg/l** are equivalent expressions of concentration.

**POINT-OF-ENTRY TREATMENT DEVICE** - a treatment device applied to the drinking water entering a house or building for the purpose of reducing contaminants in the drinking water distributed throughout the house or building.

**POINT-OF-USE-TREATMENT DEVICE** - a treatment device applied to a single tap used for the purpose of reducing contaminants in drinking water at that one tap.

**POTABLE WATER** - any water used or intended to be used for drinking and culinary purposes.

**PICOCURIE (pCi)** - The quantity of radioactive material producing 2.22 nuclear transformations per minute.

**PRIMARY DRINKING WATER REGULATION (STANDARD)** - A regulation which applies to a public water system, specifies contaminants in drinking water which have adverse health effects, sets an MCL or treatment technique for the contaminant, and assures compliance.

**SALT (GENERAL TERM)** - a class of compounds, such as sodium chloride ( $\text{NaCl}$ ), calcium chloride ( $\text{CaCl}_2$ ), or calcium carbonate ( $\text{CaCO}_3$ ).

**SECONDARY DRINKING WATER REGULATION (STANDARD)** - A regulation which applies to a public water system, specifies contaminants which protect the public welfare, and sets an SMCL for the contaminant. Examples are unpleasant odor or appearance which may cause a substantial number of people to discontinue using the water.

**SPRING** - a natural surface feature where groundwater issues from the rock or soil onto the land or into a body of water.

**SURFACE WATER** - the water found on the ground surface or contained in a stream, pond, lake, reservoir, or other natural watercourse. A surface source or surface supply is construed accordingly.

**TERATOGENIC** - tending to cause developmental changes and malformations in the unborn.

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**ADDENDUM TO INTERPRETING DRINKING WATER QUALITY ANALYSIS, 5<sup>TH</sup> ED.**  
*EFFECTIVE 2/16/99 AS PER 40 CFR PARTS 9, 141, AND 142, PART IV (12/16/98).*

**Pages 8 and 22** (MCL change)

Total trihalomethanes (TTHM)

**MCL (µg/l)**

80 (annual average)

**Disinfection Byproducts** (new MCLs)

Haloacetic acids (HAA5)

60 (annual average)

(the sum of the concentrations of mono-, di-, and trichloroacetic acids and mono- and dibromoacetic acids)

Chlorite

1000 (monthly average)

Bromate

10 (annual average)

**Disinfectant Residuals** (new MRDLs)

Chlorine (as Cl<sub>2</sub>)

**MRDL\* (µg/l)**

4000 (annual average)

Chloramine (as Cl<sub>2</sub>)

4000 (annual average)

Chlorine Dioxide (as ClO<sub>2</sub>)

800 (daily samples)

While the addition of disinfectants to drinking water is effective in controlling many microorganisms, they react with natural organic and inorganic matter in source water and distribution systems to form disinfection byproducts. Results from toxicology studies have shown several disinfection byproducts (e.g., bromodichloromethane, bromoform, chloroform, dichloroacetic acid, and bromate) to be carcinogenic in laboratory animals. Other disinfection byproducts (e.g., chlorite, bromodichloromethane, and certain haloacetic acids) have also been shown to cause adverse reproductive or developmental effects in laboratory animals. Several epidemiology studies have suggested a weak association between certain cancers (e.g., bladder) or reproductive and developmental effects, and exposure to chlorinated surface water. More than 200 million people nationwide consume water that has been disinfected. Because of the large population exposed, health risks associated with disinfection byproducts, even if small, need to be taken seriously. For these reasons, MCLs and MRDLs have been set at the above levels (compliance is based on an annual average for trihalomethanes, haloacetic acids, and bromate and on a monthly average for chlorite).

These MCLs and MRDLs apply to all community and nontransient noncommunity water systems that treat their water with a chemical disinfectant for either primary or residual treatment.

Large surface water systems are required to comply with the standards by December 2001. Ground water systems and small surface water systems must comply with the standards by December 2003.

*EFFECTIVE DECEMBER 2000 AS PER 40 CFR PARTS 9, 141, AND 142, PART V (12/16/98).*

**Pages 8 and 30** (MCL change)

Turbidity No more than 5% of the samples may exceed 0.3 Nephelometric Turbidity Unit (NTU) and the level must at no time exceed 1 NTU

*OTHER CORRECTIONS*

**Pages 8 and 25** The MCL for Copper should read 1300 µg/l (Action Level).

\* (MRDL) Maximum Residual Disinfectant Level

**INTERPRETING DRINKING WATER QUALITY ANALYSIS  
WHAT DO THE NUMBERS MEAN? (5th Edition)**

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