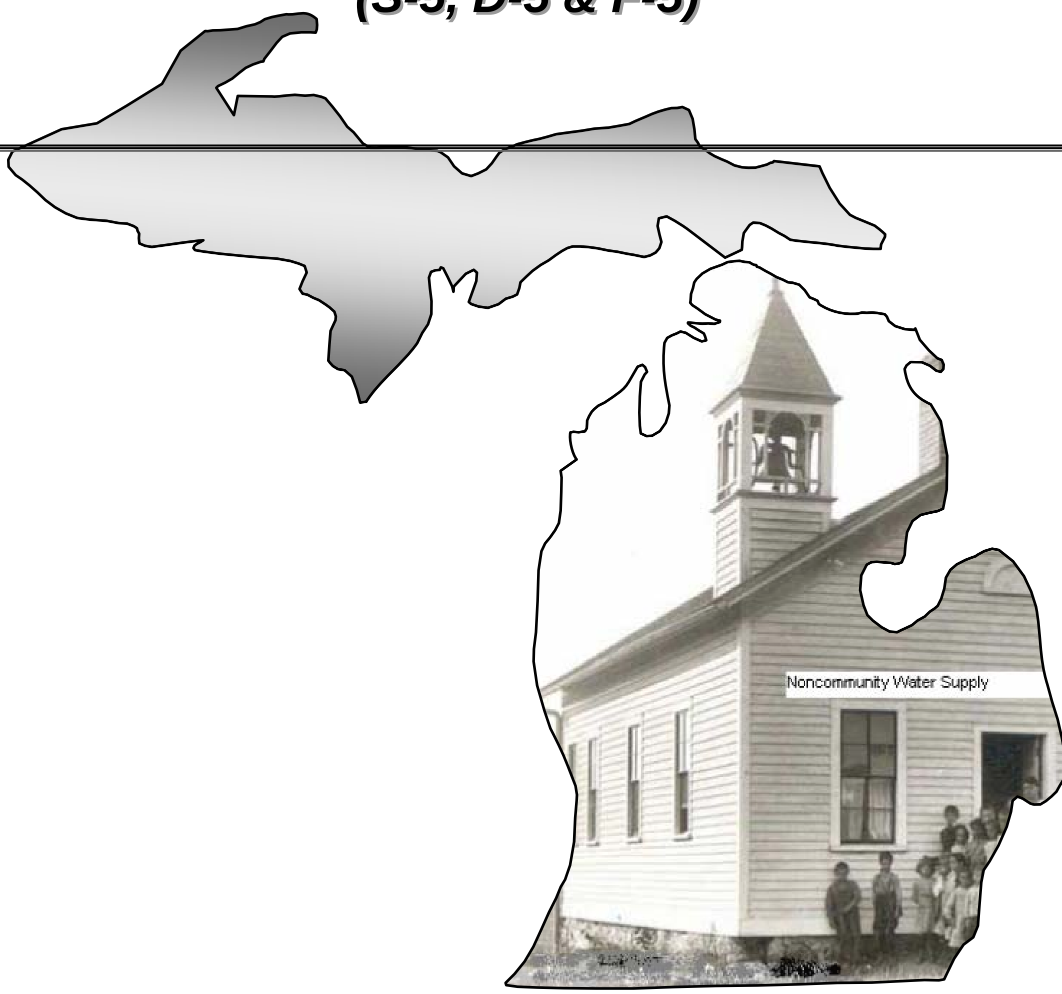
MICHIGAN NONCOMMUNITY PROGRAM

Level 5 Drinking Water Operator Guide

(S-5, D-5 & F-5)



DEQ Department of Environmental Quality

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Introduction

This manual is intended to provide basic information for persons preparing to become operators of small public water systems, primarily Level 5 nontransient noncommunity water supplies and as a reference guide for existing Level 5 certified operators. It may also be of use for the operators of other small community systems; however, there are a few differences in some of the community versus noncommunity water supply regulations.

The Safe Drinking Water Act; 1976 PA 399, as amended requires all community and nontransient noncommunity public water systems and certain transient noncommunity systems (those that treat for water quality purposes, or add chemicals to the water) to have a certified operator in responsible charge of the water system.

There are three categories of Level 5 operators; S-5, D-5, and F-5.
S-5: *Nontransient, noncommunity* supplies that do not treat their drinking water are classified as S-5. Most of the 1500 nontransient noncommunity supplies in Michigan will fall into this category.

D-5: Noncommunity water systems that apply limited treatment are classified as D-5. The following treatment is considered limited. Other treatment may also fall into this category. (Includes transient systems treating for the treatment below)

- Disinfection,
- Fluoridation,
- Iron removal,
- Ion exchange treatment (except conventional water softeners),
- Phosphate application, or
- Filtration other than complete treatment.

F-5: Noncommunity supplies with complete treatment are classified as F-5. A complete treatment system means that it uses ***disinfection, coagulation, sedimentation and filtration*** units that function together to produce finished water that meets the requirements of the state drinking water standards. An F-5 classification is typically for those supplies using surface water or ground water under direct influence by surface water. (Includes transient systems treating as such).

NOTE: *Noncommunity water supplies with extensive or complex treatment or distribution system, or large service population may be placed in another classification, such as 1-4 in F, D, or S classification on a case by case basis. These classifications require more training and continuing education units.*

Some information in the chapters is pertinent to all Level 5 classifications of operator classification (or that which is being pursued), while some is specific to S-5 or D-5 or F-5. The chapter on Treatment is specific only to D-5 & F-5 operators and need not be reviewed by S-5 operators.

Acknowledgement
This guide has been developed using information from the Minnesota Department of Health/Minnesota Rural Water Association "Safe Drinking Water for Your Small Water System: An Operator's Guide" 2002 and "Class E Study Guide" 2003, the California Department of Health Services/EPA Office of Drinking Water Field Study Training Program Manuals, Wisconsin DNR's "Small Water System Operator Certification Manual," 2003, Connecticut's Cross Connection Manual, 2003, other information obtained from the U.S. Environmental Protection Agency website, and Michigan's laws, rules, regulations and policies. Michigan Department of Environmental Quality Noncommunity Program Staff also contributed to this manual.

Unless otherwise noted, graphics, diagrams and/or pictures were obtained through Google Image search on the internet.

Disclaimer
Several photographs and illustrative drawings that appear in this manual have been furnished through the courtesy of various product distributors and manufacturers. Any mention of trade name, commercial products or services does not constitute endorsement or recommendation for use by the Michigan Department of Environmental Quality.

This manual presents a summary of regulations applicable to nontransient **Noncommunity** drinking water systems that are required by law to have a certified operator and transient noncommunity systems with treatment for water quality purposes. Some regulations for Community water supplies may be different. Should the summarized information in this document be inconsistent with a governing rule or statute, the language of the rule or statute shall prevail.

First Publication Date: Spring 2008
Holly Gohlke, R.S., Project Coordinator

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CHAPTER 1
Regulatory Authority

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The Safe Drinking Water Act

1.0 Chapter Overview

The Federal Safe Drinking Water Act was passed by Congress in 1974, giving the United States Environmental Protection Agency (USEPA or EPA) the responsibility for establishment and enforcement of public drinking water standards nation-wide. Under a **primacy** agreement EPA has delegated the authority to administer and enforce the Safe Drinking Water Act requirements to the State of Michigan. The enactment of the **Michigan Safe Drinking Water Act, 1976 PA 399**, and Administrative Rules, as amended (SDWA), allows the Michigan Department of Environmental Quality (MDEQ) to assume primary enforcement authority and responsibility for a comprehensive public water supply program in Michigan. The program includes regulations for community, noncommunity and other public water supply systems.

The Federal Safe Drinking Water Act undergoes reauthorization by Congress every 10 years and Michigan has enacted equivalent standards to maintain primacy. It is expected the regulation of public drinking water systems will continue to be a dynamic process. Under an annual contract the local health department (LHD) sanitarians perform many of the Noncommunity Drinking Water Program duties granted to the State of Michigan under the primacy agreement.

Program duties involve routine inspections of existing noncommunity water systems (NCWS), issuance of permits for new or expanded supplies, insuring that water sampling is done at required frequencies, making sure steps are taken to protect public health and returning a supply to compliance when violations of the drinking water standards occur. Government staff as well as the facility owner and operator are all responsible for ensuring public health and safety.

Primacy authority - The authority given by the USEPA to the States to implement and enforce the Safe Water Drinking Act (SDWA – MI Act 399)

1.1 Public Water System Classification

The SDWA defines what exactly a public water system is. All facilities meeting the definition of a public water system are required to meet the legal requirements of the SDWA as it is implemented here in Michigan. Keep in mind that "providing water" means that water is used for any of the following purposes: drinking, food preparation, bathing, showering, tooth brushing, or dishwashing.

1.1.1 Three Classifications of Public Water Supplies (PWS):

Type I – Community (CWS) or Municipal Supply

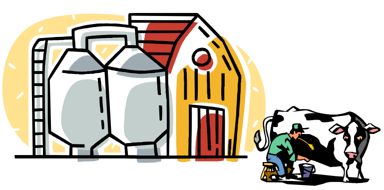
"A PWS that provides year-round service to not fewer than 15 living units or which regularly provides year-round service to not fewer than 25 residents."

Type II – Noncommunity Supply (NCWS)

"A PWS that is not a community supply, but that has not fewer than 15 service connections or that serves not fewer than 25 individuals on an average daily basis for not less than 60 days per year."

Type III – All Other Public Supplies

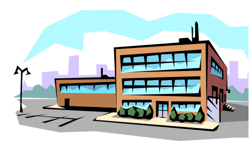
Examples include Grade A Dairy Farms & Small Apartment Complex's.



1.2 Noncommunity Supplies in Michigan

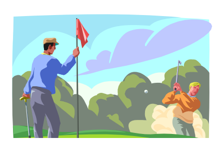
Michigan is home to over 10,000 schools, child care centers, restaurants, churches, campgrounds, motels, resorts, businesses, and industries that use their own well as a source of drinking water for their customers, students, and employees. The majority of noncommunity supplies are called ***Transient*** noncommunity water supplies (TN) and serve people at places such as restaurants, motels, highway rest stops, and parks. However, some supplies serve basically the same individuals on a regular basis such as schools and places of employment and are called **Nontransient** noncommunity water supplies (NT). All noncommunity supplies must maintain approved water systems and meet drinking water standards for acute contaminants such as coliform bacteria and nitrate. Those that serve the same consumers on a regular basis, the NT systems, must also monitor for additional drinking water contaminants that can have long term health affect over time with repeated exposure. In addition, all NT systems are required to have a certified operator for the water supply.

NCWS's can be further divided into **Type II-a** and **Type II-b** depending on the average daily water production. Type II-a are those averaging 20,000 gallons per day or more. Most NCWS's in Michigan are Type II-b. (See ***Appendix A-1*** for the Public Water Supply Type Summary chart.)



Nontransient Supply Definition:

"A noncommunity supply that serves not fewer than 25 of the same persons on an average daily basis more than 6 months per year. This definition includes water supplies in places of employment, schools, and day-care centers."



Transient Supply Definition:

"A noncommunity supply that serves 25 or more different individuals a day at least 60 days of the year (or 15 or more service connections). Examples include motels, churches, golf courses, restaurants, parks & highway rest areas."

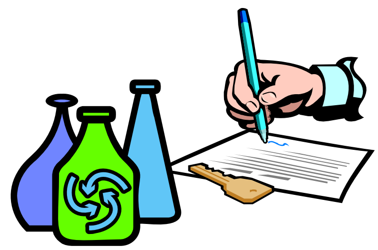
1.2.1 Water Supply Serial Number (WSSN)

In Michigan, each NCWS is identified with a specific **WSSN**. The WSSN is a seven-digit number starting with **__2__**, and ending with the two digit county code. The

LHD staff assigns the WSSN when a facility first becomes a nontransient water supply. A facility may have more than one drinking water well on the property, and each well is considered a different **Source**. The individual wells are issued a **Source Code Number,** typically starting with 001 and continuing in succession (002, 003, etc).

THE WSSN AND SOURCE CODE NUMBERS ARE VERY IMPORTANT AND ARE USED IN IDENTIFYING WATER SAMPLE RESULTS WITH THE FACILITY. **The WSSN & Source Code number MUST be included on the Laboratory water sample analysis form.**

Failure to include these numbers on the water sample analysis form will result in your facility not being credited with the results and the issuance of a **Monitoring Requirement Violation (MR).**



Example
Facility: “Joe’s Water Company of Clinton County”
WSSN: 2012319
Source Code: 001 & 002 (two wells on this property)

1.3 Operator Certification

In an effort to improve the safety of PWS through compliance with operation, maintenance and sampling requirements, amendments to the Federal Safe Drinking Water Act require that certain public water supplies have a certified operator.

Certified operator means an “operator who holds a certificate.” The operator may be the owner of a PWS or the person designated (or hired) by the owner as the responsible individual in overall charge of the water system. This person makes decisions regarding the daily operation of the PWS that could directly impact the quality and quantity of the drinking water being supplied. The certified drinking water operator is responsible to operate and maintain the waterworks system and adequately protect public health. The waterworks system shall have in place a plan for proper operation of the system when the operator in charge is not available.

A drinking water operator is certified for a 3-year period, is responsible for demonstrating knowledge and ability to operate the system and for keeping up to date on the SDWA regulations. This is accomplished through continuing education. It is the responsibility of the operator to renew their certificate by submitting (to the MDEQ) an application for renewal on the form provided by the department. To renew, the operator of a NCDWS (Level 5), must have received at least 9 hours of continuing education training which equates to 0.9 CEC’s.

The SDWA require certified drinking water operators for all NTNC water supplies and for TN systems that employ certain water treatment processes. Operators must be certified at a level equal to or greater than the classification level of the water system (F, D, or S).

Table 1.1 - Classification level of the water system:

CLASS	DESCRIPTION
F	For systems using surface water or ground water under the direct influence of surface water or any system with **complete treatment**.
D	For systems with **limited treatment**.
S	For **distribution systems** and no treatment at all or *treatment that does not require public health related oversight*.

1.3.1 Operator Classification

S-5: *NTNC* supplies that do not treat their drinking water are classified as S-5. Most of the NTNC supplies in Michigan will fall into this category.

D-5: NCWS that apply limited treatment are classified as D-5. Any of the following treatment is considered limited. Other treatment for water quality purposes not listed may also fall into this category.

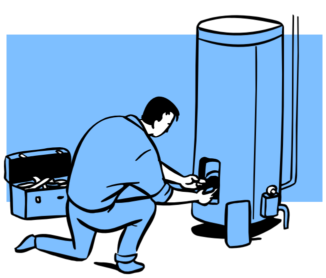
- ***disinfection***
- ***fluoridation***
- ***iron removal***
- ***ion exchange treatment (except conventional water softeners)***
- ***phosphate application***
- ***filtration other than complete treatment***

F-5: NCWS with complete treatment are classified as F-5. A complete treatment system means that it uses ***disinfection, coagulation, sedimentation and filtration*** units that function together to produce a finished water that meets the requirements of the state drinking water standards. An F-5 classification is typically for those supplies using surface water or ground water under direct influence by surface water.

NOTE: *NCWS with extensive or complex treatment or distribution system, or large service population may be placed in another classification, such as 1-4 in F, D, or S classification on a case by case basis. These classifications require more training and continuing education units.*

1.3.2 Certified Operator's Responsibilities

Generally, a Level 5 certified operator is not required to be on-site at all times at a facility, however, the PWS is required to have in place a plan for proper operation of the system when the operator in charge is not available. PWS's with treatment will require more oversight than ones with no treatment.



Typically, the operator arranges for repairs or disinfection in the case of a problem with the PWS, or for bottled water if an alternate temporary supply is necessary. The operator insures that the sampling is being done on schedule and reported to the regulatory agency as required. The operator keeps the records available, up to date and properly posts any public notices that are required. The operator implements the contingency plan should a problem arise and is the main contact for the regulatory agency in any matter regarding the PWS. The operator is also in charge of water sampling.

1.3.3 *Water System Maintenance*

Routine maintenance of the water intake, pump, water storage, distribution piping, treatment devices, cross connections, safety and security is typically the responsibility of the operator.

An operator should be able to:

1. Identify possible sources of contamination in the area around the water intake pipe
2. Inspect physical components of the treatment & distribution systems
3. Observe problems with equipment
4. Know who to contact in case of repairs or emergencies

An example of what an operator can look for:

Look for problems with the sealant used to fill the annular space between the drilled hole and the well casing. A depression in the ground around the edge of the casing can indicate that the sealant has shrunk, collapsed, or cracked.

If you can move the casing around by pushing it, that's a bad sign. Cracking and gaps allow run-off and surface water to move down the outside of the well casing and contaminate your drinking water.

1.3.4 Essential Elements in System Operation & Maintenance

1. Know the location of your well(s) & inspect on a routine basis. Inspecting it will alert you to any deterioration, damage, or other problems. Provide a secure and intact well cap. Older well caps often do a poor job of keeping insects and dirt out of the well. If possible, replace older caps with an overlapping well cap that includes a compression gasket and screened vent. See the “Well Components” section of this manual for more information.

2. Be sure the well casing extends at least **one foot** above the ground surface to reduce the possibility of surface water or other contaminants entering the well. Avoid landscaping projects that reduce the distance between the ground and the top of the well casing to less than the required minimum distance. If necessary, a licensed well driller can extend the well casing to the proper height. See the “Well Components” section of this manual for more information.

3. Direct surface and roof runoff away from the well. Surface water should not collect near the well.

4. Protect wells from potential vehicle damage. Delivery trucks, lawnmowers, snowmobiles, and other vehicles may damage wells. Sometimes the damage to the well is below ground and not visible from the surface. Water quality degradation, inconvenience, and expensive repairs are often the end result. Direct vehicular traffic away from the well or surround the well casing with rigid posts or large rocks to help protect the well from damage. See the "Well Casing Protection" section of this manual for more information.

5. To the extent possible, remove any potential sources of contamination from the area near the well. All new wells must meet the minimum requirements for separation from potential contaminant sources. Required minimum isolation distances are listed in the Appendix.

6. Operate and maintain all water treatment devices according to the manufacturer's specifications. This includes routine replacement of some filter cartridges and maintaining an adequate level of salt in the brine tank, if you have a water softener. Poorly maintained treatment devices often lead to water quality problems.

7. Eliminate cross connections and dead ends in the plumbing system. A dead end, as the name implies, is a portion of your drinking water piping that does not have water regularly moving through it. Dead ends result in stagnant water that deteriorates and can affect water quality elsewhere in the system. Plumbing cross connections potentially allow contaminants to enter the potable water supply.

8. Always have the plumbing system disinfected **by a licensed well drilling contractor or a Master Plumber**, after repairs or modifications. New fixtures, piping, or other plumbing components can introduce bacterial contamination. All seasonal wells and plumbing systems should be disinfected and sampled for coliform bacteria prior to start-up by an authorized person and the LHD representative contacted. All distribution system lines must be thoroughly flushed before returning to use.

9. State law requires NTNC drinking water supplies to have a certified water operator for the system. Certification is obtained from the state when a person passes an examination. Certification is good for 3 years and within that period the operator must attend continuing education classes.

10. Prior to making changes to the water system, contact your LHD representative. A permit may be required before proceeding.

11. Know whom to contact in case of emergency if there are problems with your water system. This would include LHD staff, a well contractor, and a plumber.

It is important to take note of any changes in the operating characteristics of the treatment equipment as it may allow pathogenic organisms to pass through into the drinking water supply.

NOTE: *The owner is still legally responsible for compliance with the SDWA and must be informed by the operator on compliance issues.*

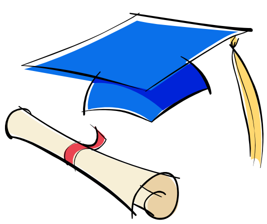
1.3.5 Level 5 Operator Certification Procedures

For an individual to become a Level 5 certified drinking water operator the following must be done:

1. Complete and mail an exam application to the DEQ Operator Certification & Training Unit. Application must be received by the DEQ not less than 45 days before the announced examination date. There is no fee to take the exam and the only requirement to sit the exam is that the person has a high school diploma or GED equivalency.
   (Refer to www.michigan.gov/deqoperatortraining)
2. Demonstrate knowledge of the SDWA and the operation of a public water system by passing an exam prepared by DEQ with a score of 70 percent or better. Persons passing the exam will receive a certification document indicating their operator identification number and expiration date.

1.3.6 Continuing Education and Renewal of Certificates

Once certified, all operators must take continuing education classes in order to renew their certificates. Operator certification is good for three years. Within that three year period, Noncommunity Level 5 operators in Michigan are required to obtain a minimum of nine hours of DEQ approved continuing education credits (0.9 CECs). If the certificate expires, the person must reinstate the certificate within one year, otherwise, they will have to pass the examination to become certified again.



Note: This certification is YOURS, like your drivers license. Make sure you use YOUR home address, phone number, etc., when filling out the exam application. Your renewal form and other important information regarding your certification are sent to your home address (or the address you originally provided on the exam application form). Include the information for the facility(s) you will be working at in the "Business" section. Don't forget to include ALL facility WSSN's.

Statute authority
Refer to:
Michigan Safe Drinking Water Act
Part 19. Examination & Certification of Operators

1.3.7 Other Operator Information:

Many NCWS certified operators are the owners or employees of the facility, however a third-party contractor may be hired by the PWS owner provided they are certified at the level required by the classification of the PWS or they are certified at a higher level. ***All certified drinking water operators, no matter whether they are employed within or hired from outside the PWS facility, have the same responsibilities of operating and maintaining the system, meeting all SDWA regulations, and providing safe drinking water to the public.***

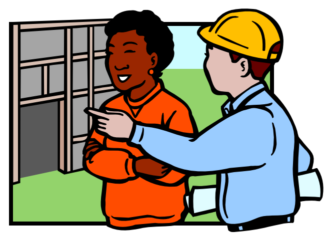
A certified operator may operate any waterworks system as follows:

1) Within a classification at or below the level of his or her certificate.

2) At a different classification as follows

- An operator who holds an F certificate meets the qualifications to operate a D treatment system of comparable numerical classification.

- An operator who holds an F certificate or D certificate meets the qualifications to operate a class S-5 system.



1.4 Owner Responsibilities

Although the owner of a PWS may hire someone to do one or more of the following duties, ***the owner*** is ultimately responsible for providing safe drinking water and meeting all of the legal requirements that apply to the water supply.

PWS Duties:

- Provide an adequate supply of safe water to the public.
- Maintain and operate the system in a safe and sanitary condition.
- Collect required water samples.
- Notify the public in cases of noncompliance.
- Obtain permits for construction or alteration of water well supply.
- Maintain NCWS records.
- Notify the LHD within 7 days when the supply no longer has the services of an operator.

At times, a well contractor, licensed plumber, or other water professional may need to be hired to assist with your water system.

1.5 Plan Review & Permit Overview

The SDWA requires owners of Type II public water supplies to obtain a permit from the DEQ or its' representative (local health agency) **PRIOR** to the construction and use of a PWS source or treatment facility or in the event of alterations to the system. The purpose of the plan review is to verify that the design complies with Michigan rules and standards, and that no system is installed that may endanger public health. The construction or alteration must be inspected on site and approved by the LHD staff before the water can legally be served to the public.

Consulting with the local health agency noncommunity program coordinator in advance has also resulted in owner/facility savings both financially and time wise. If alterations, replacements, or repairs are made without consulting with the health agency, the change might not meet the requirements of the SDWA and the water inspector has the authority to have the owner "undo" what was done at the owner's expense. A flow chart depicting the following steps can be found in ***Appendix B-1***.

1.5.1 Steps PRIOR to Water System Changes:

1. Owner or certified operator contacts LHD for consultation on proposed, alteration or change to find out if a permit is necessary.

2. ***Permit necessary:*** Owner or certified operator submits construction details and acceptable scaled drawing (properly dimensioned) showing important aspects of the general layout of a proposed waterworks system or a portion of the system to the LHD.

3. LHD reviews and approves plan then issues a permit for the construction or alteration. The permit is also required for any treatment facilities which are to be used for public health purposes ***before the water may be used***.

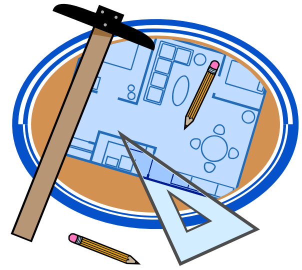
4. Work may be started and completed according to the permit specifications.

5. If permit is not necessary, the owner is authorized to make changes or alterations by the LHD without a permit.

6. If the plans or information is incomplete, the LHD will request more information from the owner. The LHD will re-review information as it is received and either approve or deny the permit request.

7. If the plans or information do not comply with the SDWA regulations, the LHD will deny the permit and the changes or alterations cannot be made.

1.5.2 When a Plan Review is Required:



1. Plumbing Construction/Modifications
2. Installation of Water Treatment Systems
3. Wells Serving Community Water Supplies

1.5.3 When Permits are Required:

1. Plumbing Construction/Modifications
2. Installation of Water Treatment Systems*
3. New or Replacement Wells Serving Noncommunity Water Supplies

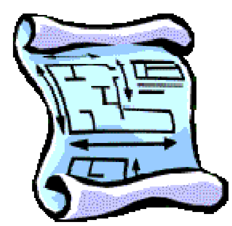
1.5.4 Treatment Permit Requirement

***Treatment systems** to meet drinking water standards, or that inject treatment chemicals into the water supply for **any purpose** also require a construction permit because of public health concerns if chemical injection is done improperly. This chemical injection includes, but is not limited to:

1. Continuous disinfection with chlorine, ozone, or any other disinfectant
2. Fluoride addition
3. Phosphate injection to sequester iron or prevent leaching of lead or copper
4. pH adjustment
5. Potassium permanganate with greensand iron removal.

1.5.5 New Wells

A well construction permit is issued to construct a new well if the proposed construction details and well site are satisfactory. The LHD makes an initial site visit evaluation to approve the proposed well location. Final approval to put the well in service may be granted when the LHD has approved of the well construction, pump installation, water sample analysis results, and has received a satisfactory well log from the driller.



1.5.6 Plan Review & Permit Application Forms

The forms can be obtained from the LHD in your area.

1.5.7 Permit Denial

Rule 1307 of the SDWA states that the department may deny a permit request when it determines that a PWS cannot provide a continuous and adequate supply of water meeting the state drinking water standards.

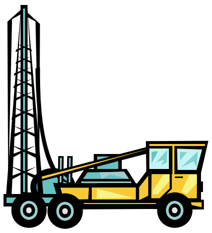
1.6 Revision of Approved Plans & Specifications

The owner must notify the LHD if changes to the approved permit are needed.

1.7 Approved Standards

1.7.1 Equipment & Materials

Section 13 (2) of the SDWA requires that all water treatment chemicals at a PWS have the National Sanitation Foundation (NSF) NSF-60 certification and all products that come into contact with water at a PWS have the NSF-61 certification. Also, Rule 505(e) of the SDWA states, "A supplier of water shall comply with all applicable state and local plumbing codes."



1.7.2 Well Construction

All public drinking water wells constructed in the state must meet the construction standards of the Michigan Water Well Construction and Pump Installation Code, Part 127 and installed by a Michigan licensed well drilling contractor. A well construction permit is also needed for a replacement or additional well.

1.8 Capacity Development

Construction of a ***new*** NTNC PWS cannot begin until the owner has satisfactorily demonstrated the facility has the capacity to comply with the provisions of the SDWA. Existing supplies (typically transients) applying ***to become*** a nontransient water supply must also complete a Capacity Development form.

Capacity is defined as the overall capability of a water supply to reliably produce and deliver water meeting all national primary drinking water regulations in effect or likely to be in effect, on the date of commencement of operation.

Capacity encompasses the *technical*, *managerial*, and *financial* capabilities that enable the water system to plan, achieve, and maintain compliance with drinking water standards. The Capacity Development should help educate the applicant about initial and future requirements/costs of being a PWS owner.

Statute authority
Refer to:
Michigan Safe Drinking Water Act
§325.1004, §325.1008, §325.1015

1.9 Michigan's Drinking Water Regulatory Agencies

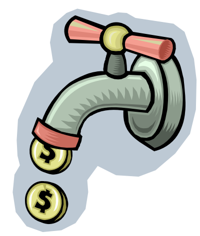
1.9.1 State Department of Environmental Quality

As mentioned earlier, the State of Michigan adopted the federal safe drinking water regulations and obtained primacy to enforce it. The DEQ, noncommunity program staff is located in Lansing and district offices. The state authorized and contracts with LHDs to provide primary direct service to noncommunity system owners and operators. The DEQ works closely with LHD staff and system owner/operators to maintain safe drinking water supplies.

1.9.2 Local Health Departments

Noncommunity program coordinators in the Environmental Health division at LHDs provide noncommunity program oversight and technical assistance for required water quality monitoring and reporting in accordance with the SDWA.

1.10 Public Drinking Water Annual Fee



Per Section 325.1011 b of the SDWA, annual fees are charged to owners of all noncommunity water supplies. These funds are collected by the DEQ and distributed to LHDs in order to support services provided to NCWSs.

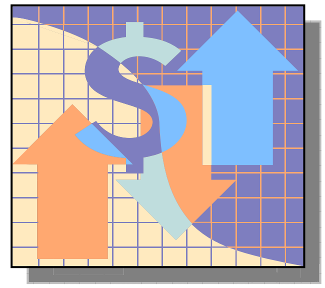
1.10.1 What is the Fee Used For?

Federal law requires all states to implement the SDWA and allow states to reduce or waive many of the requirements based on ***inspections***, ***tracking of historical data***, and ***assessments*** of the water supply's vulnerability.

The fees collected are used to help provide the funding to enable the DEQ to contract with LHDs to perform the required activities listed above. Retaining state and local control of the program may help to save the water supply owner considerable time, effort and/or money by:

- Allowing the DEQ to maintain a state run program as opposed to direct federal administration.
- Allowing more flexibility in implementation of certain rules, including *significant reductions* (based on a good compliance history) in sampling that would not be available in a federal program.
- By providing easier access to technical assistance and information to public water system owners and the people of Michigan.

For example, under Federal regulations, a NTNCS would have to take at least one volatile organic water (VOC) sample *every quarter*, at considerable expense to the owner. Michigan may allow a reduction in that number to once every six years, provided the supply is not at risk for VOC contamination.



1.10.2 How is the Fee Assessed?

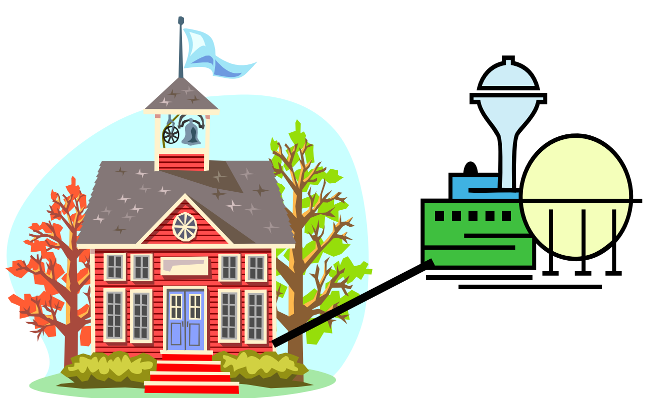
- The fee is assessed each October 1st to all active systems to be applied to the next fiscal year. For example, a fee is imposed on a water supply on October 1, 2005 for Fiscal Year 2006. Invoices are generally sent out in late October or early November.
- The fee is adjusted every year by applying the percentage adjustment using the Detroit Consumer Price Index (CPI).
- In addition to the CPI adjustment, at the end of the fiscal year, 75% of any unspent fee revenue from previous annual fee payment is applied as a credit adjustment on a pro-rated basis to the fee the following year in accordance with the SDWA.

1.10.3 Noncommunity Water Supply Status Change

It is the facility owner's responsibility to document any changes in status, ownership or mailing address to the LHD. If a facility believes they are no longer a Type II or has changed status, the facility is required to send the invoice back to the Michigan Department of Treasury along with a note stating any changes to its PWS status and notify the LHD representative in writing to inform them of any change. The LHD NCWS program coordinator will verify the change in status with the DEQ.

<u>What Constitutes a Change?</u>

- The water supply facility has closed
- The water supply facility has changed ownership
- The water supply facility has changed its status (changed from Type II to Type III)
- The water supply facility has hooked to municipal water
- Has a different mailing address or name



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CHAPTER 2
Drinking Water Sources & Protection

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Drinking Water Sources & Protection

2.0 Chapter Overview

Water for consumption, or **potable** water, comes from fresh water on the surface or underground **aquifers**. An aquifer is an underground water-bearing layer of gravel, sand, sandstone, shattered rock, limestone, or other formation which is saturated and which transmits water in sufficient quantities to serve as a water supply. Water is not *naturally* pure, no matter what source it comes from. In nature, all water contains some impurities. Some impurities are harmless, while others may adversely affect human health. The SDWA is written to protect the public against harmful impurities that may be found in drinking water sources. A basic understanding of groundwater characteristics is important for the protection of our water sources and to provide safe drinking water to the public.

2.1 Surface Water Sources

Not many NCWS's use surface water for a drinking water source. Surface water can be obtained from a river, lake or other surface impoundment. Surface waters are exposed to many different contaminants such as animal wastes, pesticides, insecticides, industrial wastes, algae and many other organic materials. Compared to groundwater, surface water has high ***turbidity*** and suspended solids. Strict monitoring and treatment is required if this source is used for drinking water. Any facility using surface water as its drinking water source MUST provide complete treatment and ensure the safety of its users.

2.2 Groundwater Sources

Most water systems in Michigan have a well or wells meaning that they are using **groundwater** as a water source to meet their water use needs. A water well is constructed into an underground aquifer. The well acts like a straw to pull water out of the ground and then transports it to the facility by use of pumps and pipes. Groundwater is generally less susceptible to contamination than surface water, but typically has higher concentrations of dissolved solids than surface water.

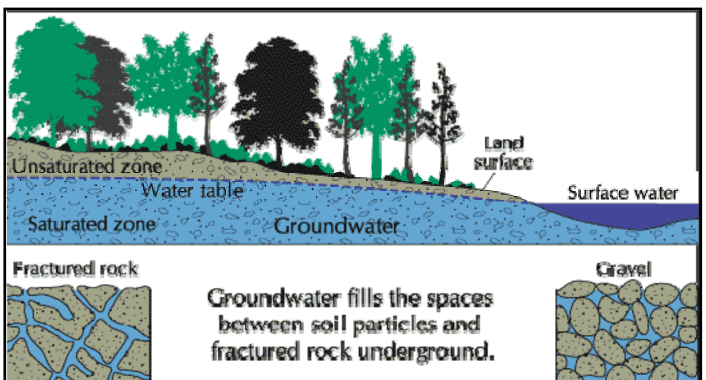
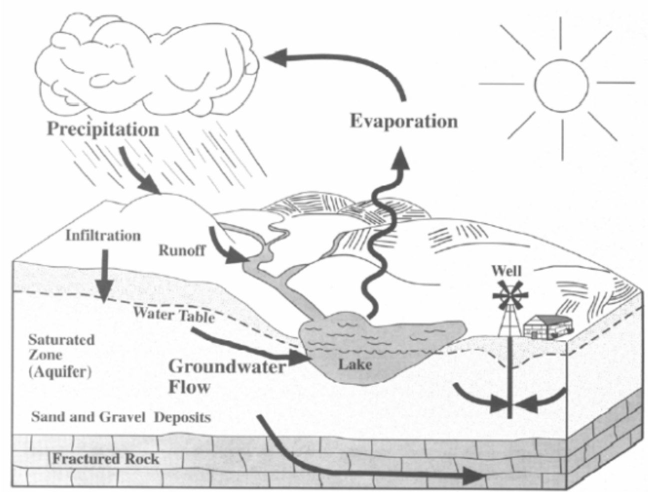


Image compliments of US Geological Survey, adapted by The Groundwater Foundation.

2.3 The Water Cycle

The water cycle is also referred to as the ***hydrologic cycle****.* This cycle is the continuous process of water evaporating from the earth, moving to the clouds, returning to the ground as precipitation, and flowing on or through the earth's surface.

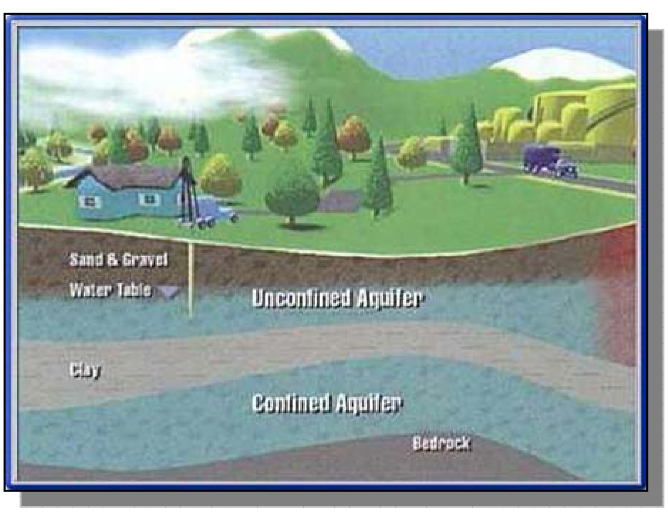


Because of many sources of recharge, groundwater may contain any or all of the contaminants found in surface water as well as the dissolved minerals it picks up during its long stay underground. Groundwater's susceptibility to contamination depends on well construction and maintenance, the type and thickness of soil and rock layers, depth to the groundwater, and the type of contaminants.

It takes longer to replenish a ground water supply source than a surface water source. Recharge is relatively slow because the replacement (recharge) water from rain or snow melt generally must filter down (infiltrate) slowly through the soil and rock to the ground water table. It is also difficult and expensive to cleanup contaminated ground water.

2.4 Aquifers

As mentioned above, an aquifer is a saturated underground water-bearing formation capable of transmitting sufficient quantities of water. Some aquifers are better to use for drinking water purposes than others. An aquifer located below a thick confining layer of clay or dense soil material that liquids do not pass through easily or quickly, is less likely to become contaminated by surface materials and may serve as a better drinking water source. However, some areas in Michigan may only have one viable formation for drinking water.



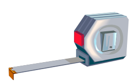
2.5 Source Water Protection

Drinking water coming from a surface or groundwater source is vulnerable to being contaminated if the source is not protected. Source water contamination could create potential health problems and cause increased expenses for water system owners in their pursuit of correcting the problem or searching for a new source of drinking water. "Source Water Protection" refers to the efforts made by PWS to protect their water supply source.

The 1996 amendments to the federal Safe Drinking Water Act required states to develop a Source Water Assessment Program (SWAP). A source water assessment is a study and report, unique to each water system that provides basic information about the water used to provide drinking water. SWAP was designed to identify areas that supply public drinking water, assess the susceptibility of those water supplies to contamination, and inform the public of the results.

Source water protection begins with maintaining a required isolation distance from any known source of contamination to the wellhead or water inlet and monitoring or relocating all existing contaminants that don't meet the isolation distance. It is the responsibility of the owner and certified operator to do what is needed to protect their source water.

2.5.1 Isolation Distances



Isolation distances are the minimum physical separations that are required between a well and a potential source of contamination. There are two types of isolation distances, "standard source" and "major source".

Failure to observe isolation distances may contribute to contamination of the well and is considered a violation of the SDWA.

2.5.2 Standard Sources of Contamination

The Michigan SDWA establishes the standard isolation areas from any existing or potential sources of contamination, including, but not limited to, storm and sanitary sewers, pipelines, septic tanks, drain fields, dry wells, cesspools, seepage pits, leaching beds, barnyards, or any surface water, other area or facility from which contamination of the groundwater may occur, for PWS's. (Act 399 - Rule 808)

2.5.3 Major Sources of Contamination

Michigan also established isolation distance requirements for PWS's from known major sources of contamination, including, but not limited to, large-scale waste disposal sites, land application of sanitary wastewater or sludges, sanitary landfills, and chemical or waste chemical storage or disposal facilities.

The department may require an increase or approve a decrease in the isolation distances based on hydrogeological data; what type of soil is found above the aquifer, the groundwater flow direction, and the volume of the contaminant.

A well shall not be located in an area subject to flooding and the ground surface immediately adjacent to a well casing shall be graded so that surface water is diverted away from the casing. The casing must extend at least 12 inches above grade. Surface flooding shall not be allowed closer than 25 feet from the well. (Act 399 - Rule 816)

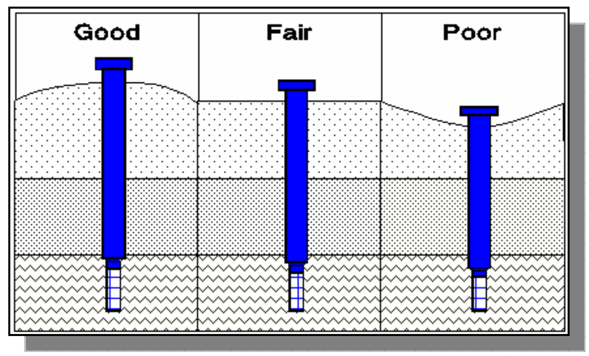
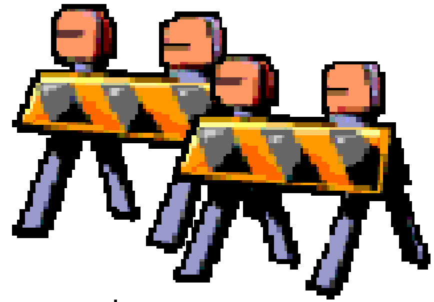


Table 2.1 Isolation Distances to a drinking water well

Noncommunity Well Type	Minimum Distance to Contamination	
	Major Source	**Standard Source**
Type II-A	2000 feet	200 feet
Type II-B	800 feet	75 feet

2.6 Multiple Barrier Protection



Over the years the principles of **multiple barrier protection** has become the foundation of Michigan's drinking water programs. The primary barriers to prevent contamination and protect public health are proper location, construction, operation, and maintenance of sources and water systems, supported by periodic monitoring to measure the ongoing integrity of the systems. There are numerous elements to each these barriers that essentially make up the drinking water program as a whole. The elements include training and licensing of water well drillers and pump installers, strict construction codes for all water well location and construction, plan review and permitting of new construction or alteration of public water systems, training and certification of operators, source water assessments, cross connection control, treatment where applicable, and regular sanitary survey inspections.

Ongoing sampling is required for all noncommunity water systems. This monitoring is very important, however periodic monitoring is not a substitute for the multiple barriers (i.e. properly located, constructed, and operated water supplies) since exposure to contaminants will have already occurred by the time results from routine samples are known. Similarly treatment to remove or inactivate contaminants with public health implications is also not a substitute for a safe source. Continuous removal of contaminants that impact public health requires significant technical and operational expertise and regulatory oversight. In principal it is a last resort especially for small water systems and is far less protective of public health than relying on a source that is not contaminated.

2.7 Water Quality Safeguards

1) **Continuous Positive Pressure**
   - Prevents backsiphonage & entry of contaminants
   - Result of adequate supply & storage and proper design
   - Loss of pressure = posting, chlorination & sampling

2) **Frequent Testing & Record Keeping**
   - Lets you know if there is a breech in system
   - Records let others know what has happened in your absence

3) **Routine Maintenance**
   - Well/pump, water storage, distribution piping, treatment devices, cross connections, safety & security

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CHAPTER 3
Drinking Water Quality

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Drinking Water Quality

3.0 Chapter Overview

Water quality can be grouped into three general categories: biological; chemical; and physical. Biological characteristics include the presence of organisms (viruses, bacteria, algae, & other microscopic organisms) alive or dead, and their metabolic products. Chemical characteristics include mineral content, pH, and hardness. Physical characteristics include color, turbidity, temperature, taste and odor. To be suitable for human use, water should be free from all impurities which are offensive to the senses of sight, taste, and smell and MUST be made free from disease-causing (pathogenic) organisms.

Groundwater is a "naturally protected" underground source less likely to become polluted than surface water. Groundwater typically has higher concentrations of dissolved minerals and lower turbidity than **surface water**. The type and concentration of dissolved minerals in groundwater can affect its usefulness for various purposes. If certain mineral constituents are present in excessive amounts, some type of treatment may be necessary to either change or remove the dissolved mineral before the water can be used. Most groundwater contains no suspended particles and practically no bacteria or organic matter. It is usually clear and odorless. These characteristics contrast with surface waters, which generally contain suspended matter and considerable amounts of bacteria.

3.1 Biological Characteristics

Microbial contaminants such as **bacteria**, **viruses**, and **microscopic organisms** pose the greatest health risk challenge for water system owners and operators. Mild to moderate illness lasting days to weeks can result from exposure to microbial **pathogens**. Most serious health problems, even death, can result when people with weakened immune systems are exposed to pathogens. Microbial pathogens are present in human and animal feces, which can, in turn, contaminate drinking water.

3.1.1 Coliform Bacteria

Bacteria found in water, such as **coliform**, salmonella, Legionella, and **E. coli**, are generally attributed to human and animal wastes. The **total coliform** group of bacteria are found nearly everywhere in the environment, except in clean water. While most forms of coliform bacteria are harmless, their presence in drinking water can indicate that either the water source or the distribution system has been contaminated by an external source.

Specific types of coliform bacteria reside in the digestive tracts of humans and many animals and the presence of coliform bacteria, specifically E. Coli (a particular type of coliform bacteria), in water is an indication that fecal matter is present, even if in small quantities. This is cause for concern because pathogenic bacteria may also be present in the water. The pathogenic bacteria are almost impossible to test because they represent only a small proportion of the total bacteriological count. The greatest proportion of intestinal bacteria is the coliform group and tests for the presence of coliform bacteria are relatively simple and inexpensive.

If the water is being disinfected on a continual basis, the presence of the "**indicator**" bacteria (coliform) may indicate that water treatment system is not working properly. In these cases, disinfection equipment repair, flushing or upgrading the distribution system, and enacting a source water protection program may be necessary.

Viral infection of drinking water supplies is another major concern in the protection of public health. Examples of waterborne viruses include enterovirus, rotovirus, and hepatitis. As with bacteria, the presence of viruses in drinking water may be associated with human wastes. If viruses are detected, immediate steps must be taken to rectify the problem.

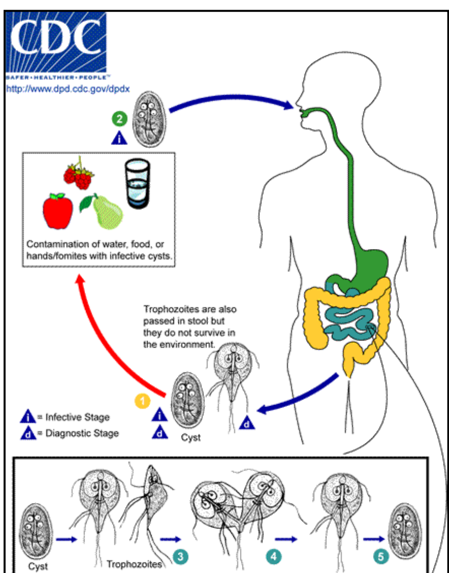


Figure 3.1 Giardia Life Cycle

Although most disease causing microscopic organisms, or **protozoa's**, are not naturally found in water, they can survive in water for a period of time. Examples include **Giardia** and **Cryptosporidium**. These organisms are **parasites** that enter lakes and rivers through sewage and animal wastes, but unlike most bacteria & viruses, they can be particularly difficult to detect and treat in drinking water. Cryptosporidium **spores** are resistant to chlorine and both parasites can easily pass through inefficient filtration devices. Proper disinfection and/or filtration, system maintenance, and regular system upgrades are essential to protecting human health from these pathogens.

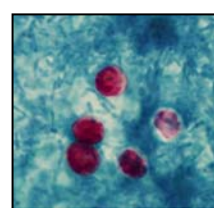


Figure 3.2 Cryptosporidium

Bacteriologic and protozoan pathogens are known to cause typhoid, dysentery, cholera, and some types of **gastroenteritis**. Viruses can cause human maladies including polio, infectious hepatitis, and some forms of gastroenteritis.

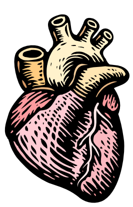
3.2 Chemical Characteristics

Several chemical aspects of water are significant. Calcium and magnesium cause **hardness** in water. Alkalinity is important for corrosion control. Iron and manganese may cause staining of clothes and of plumbing fixtures. Chlorides cause the water to taste salty. Excessive amounts of fluoride may cause staining (mottling) of children's teeth (however in lower concentrations of about 1 ppm it may help to prevent cavities). Nitrates and nitrites are an indication of chemical fertilizer pollution and can be very harmful to infants by causing a condition known as "blue babies". Some chemicals taken over long periods of time or in high concentrations such as arsenic can cause cancer. Minerals and chemicals such as mercury, lead, copper, volatile organics, pesticides, and herbicides can also cause serious health effects.

The chemical characteristics of water can be broken down into two main groups: organic & inorganic. Organic chemicals are carbon based, whereas inorganic chemicals are not. Organic chemical characteristics in water come from the breakdown of naturally occurring materials, introduction of contaminants from human activities, and the reactions that occur during water treatment and distribution. The most common organic chemicals come from the breakdown of natural materials such as leaves and plants, aquatic decomposition, and other natural by-products. Inorganic chemicals are mostly human made solvents, pesticides, herbicides and other commercial and industrial products and may also be found in drinking water sources if the source is not properly protected.

3.2.1 Nitrates & Nitrites

Nitrates often reach the groundwater due to a breech in well construction or a leaching of farming and lawn fertilizers down to the drinking water aquifer. The decomposition of septic waste is also a common source of high nitrates. The presence of nitrates may be especially harmful to those with potential respiratory impairments including the elderly or young children (less than 6 to 12 months old).



Nitrates may be transformed into nitrites by bacteria in the digestive tract and may then be absorbed into the blood stream. In infant digestive systems, there is insufficient hydrochloric acid to kill nitrite-producing bacteria. Nitrites in the blood inhibit the transport of oxygen in the blood stream, which can cause shortness of breath, heart attacks or asphyxiation. Because the condition can create a bluish skin color, it is called "**blue baby syndrome**" (**methemoglobinemia**). High nitrate levels are commonly treated with ion- exchange or reverse osmosis systems. Boiling water <u>*increases*</u> the nitrate concentration.

3.2.2 Arsenic

Arsenic is a semi-metal element in the periodic table. It is odorless and tasteless. Arsenic occurs naturally in rocks and soil, water, air, and plants and animals. It can be further released into the environment through natural activities such as volcanic action, erosion of rocks and forest fires, or through human actions. Approximately 90 percent of industrial arsenic in the U.S. is currently used as a wood preservative, but arsenic is also used in paints, dyes, metals, drugs, soaps and semi-conductors. High arsenic levels can also come from certain fertilizers and animal feeding operations. Industry practices such as copper smelting, mining and coal burning also contribute to arsenic in our environment.

Higher levels of arsenic tend to be found more in ground water sources than in surface water sources (i.e., lakes and rivers) of drinking water. The demand on ground water from municipal systems and private drinking water wells may cause water levels to drop and release arsenic from rock formations.

Non-cancer effects can include thickening and discoloration of the skin, stomach pain, nausea, vomiting; diarrhea; numbness in hands and feet; partial paralysis; and blindness. Arsenic has been linked to cancer of the bladder, lungs, skin, kidney, nasal passages, liver, and prostate.

Soluble, inorganic arsenic exists in either one of two valence states depending on oxidation-reduction conditions. If arsenic is found in groundwater, it is typically non-oxidized and is in a trivalent form called ***arsenite*** or ***As (III)***. Surface water has aerobic conditions and arsenic is found in its ***arsenate*** or oxidized pentavalent form, ***As (V)***.

3.2.3 Corrosiveness

Corrosivity is a complex characteristic of water related to pH, alkalinity, dissolved oxygen, total dissolved solids, and other factors. Corrosive water, in addition to dissolving metals (corrosion of toxic metal pipe materials such as lead can create a serious health hazard) with which it comes in contact, also produces objectionable stains on plumbing fixtures. Corrosivity can be a naturally occurring property that may be controlled by pH adjustment or the use of chemical stabilizers.

3.2.4 Dissolved Solids

The total concentration of dissolved minerals in water is a general indication of its suitability for use. Groundwater high in dissolved solids should be viewed as potentially corrosive to well screens and other parts of well structures, regardless of other chemical characteristics of the water. Excessive amounts of dissolved solids will adversely affect the disinfection ability of chlorine and may have a bad taste to it. Solid particles in surface water may be the cause of high turbidity which may have adverse affects on drinking water quality.

3.2.5 Hardness

Hardness is a characteristic of water caused mainly by the salts of calcium and magnesium and can cause **aesthetic** problems. They react with soap & produce a deposit called "soap curd" that remains on the skin and clothes and, because it is insoluble and sticky, cannot be removed by rinsing. Soap curd changes the pH of the skin & may cause infection & irritation. It also remains on the hair making it dull and difficult to manage. Soap curd picks up the dirt from laundry water and holds it on cloth, contributing to a gray appearance of white clothes, causes a ring around the bathtub and spotting on glassware.

Excessive hardness causes deposition of scale in pipes & equipment, damage in some industrial processes, and it sometimes causes objectionable tastes in drinking water

3.3 Physical Characteristics

3.3.1 Aesthetic Issues

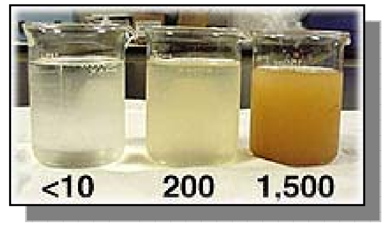
Unpleasant appearance, odor, or taste may be of concern for water systems. Some major groundwater constituents that may cause aesthetic problems if in excess include: silica, sulfate, sodium, chloride, magnesium, calcium, iron, and manganese. For example, excessive iron causes a "rust stain" and a potential for iron bacteria growth, too much sulfate causes a "rotten egg odor", and high levels of sodium will give water a salty taste. Surface water sources may also contain substances that are aesthetically unappealing which may be eliminated from the water through treatment. Aesthetic problems may also indicate possible health hazards or the potential for reduced operating efficiency of well equipment; and therefore should not be ignored.

3.3.2 Taste and Odor

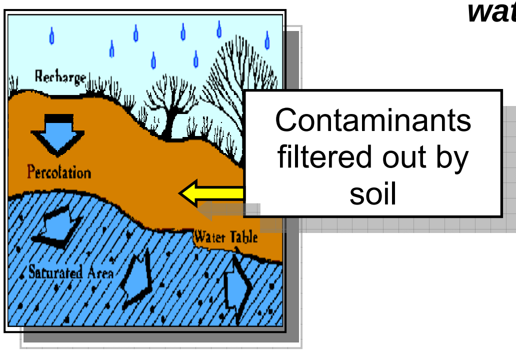
Taste and odor can affect the quality of water by tainting certain foods and vegetables and by reducing the palatability of foods cooked in water. The main sources of odor- and taste-bearing substances are harmless organic materials like iron bacteria, and certain inorganic chemical constituents such as hydrogen sulfide. Most taste and odor problems are solved by eliminating the substances that cause the problem. Treatment techniques include activated carbon filtration and/or oxidation using chlorination, potassium permanganate, ozonation or aeration.

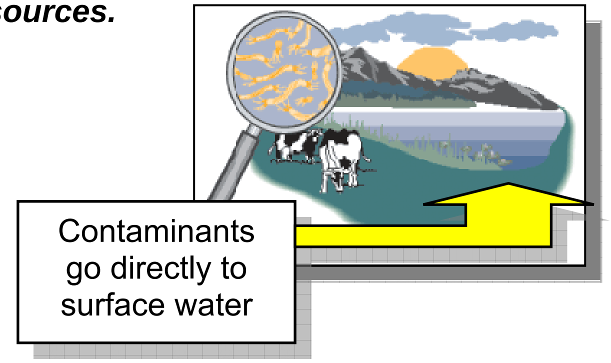
3.3.3 Turbidity and Color

Turbidity is a visual haziness in water caused by the presence of insoluble suspended particles. Generally, turbidity is more common in surface water than groundwater because groundwater moves too slowly to carry particles of sediment. Turbidity is undesirable for health as well as for aesthetic reasons because turbidity can interfere with disinfectants by providing a hiding place for microorganisms.



Overall, the water quality of groundwater tends to be better than surface water sources.





CHAPTER 4
Water Quality Monitoring

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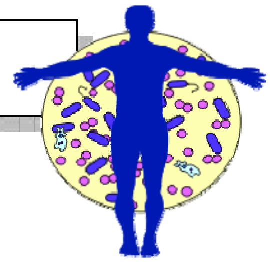
Water Quality Monitoring



4.0 Chapter Overview

Groundwater is not "pure" water as it naturally contains some impurities. The cycle of water from precipitation, streams, lakes, etc. filters through layers of soil and rock in the ground, dissolving or adsorbing the substances it touches. Some substances are harmless; however, at certain levels minerals and man-made chemicals or wastes are considered contaminants that can make water unpalatable or even unsafe.

Although groundwater is typically a safe source of drinking water and actual events of drinking water contamination are rare, contaminants can enter the drinking water supply if any of the protective barriers are breeched. Heightened public awareness, concern for public health, and advancements of technology are factors behind legislative action to set national standards regarding the levels of contaminants in drinking water. Facility owners and operators need to be familiar with state and federal laws and standards that apply to the PWS industry. Water quality monitoring has an important role in identifying breeches in the system that may threaten the safe and aesthetically pleasing water to its consumers, however, it is important to understand that a water sample is just a "**snapshot in time**" and one non-detect result does not necessarily indicate that the water supply is in compliance or free of contaminants.

Surface waters are obviously subject to many contaminants and must be treated to remove contaminants that are harmful to public health if used for drinking purposes.

This chapter explains monitoring and reporting requirements for NCWS systems.

4.1 Types of Contaminants

The types of contaminants that are monitored in the public drinking water program include both **acute** and **chronic** contaminants.

4.1.1 Acute Contaminants

Acute contaminants may have the potential to pose an immediate health risk if consumed. ***All public water systems must monitor for acute contaminants.*** E. coli bacteria, cryptosporidium, giardiasis, and nitrate are examples of acute contaminants.

4.1.2 Chronic Contaminants

Certain contaminants may cause cancer or other ill health effects when consumed at relatively low concentrations over extended periods of time. These types of contaminants may cause chronic health problems. Examples include arsenic, benzene, atrazine, and lead. ***Chronic contaminants are monitored only at NTNC and community water systems because people served by these systems may consume the water for extended periods of time.***

4.2 Maximum Contaminant Level (MCL)

MCLs are established by the United States Environmental Protection Agency (USEPA) for regulated contaminants. **The MCL is the greatest amount of a particular contaminant allowed in drinking water.** This is a standard set by USEPA and enforced by local health departments contracted with the DEQ. "National Primary Drinking Water Standards" are those established by the EPA for contaminants that affect public health, and MCL's are assigned to these based on scientific research. Contaminants that are based on aesthetic effects only are not enforceable and are called "Secondary Drinking Water Standards" by the EPA. Secondary contaminants include substances such iron, manganese, and sulfate. If a water sample exceeds the **MCL**, it is a violation of the SDWA and precautionary measures, along with re-sampling, must be conducted at the facility.

4.3 Action Level (AL)

An AL is a contaminant concentration that if reached in a certain percentage of samples requires specified actions by the public water supply. Lead is an example of a contaminant assigned an AL rather than an MCL.

4.4 Water Quality Standards

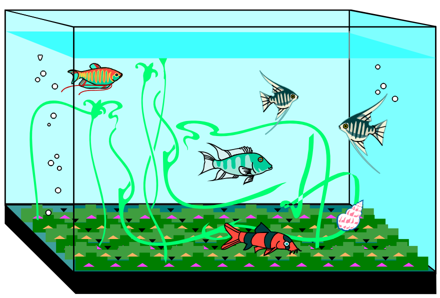
There are potentially thousands of different contaminants that could find their way into drinking water systems that may be harmful to health. It is impractical to attempt to test for all possible contaminants. Priorities for testing are determined, in general, by the federal government which decides which contaminants to monitor based on national occurrence data, health effects and technology. The EPA has set standards for more than 80 contaminants that may occur in drinking water and pose a risk to human health. EPA sets these standards to protect the health of everybody, including vulnerable groups like children.

The contaminants that the EPA established enforceable standards for are also called ***Primary Standards.*** There are other substances that the EPA has set ***Secondary Standards*** for based on aesthetic effects only. These are not enforceable; however they may be used in establishing health advisories as needed. (See ***Appendix C-1*** for EPA Primary & Secondary lists or www.epa.gov/safewater/contaminants/index.html).

4.5 Routine Monitoring

The **owner** of a public drinking water supply system is responsible for making sure **all** required water samples are *collected* and *reported* to the LHD in a timely manner. The owner may delegate the sampling to any qualified person such as a certified operator. All procedures must be strictly followed when collecting samples and sending them in for analysis. If the sample is not taken in the proper location, if specific techniques are not followed, if the paperwork is missing information or found with inaccurate information, or if the sample is not analyzed by a certified state laboratory, the sample results will be rejected by the regulatory agency and enforcement actions may be taken.

Sampling requirements are tied to the classification, population served, source of water, past sample results, vulnerability of the water supply, and results of the last **sanitary survey**. Reduced sampling requirements may be authorized by the LHD if a sanitary survey is conducted at least every five years and the survey results in a compliant PWS.



It is important to understand that a water sample is only a ***VERY SMALL PART*** of the total water supply and is ***NOT*** a protective barrier. Just because a water sample result is non-detect for a contaminant, does not necessarily mean the water supply is completely safe. It is like dipping a net into a fish tank without looking, sometimes the net catches fish, and sometimes it does not!

4.5.1 Samples Required for Transient and Nontransient Facilities

All noncommunity PWS's are required to sample on a routine frequency for **Coliform bacteria**, **Nitrates**, and **Nitrites.**

4.5.2 Additional Samples Required for Nontransient Facilities

NTNC's are required to also sample for arsenic, complete metals, lead and copper, volatile organic chemicals (VOC's), synthetic organic chemicals and cyanide on routine frequencies. On a case by case basis, TN's may be required to sample for any of these if the LHD determines it is necessary for public health reasons.

4.5.3 Reading and Understanding Lab Results

After the laboratory staff has analyzed the water samples, they will mail you the results for your water system. You will be called if there is an immediate problem with your water system, such as the presence of coliform bacteria that would require you to take immediate action. If any water sample result exceeds the "primary standard", an **MCL** occurs and precautionary measures must be immediately put in place. If you have questions about your water test results, contact your LHD representative.

4.6 Total Coliform Rule (TCR)

The TCR establishes an MCL based on the presence or absence of total coliform bacteria, modifies monitoring requirements including testing for fecal coliforms or E. coli, requires use of a sample siting plan, and also requires sanitary surveys for systems collecting fewer than five samples per month.

4.6.1 Coliform Bacteria

Although it is not a common occurrence, disease causing bacteria, viruses, and protozoa can sometimes find their way into drinking water supplies and cause human illness. If these disease causing organisms, or pathogens, make it into the drinking water supply, they typically occur at very low levels and are not easily identified with laboratory testing. This makes testing of pathogens difficult and very expensive. For these reasons, the standard approach for identifying microbiological contamination is to look for "**indicator organisms**" called **coliform bacteria**. Coliform bacteria quickly and inexpensively give an indication that disease-causing organisms may be present.

Coliform bacteria are present in great numbers in human and animal waste, soil, and surface water. While coliform bacteria themselves pose little health risk, their presence of the organism in drinking water indicates potential for other harmful disease causing organisms having entered the water supply. Routine testing for coliform is required. Repeat sampling is required if a routine test indicates the presence of the organism. If repeat testing confirms the presence of coliform, an alternate source of water must be supplied until the problem has been solved and the public must be notified.

Coliform bacteria cannot be detected by direct sight, smell or taste.

4.6.2 Pathogenic Bacteria

Bacteria of many kinds occur in both soil and surface water. One group, not commonly found in soil or water, are the **fecal coliforms**, which reside in high numbers in the digestive tract of all warm-blooded animals. Because they prefer the animal system, fecal coliforms typically survive less than four days in soil or water. While ground water generally contains bacteria, it should not contain any fecal coliform. When fecal coliforms are found, it suggests surface water or some waste source has directly entered the water supply because a breach or malfunction has occurred somewhere in the drinking water system. Since surface water receives frequent inputs from many sources, fecal coliforms are common and indicate recent contamination.

When water supplies contain coliform bacteria in levels greater than one per 100 ml of water (a bacteriological sample **MCL**), the water may also contain pathogens that cause acute intestinal infections. While generally considered to be a discomfort to health, these infections can prove fatal for infants, the elderly and those who are ill. Water-related disease outbreaks tend to occur in the summer. Although rarely encountered today, typhoid, hepatitis and cholera, can spread through water supplies. Other sources, besides water, also transmit these diseases.

The presence of **E. coli** or **fecal** coliform is a more serious situation than the presence of total coliform alone. E. coli or fecal coliform presence indicates that human or animal fecal material has contaminated the water system and any ingestion of this water poses a serious health threat.

The water must not be consumed in any way.

The public water system needs to act promptly, notify the public, restrict the use of water, and provide an alternative water supply until the problem is corrected.

4.6.3 Routine Coliform Bacteria Sampling.

The Michigan SDWA has a table for Community water supply minimum number of coliform samples per month required per population served (Act 399 - Table 1 of Rule 10705). A noncommunity facility that serves more than 1,000 people or for which “complete” water treatment is required (Act 399 - Rule 10611), shall monitor at the same frequency as a like-sized community water system for coliform bacteria as specified on Table 1 on the following page.

A supplier using only groundwater not under the direct influence of surface water and serving fewer than 1,001 people shall monitor each calendar quarter that the system provides water to the public. However, the department may reduce the monitoring frequency to at least **once per year** for this type of noncommunity supply that has a satisfactory sanitary survey and sampling history.

Noncommunity water systems which do not collect 5 or more routine coliform bacteria samples per month must have a sanitary survey inspection every 5 years. Based on the results of each sanitary survey, the department shall determine whether the existing monitoring frequency is adequate, and what additional measures, if any the supplier shall take to improve drinking water quality (Act 399 – Rule 702). The water supplier may be required to collect monthly samples if a sanitary survey is not completed at least once every 5 years.

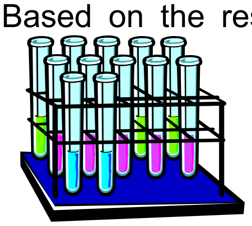
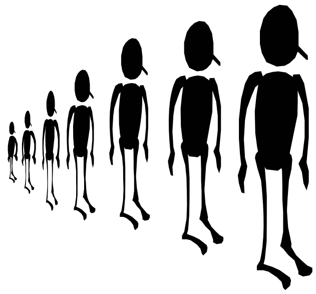
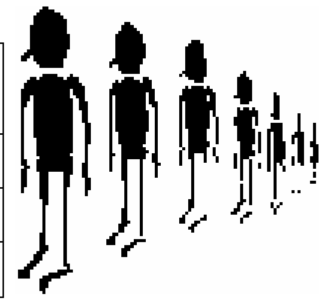


Table 4.1 – Bacteria Monitoring



Population Served	Samples per Month
25 to 1,000	1
1,001 to 2,500	2
2,501 to 3,300	3



4.6.4 Sampling Site Plan

A supplier of a NCWS shall collect samples for total coliform analysis at sites representative of the water throughout the distribution system according to a written sample siting plan that is subject to department review and revision. This written sample siting plan may be found in the most recent sanitary survey report.

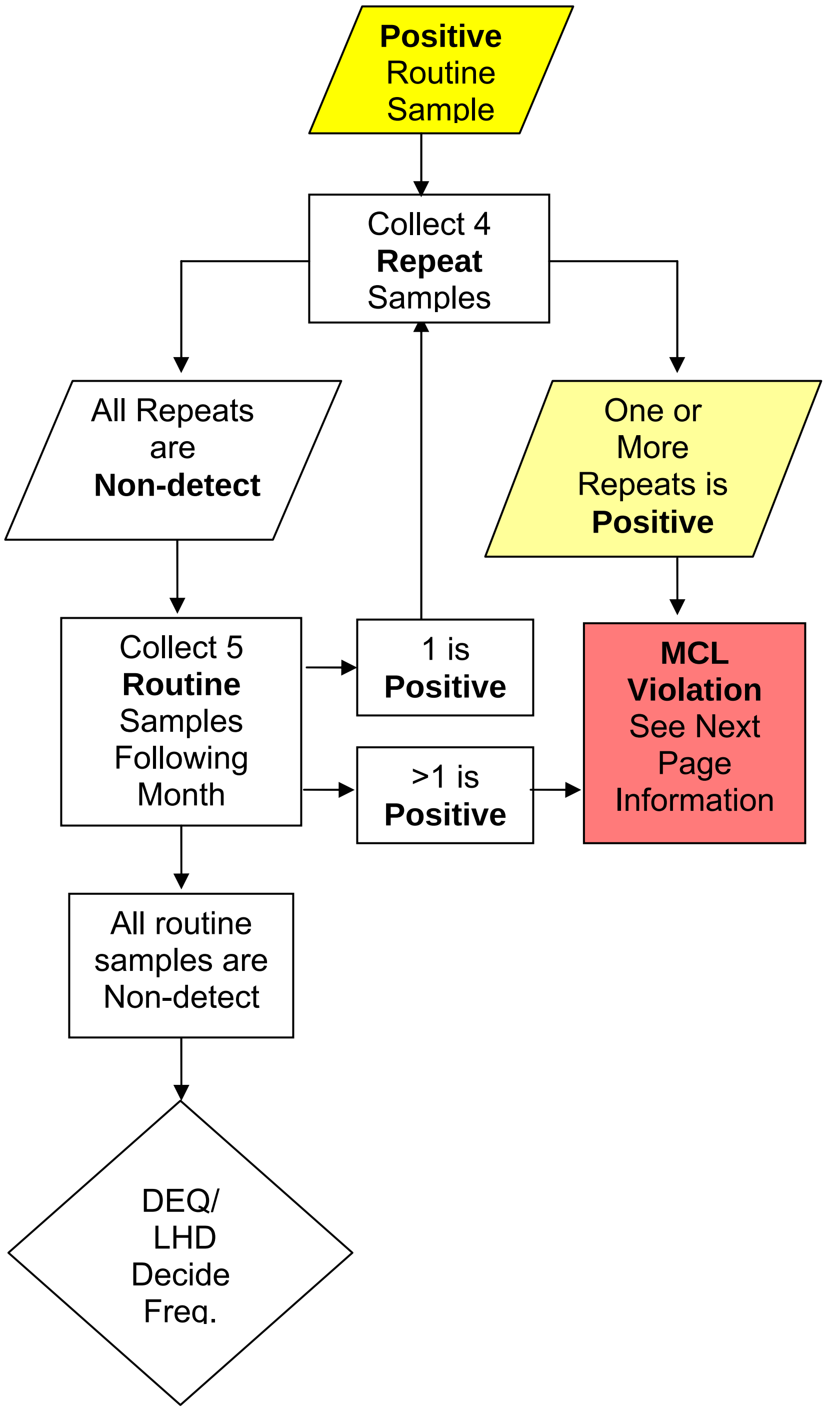
4.6.5 Repeat Coliform Bacteria Sampling

If a ***routine*** sample is total coliform-positive (constituting an **MCL**), the water supplier **must** collect a set of repeat samples within 24 hours of being notified of the positive result. A supplier that normally does not collect monthly samples must collect at least **4 *repeat*** samples within 24 hours pursuant to the sample siting plan provided by the LHD. If the repeat samples are non-detect for coliform bacteria, the supplier must collect **5 additional samples** during the next month. These samples should be labeled as ***ROUTINE*** samples on the laboratory Request for Analysis form. If the 5 samples are also non-detect for coliform bacteria and the local health agency determines the water system to be in compliance, they may reduce the routine monitoring frequency to quarterly.

For the 4 repeat samples; the supplier of water shall collect at least 1 repeat sample from the sampling tap where the original total coliform-positive sample was taken and at least 1 repeat sample at a tap within 5 service connections upstream and at least 1 repeat sample at a tap within 5 service connections downstream of the original sampling site (R 325.10707). A sample closest to the source water (well) is also recommended.

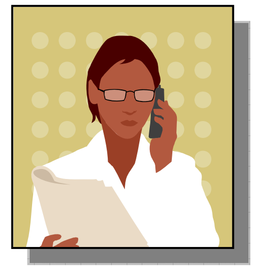
The flow chart on the next page shows the basic procedure the owner/operator needs to take if a routine sample is positive for coliform or E. coli bacteria.

Figure 4.1 – Flow Chart of Positive Bacteria Sample Procedure



4.6.6 Coliform Bacteria MCL Violation

When at least one repeat sample is positive for total coliform bacteria, or if ANY sample is positive for **fecal coliform**, a maximum contamination level violation (**MCL**) has occurred and the supplier **must** do all of the following:



1. Initiate an investigation to determine the extent of the problem, which may include the collection of additional samples.
2. Initiate precautionary measures and appropriate corrective actions as required by the local health agency until it is determined by the agency that the problem has been resolved.
3. Conduct additional sampling at a frequency approved by the agency until such time that it is determined the problem has been resolved. **<u>The water must not be consumed in any way.</u>** Water users should be aware of potential consumption risk through food preparation, making ice, brushing teeth and washing dishes.

4.6.7 Disinfection By-Products Rule (DBPR)

When a facility chemically feeds disinfectants to the water supply to oxidize arsenic or to kill bacteria, a "by-product" in the water may form. The USEPA established the DBPR in order to improve public health protection by reducing exposure to these disinfection by-products (DBPs) and, aims to reduce the risks associated with DBPs without increasing the risk of microbial contamination. The DBPs result from chemical reactions between chemical disinfectants and organic and inorganic compounds in source waters. Some disinfectants and disinfection by-products have been shown to cause some cancer and reproductive effects in humans.

Systems Affected:

- CWSs & NTNCWSs that add a chemical disinfectant to the water in any part of the drinking water treatment process or deliver water that has been disinfected.

- TNCWSs that use chlorine dioxide for treatment.

DBPR Sampling Requirements:

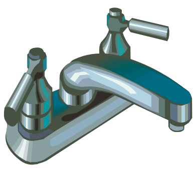
DBPR requires routine sampling for DBPs. Trihalomethanes are by-products of chlorination which include chemicals that may cause cancer in humans. These by-products include chloroform, bromodichloromethane, dibromochloromethane, and bromoform. They are formed when chlorine comes in contact with organic compounds in the water. Organic compounds primarily come from the decayed plant matter and are more likely to be found in surface water than in groundwater. ***See Table 4.1*** for a complete list of regulated contaminants/disinfectants and their MCLs and ***Table 4.2*** for general NCWS Primary Drinking Water Standards.

4.7 Chemical Contaminant Sampling

The noncommunity water supply owner and operator should consult with the LHD Type II Coordinator who will determine the chemical **analytes**, monitoring frequencies and number of samples required for that particular facility. Table 8.1 (Summary of Primary Drinking Water Standards) shows the normal monitoring frequencies for chemical sampling. If a PWS and water sampling history is in compliance with the SDWA, sampling for inorganic and organic chemicals will follow a specific **compliance period** as determined by the USEPA.

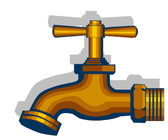
The monitoring frequency for **nitrates** is <u>annually</u> for all noncommunity water supplies.

4.7.1 Chemical Sampling Locations



Sampling locations for each regulated contaminant are assigned by the SDWA and the specific tap or faucet the sample is to be taken at is designated by the LHD official in the most recent sanitary survey or other correspondence.

Some chemical samples such as lead/copper samples, are to be collected from the water "**distribution**" system. This means they are collected from taps or faucets in the building(s) served by the water supply. Distribution sample points should be representative of water that is actually being consumed from the water supply.

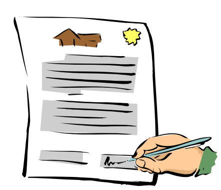


The majority of routine chemical samples, including nitrate/nitrites and the chemical group contaminants, are to be collected at the "**raw water tap**" or at the "**entry point**" to the distribution system representative of each well after treatment for water quality purposes.

4.8 Sampling Techniques

It is critical that the person collecting the water samples does not mistakenly contaminate the sample bottle and follows all procedures indicated on the laboratory sample instruction sheet. Failure to properly collect the sample may result in false sample results, public notification of contaminated water, and additional sampling requirements.

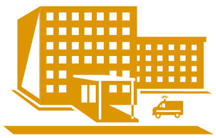
4.9 Laboratory Sample Forms



Forms to be submitted to the laboratory must be COMPLETED IN FULL and sent along with the sample for analysis.

IT IS OF UTMOST IMPORTANCE TO COMPLETE EVERY BLANK <u>PROPERLY</u>. Missing or incorrect information may result in laboratory confusion for reporting purposes, non-analysis of the sample, and regulatory problems as well as future confusion with water quality analysis history.

4.10 Certified Laboratories



All public drinking water samples required by law must be sent to a laboratory certified by the State of Michigan. Samples can be submitted to the State of Michigan Laboratory or a certified private lab. The DEQ State Laboratory has a listing of all certified labs.

4.11 Water Sample Results

After the laboratory has analyzed the water sample(s), they will mail the results to the owner of the facility. The facility will also be immediately contacted if there is a problem with the water quality that would require immediate action. It is the owner's responsibility to make sure the regulatory agency has a copy of the water sample results. The State Lab automatically sends results to the LHD and posts the results in the noncommunity program database. Other, private labs that are certified by the State, may not report the results to the regulatory agency, therefore making it the owner/operators responsibility. ***See Appendix D*** for laboratory report examples.

4.12 Summary of Noncommunity Standards

Table 4.1 DBPR Regulated Contaminants/Disinfectants*

Contaminant or Disinfectant	Maximum Level Allowed in mg/L
1. Total Trihalomethanes (TTHM) - Chloroform - Bromodichloromethane - Dibromochloromethane - Bromoform	**0.080**
2. Haloacetic Acids (HAA5) - Monochloroacetic acid - Dichloroacetic acid - Trichloroacetic acid - Bromoacetic acid - Dibromoacetic acid	**0.060**
3. Bromate (facilities that use ozone)	**0.010**
4. Chlorite (facilities that use chlorine dioxide)	**1.0**
5. Chlorine	**4.0 as Cl_2**
6. Chloramines	**4.0 as Cl_2**
7. Chlorine dioxide	**0.8**

***Refer to the SDWA Rule 610 for specific DBPR sampling requirements. Applies to Nontransients using chlorine or ozone.**

Table 4.2 Summary of Primary Drinking Water Standards:

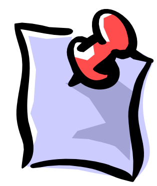
Contaminant	MCL or AL	Source(s)	Health Risks	Monitoring Frequency*
Bacteria (Microbiological)	Confirmed **Presence** of Coliform Bacteria or E.coli	Naturally occurring in environment, human & animal wastes	Acute	Monthly, Quarterly, or Annual
Nitrate (Inorganic)	**10** milligrams per liter (mg/l)	Animal wastes & fertilizers	Acute	Annual Increased monitoring to quarterly based on elevated results
Arsenic (Inorganic)	**10** micrograms per liter (ug/l)	Naturally occurring mineral in soil & bedrock	Chronic	GW systems- every 3 yrs. If initial is <5 SW systems- Annual if <5
Lead & Copper	Lead = **15** micrograms per liter (ug/l) Copper = **1300** micrograms per liter (ug/l)	Brass fixtures, solder in plumbing, & lead pipes	Chronic	2-consecutive 6 month samples then Annual then 3 yr.
Inorganic Chemicals (IOC's)	**Specific for each contaminant	Metals, salts, etc.	Chronic	1 every 3 years
Synthetic Organic Compounds (SOC's)	**Specific for each contaminant	Compounds used for industrial & agricultural purposes	Chronic	Begins quarterly & reduced based on historical monitoring & source vulnerability
Volatile Organic Compounds (VOC's)	**Specific for each contaminant	Compounds used for industrial & manufacturing purposes	Chronic	Begins quarterly & reduced based on historical monitoring & source vulnerability

*Additional monitoring may be required if contaminants are detected at elevated levels. Reduced monitoring is based on a history of samples below the MCL.
**See the SDWA for specific MCLs.

4.13 Follow-up Monitoring & Corrective Action

When a contaminant is found in the drinking water additional monitoring may be required. If the follow-up monitoring indicates that a particular contaminant exceeds the established MCL, the owner/operator will be required to take corrective actions. The LHD staff should be contacted immediately by the owner/operator for consultation on this matter and provide an alternate source of drinking water to the public until the supply is known to be safe.

4.14 Public Notification



If a PWS fails to meet or comply with requirements regarding an applicable MCL, it must notify the public and provide an alternate source of safe drinking water until the problem has been corrected.

A **Public Notice** warns all potential users of the water supply that the water has been found to be in violation of the SDWA. The notice must include possible health effects from consuming the water and the location where safe water is available if the system is required to provide an alternate source of water. For many public water supplies, an acceptable method of providing public notification is to post warning signs at all potential drinking water taps.

Specific health effects language is required on the public notice. The LHD staff will have the appropriate notice for the contaminant with the MCL. ***Appendix E*** shows some example public notices.

Public Notices MUST remain in place for as long as the violation or situation exists, but not for less than 7 days, even if the violation or situation is resolved.

Michigan Safe Drinking Water Act

Public Notification and Public Education information:

Part 4, Rule R 325.10401 through R 325.10420

Specific language for each contaminant found on Table 1 in Part 4

4.14.1 Public Notice - Timing & Distribution

NCWS owners/operators must notify persons using the water **AND** the LHD staff working as the noncommunity program coordinator **within 24 hours** when notified of the violation. **Immediate** action to do what is needed to prevent consumption of the water and notification of the public by posting a Public Notice at all water outlets that may be used for consumption is required to protect public health.

Immediate posting of a public notice is required for the following violations:

Fecal coliform
Nitrate
Chlorine dioxide
Turbidity
Waterborne disease outbreak or other waterborne emergency
Other violations or situations determined by the primacy agency

Public Notices are also required when an MCL occurs, the failure to collect the proper water quality samples on time (monitoring violations) and treatment technique violations occur. The LHD may also require a public notice upon failure to comply with variance and exemption conditions.

4.14.2 Contents of a Public Notice

Unless otherwise specified in the regulations, each notice must contain:

1. A description of the violation including contaminant levels

2. When the violation occurred

3. Any potential adverse health effects
(use language from SDWA Table 1 Regulated contaminants of the public notification rule 405)

4. The population at risk

5. Whether alternative water supplies should be used (or bottled water)

6. What actions consumers should take

7. What the system is doing to correct the violation

8. When the water system expects to return to compliance or resolve the issue

9. The name, business address, and phone number of the water system owner or operator

10. A statement encouraging distribution of the notice to others, where applicable

4.15 Monitoring Requirements for Surface Water Sources

The Surface Water Treatment Rule (SWTR) relates to PWS's using surface water sources or ground water sources under the direct influence of surface water. These systems are also referred to as "subpart H" systems in parts 7, 9 and 10 of the SDWA (reference to surface source filtration and monitoring).

4.15.1 Specifics of the SWTR/Subpart H Systems

The SWTR includes:

1) Criteria under which filtration is required and procedures by which the States are to determine which systems must install filtration; and
2) Disinfection requirements.

Pathogens, such as ***Giardia*** and ***Cryptosporidium***, are often found in surface water, and can cause gastrointestinal illness (e.g., diarrhea, vomiting, and cramps) and other health risks. In many cases, this water needs to be filtered and disinfected through the use of additives such as chlorine to inactivate (or kill) microbial pathogens.

Cryptosporidium is a significant concern in drinking water because it contaminates surface waters used as drinking water sources, it is resistant to chlorine and other disinfectants, and it has caused waterborne disease outbreaks. Consuming water with Cryptosporidium can cause gastrointestinal illness, which may be severe in people with weakened immune systems (e.g., infants and the elderly) and sometimes fatal in people with severely compromised immune systems (e.g., cancer and AIDS patients).

The USEPA further developed the **Long Term 2 Enhanced Surface Water Treatment Rule (LT2 rule)** to improve drinking water quality and provide additional protection from disease-causing microorganisms and contaminants that can form during drinking water treatment. The rule provides a higher level of protection of the drinking water supply than the original SWTR by:

1) Targeting additional *Cryptosporidium* treatment requirements to higher risk systems.

2. Requiring provisions to reduce risks from uncovered finished water storage facilities.

3) Providing provisions to ensure that systems maintain microbial protection as they take steps to reduce the formation of disinfection byproducts.

This combination of steps, combined with the existing regulations, is designed to provide protection from microbial pathogens while simultaneously minimizing health risks to the population from disinfection byproducts.

4.16 Retention of Records

A supplier of a Noncommunity water system shall retain, on its premises or at a convenient location near its premises certain records and documents for a prescribed amount of time according to the ***SDWA Rule 1506***. These records include items such as: bacteriological and chemical sample results; records of action taken by the supplier to correct violations of the state drinking water standards; copies of any written reports, summaries, or communications which relate to sanitary surveys of the public water supply and which were conducted by the public water supply itself, by a private consultant, by the division, or by any local, state, or federal agency; records that involve a variance or an exemption that was granted; records that involve any emergency or public notification; and systems that employ conventional filtration or direct filtration treatment must retain certain filter and flow information.

Table 4.3 RETENTION OF RECORDS (SDWA – R325.11506)

Record to Retain	Time to Keep (not less than)
*Bacteriological analysis	**5 years**
*Chemical analysis	**10 years**
*Radiological analysis	**10 years**
Lead/copper corrosion control papers**	**12 years**
Action taken to correct violations	**3 years (after last action taken w/respect to viol.)**
Sanitary surveys***	**10 years**
Variances or exemptions	**5 years (after expiration date of either)**
Emergency or public notices	**3 years (after emergency or Public Notice)**

*Actual laboratory reports for chemical, bacteriological, and radiological analyses shall be kept; however, the analyses data may be transferred to tabular summaries if all the following information is included:

1. Date, place, & time of sampling & name of person sampling
2. Identification of the sample as a routine, check, raw or treated water sample, or other special purpose.
3. Date of analysis
4. Laboratory & person responsible for performing the analysis
5. Analytical technique or method used
6. Results

**Original records of all sampling data, analysis, reports, surveys, letters, evaluations, schedules, department determinations, or other info.

***Copies of any written reports, summaries, or communications which relate to sanitary surveys.

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CHAPTER 5
Groundwater Well Construction

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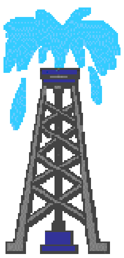
Groundwater Well Construction

5.0 Chapter Overview

Most water systems in Michigan have a well or wells meaning that they are using groundwater as a water source, to meet their water use needs. A basic understanding of drinking water well construction is essential for the operation and maintenance of the drinking water supply as well as protection of the source water and public health. This section refers to ***water supply wells***, or wells that are used to provide ***potable*** water for drinking or domestic purposes.

5.1 Well Construction



In order to get the water out of the ground, there has to be some method or device to do so. A "***well***" is a structure designed to withdraw water from the ground and is either a "drift" or "rock" well depending on what type of formation the casing terminates in. Because there is a direct opening from the surface down into the groundwater, it is of utmost concern to construct and maintain the well properly so the source water is not polluted. *C*leaning up a contaminated groundwater supply may be costly, complicated, and sometimes impossible to do therefore, the best way to guarantee clean and safe groundwater is to ***prevent*** contamination.

Safety of groundwater depends on:

1. Proper Selection of the well site
2. Good well design and construction
3. Geology

Depending on the depth to groundwater, the amount of water needed, and the water quality, wells can range from a few feet to thousands of feet deep. The methods used for constructing wells are dug, driven & drilled. ***A permit must be issued by the regulatory agency before the construction or alteration of any waterworks system can begin*** (Act 399, R325.1004). New wells must meet the minimum depth and isolation distances to potential contaminants as specified in chapter 2 of this manual and in the SDWA, Rules 807 – 813 and, in Michigan can only be installed by a Michigan licensed well driller.

5.1.1 Formations

A "***drift***" well terminates in a layer of water bearing sand and gravel, requires a screen to keep the sand out of the well & may include gravel pack around screen to increase capacity.

A "***rock***" well terminates in porous, water bearing limestone or sandstone, water enters the well through an open borehole below the casing & no well screen is required.

5.1.2 Types of Wells

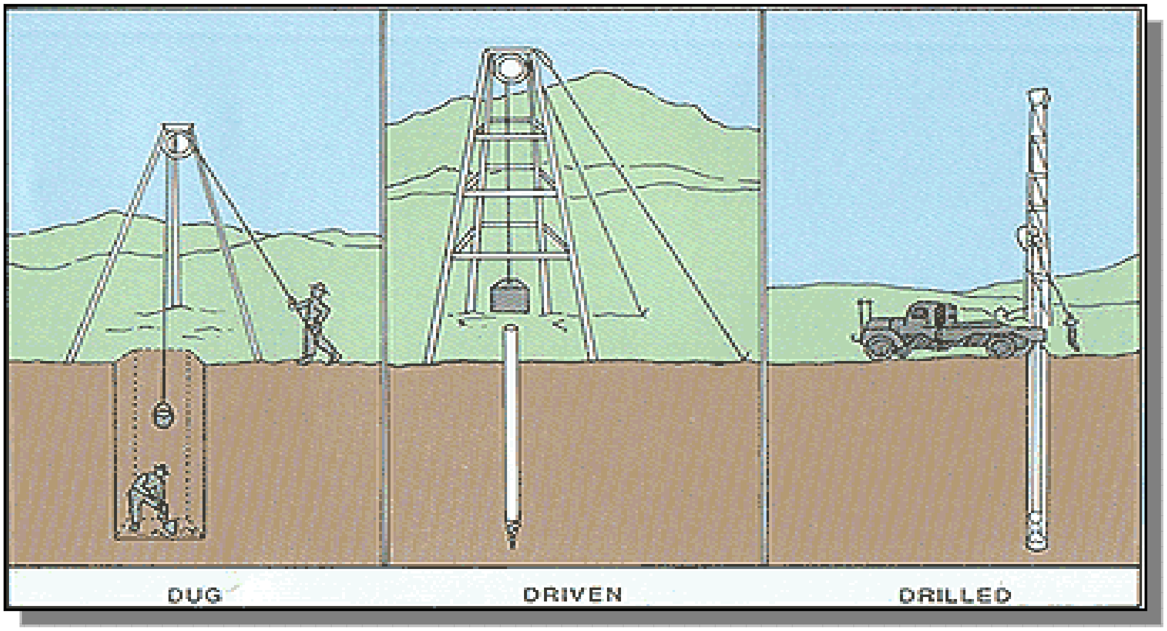
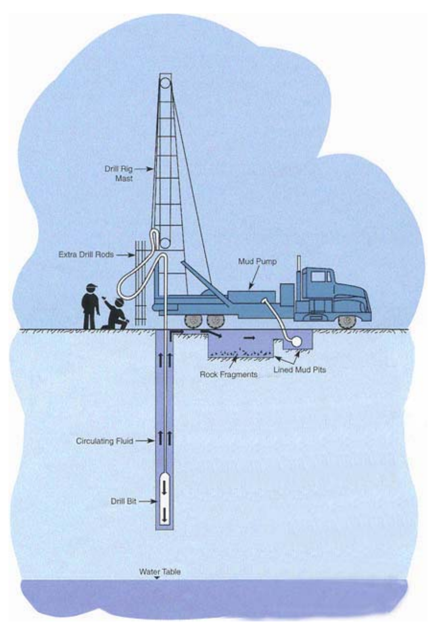


Figure 5.1- Types of Well Drilling Methods

5.1.3 Drilled Wells

Most wells in Michigan are constructed using a drilling method. Drilled wells are typically done with a "**Cable Tool**" well rig or a "**Rotary**" well rig (Figure 5.2).
The rotary method involves drilling a hole, installing steel or plastic casing and grouting around the casing to prevent entry of contaminants into the groundwater. A properly constructed drilled well provides good protection of the water supply source (*Minnesota Dept. of Health, 2002*).

Figure 5.2 – Rotary Rig



5.1.4 Water Well Record

The “**well log** report” is prepared by the driller and given to the well owner when the well is completed. In addition to routine address and well location information, the well log report describes each geologic stratum encountered, the various depth(s) where water was encountered, and the overall depth of the well. It also lists construction details such as casing type and size, perforation type and depth, screens used, grout and sealing methods, etc. Careful study will also reveal static water level, test pump rates, and drawdown. Interpretation of the data will help to determine whether the well is in a confined or unconfined aquifer, what the maximum pumping rate of the well should be, and other useful information.

The well log record should be kept on file at the facility. If the facility doesn’t have a record, they could contact the well driller who may keep a file of all the well log reports for the wells he has drilled. If a well log report cannot be found, have the well evaluated for static water level, depth of casing and total depth of well the next time the pump is replaced, or work is done on the well (i.e. bulk chlorination).

Well information is entered into a statewide database and each well record is given a unique identification number (Well ID).

Figure 5.3 - Example of a “Well Log”

DEQ

WATER WELL AND PUMP RECORD

Completion is required under authority of Part 127 Act 368 PA 1978.

Failure to comply is a misdemeanor.

Well ID: 47000005092

Import ID: 47017626401

Tax No: | Permit No: | County: Livingston | Township: Green Oak

Well ID: 47000005092

Fraction: SE¼ SE¼ SE¼ | Section: 24 | Town/Range: 01N 06E | French Claim: | WSSN: 2073447

Distance and Direction from Road Intersection: 2073447;1 COUNTRY ACRES VILLAGE

Elevation:
Latitude:
Longitude:

Well Name: 001
Well Owner: Country Acres Village

Well Address: 12596 TEN MILE RD SOUTH LYON MI 48178

Owner Address: 12500 TEN MILE RD SOUTH LYON MI 48178

Drilling Method: Cable tool
Well Depth: 54.00 ft. | Well Use: Type II public
Well Type: New | Date Completed: 10/24/1996
Casing Type: Steel - black
Casing Joint: Threaded & coupled
Diameter: 6.00 in. to 48.00 ft. depth

Bore Diameter 1:
Bore Diameter 2:
Bore Diameter 3:
Height: 1.00 ft. above grade
Casing Fitting: Drive shoe

Static Water Level: 22.00 ft. Below Grade(Not Flowing)
Yield Test Method: Unknown
Measurement Taken During Pump Test:
42.00 ft. after 4.00 hrs. pumping at 40.00 GPM

Abandoned Well Plugged: No
Reason for not plugging Well:
Abandoned well ID:

Screen Installed: Yes Well Intake:
Filter Packed: No

Pump Installed: Yes
Pump Installation date:
Manufacturer: Red Jacket
Model Number:
Length of Drop Pipe: 999.00 ft.
Diameter of Drop Pipe:
Draw Down Seal Used: No

Pump Installation only: No
HP:
Pump Type: Submersible
Pump Capacity:
Id of Well:

Pressure Tank Installed: No
Pressure Tank Type:
Manufacturer:
Model Number : Tank Capacity : Gallons
Pressure Relief Valve Installed : No

Formation Description	Thickness	Depth to Bottom
Clay & Gravel	26.00	26.00
Sand Wet/Moist	2.00	28.00
Lithology Unknown	13.00	41.00
Sand Wet/Moist	13.00	54.00

5.1.5 Common Well Terminology

Static Water Level

Static water level is measured as the level water is standing in a well when no water is being removed from the aquifer.

Drawdown

Drawdown is a drop in the water table or groundwater when pumping is being pumped from a well. Drawdown is determined by the ability of the aquifer to replace the amount of water that is being pumped from the well. If there is an abundance of water in an aquifer and the water can move freely to the well, the drawdown will be fairly low, typical of sand, gravel, and bedrock formations. Conversely, if the water cannot move through the formation quickly enough to replace the water being pumped, the drawdown can be quite high (Wisconsin DNR).

Pumping Water Level

The pumping water level is where water stands in the well when pumping is in progress. The pumping water level is an indication of the amount of water that can be safely removed from the aquifer.

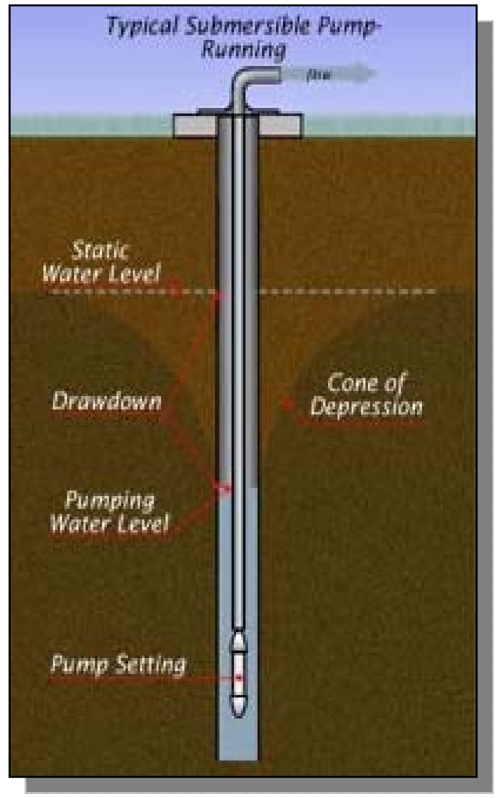


Figure 5.4 – Groundwater Terms

Cone of Depression

The cone of depression is a conical depression, around the well casing, of the water table produced when pumping occurs. The cone of depression defines the area of influence of a well and how far the well needs to be away from potential sources of contamination. It varies in size and shape depending on pumping rate, duration, aquifer characteristics, recharge conditions, etc.

Well Yield

Well yield is commonly referred to as the gallons of water that can be pumped per minute from the aquifer.

Specific Capacity

The specific capacity of a well is the rate of water that discharges from a well per unit of drawdown (usually feet). It is typically measured after 24 hours of pumping. The specific capacity decreases as pumping increases or pumping time increases. By tracking the specific capacity of a well over time, an operator can identify well & aquifer performance problems.

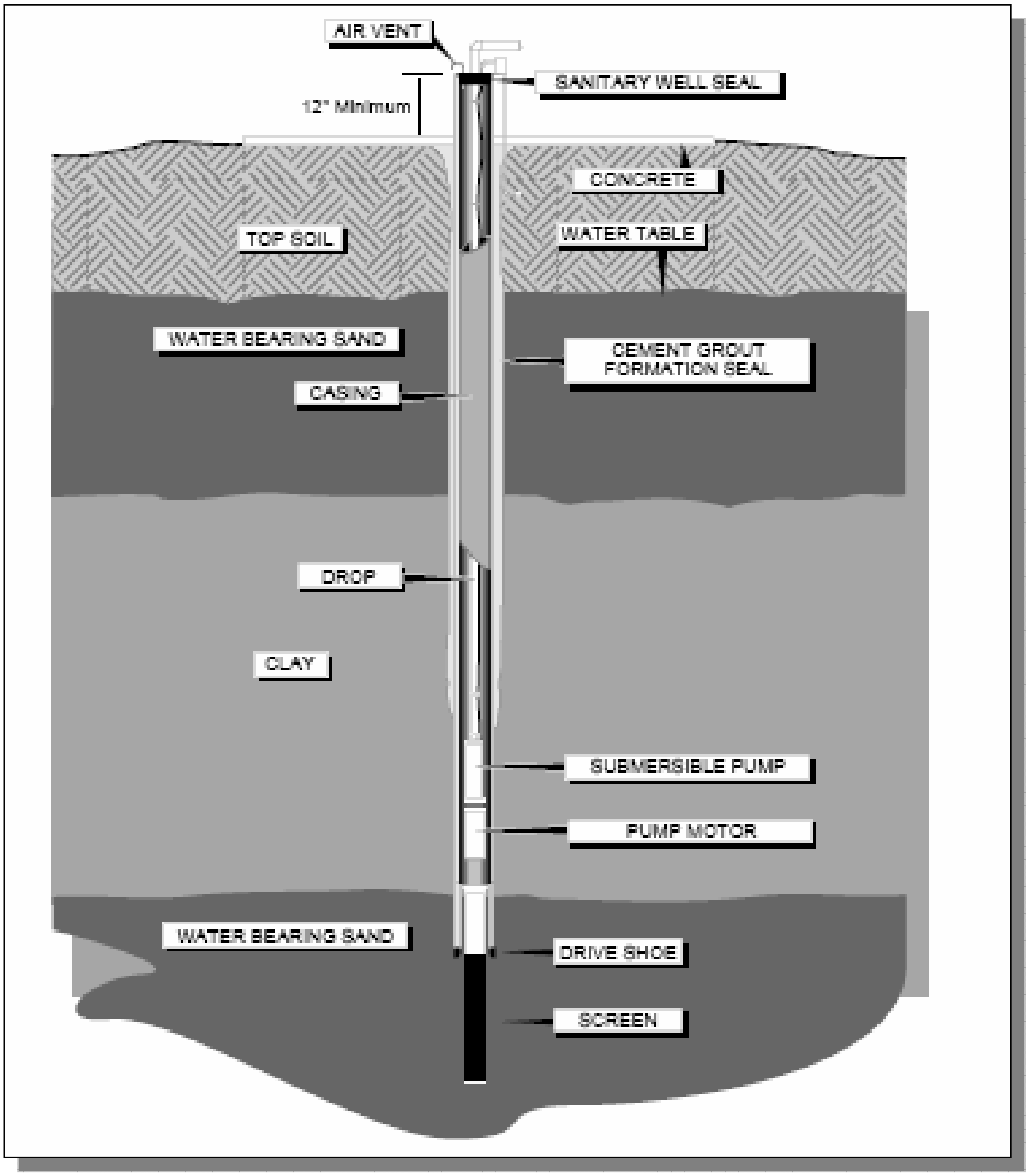


Figure 5.5   A submersible pump well cut away view.

5.1.6 Well Abandonment

The SDWA, refers to Part 127, of Act 1978 PA 368, Groundwater Quality Control Rules, for regulations of the abandonment of any well which; has its use permanently discontinued, is in such disrepair that its continued use for the purpose of obtaining groundwater is impractical, which has been left uncompleted, which is a threat to groundwater resources, or which is or may be a health or safety hazard.

5.1.7 Well Disinfection

Well disinfection is an important part of providing safe drinking water. If not done correctly, it is simply a waste of time and money. Michigan has specific rules for licensed well drillers to follow. ***Disinfection of a noncommunity drinking water well must be completed only by a licensed well driller, pump installer, or Master Plumber..***

CHAPTER 6
Water Supply Equipment

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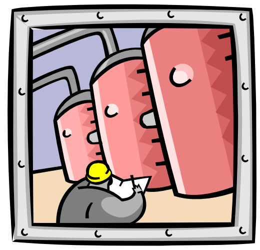
Water Supply Equipment



6.0 Chapter Overview

The water supply system may be divided into the water source, (groundwater or surface water), the well and pump for groundwater sources or water intake structures for surface water sources, storage facilities, treatment facilities and the distribution system (the pipes which deliver water to consumers). If the water supply system and equipment are not being operated effectively and reliably, or if the equipment does not meet construction standards, the water served to consumers may not be pleasant tasting, safe to drink, or an adequate amount of water and pressure may not be available.

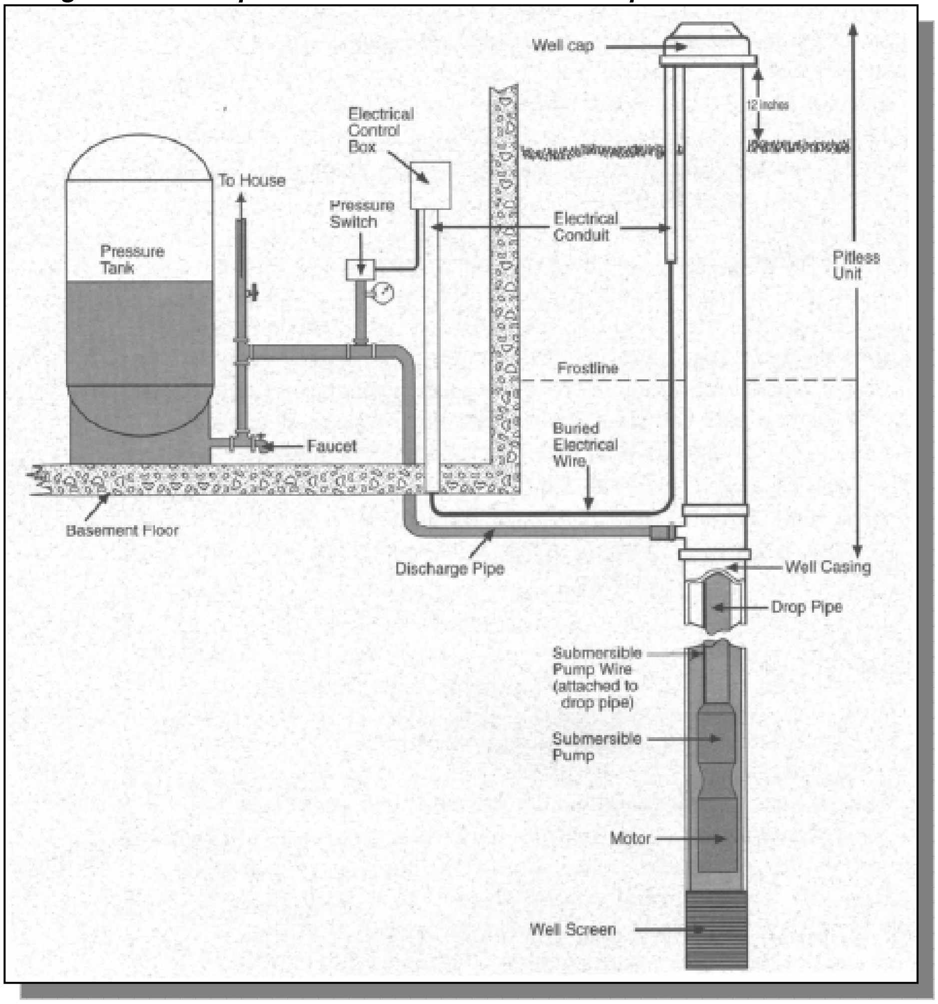
6.1 Equipment Standards

Water supply equipment must meet the Michigan Plumbing Code regulations and standards. Some examples of agencies that approve equipment standards are: The American National Standards Institute (**ANSI**), American Society of Mechanical Engineers (**ASME**), American Society of Sanitary Engineering (**ASSE**), ASTM International (**ASTM**), and the National Sanitation Foundation (**NSF**). Products that contact water must be NSF 61 certified and chemicals injected into water supply must have NSF 60 certification.

6.2 Water Well Components

Properly designed and constructed wells minimize the risk of well water pollution by sealing the well from anything that might enter from the surface. The most common well pumps in use are called "**submersible**. "They are powered by electricity and push the water up to the surface. In any area where there is frost, the water pipe comes from the well through a **pitless adapter** below ground level. In warmer climates there is no need to use a pitless adapter; the water pipe can come out of the top of the well. Figure 4.1 on the next page illustrates some above ground and below ground well components of a submersible well and figure 4.2 shows a general picture of the well connection to the building it serves. The pump must remain submerged below water level in the well to help cool them.

Figure 6.1- Components of a Submersible Pump Well



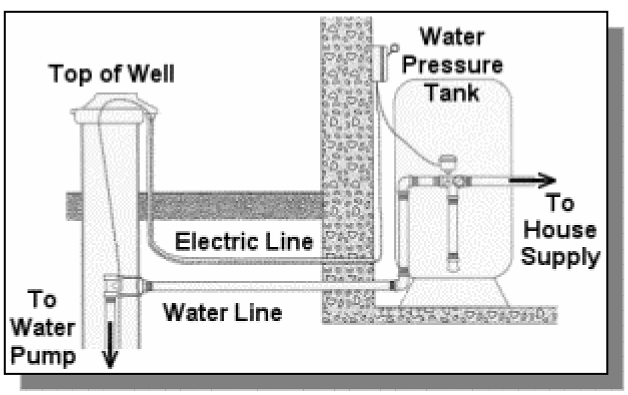


Figure 6.2 Typical Small System Well Connection into Building

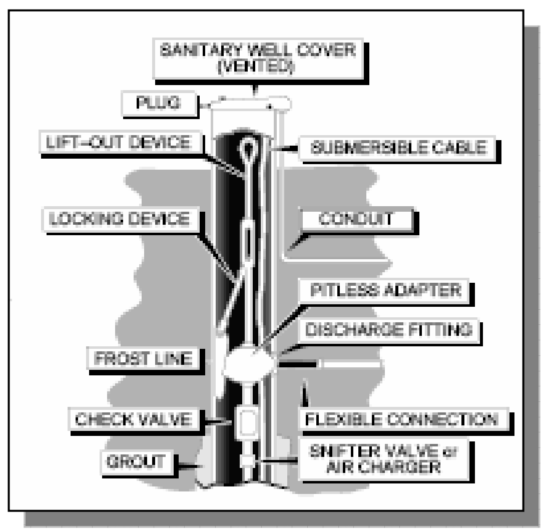


Figure 6.3 Cut Chapter of Well

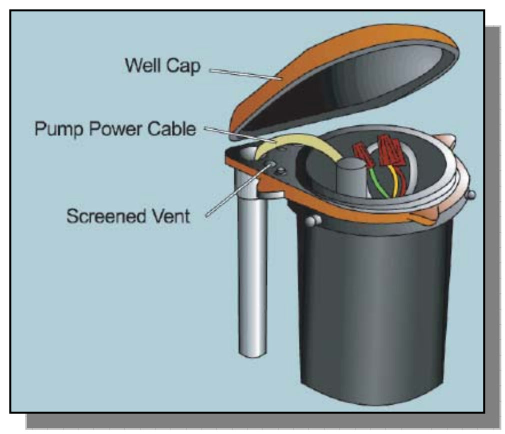
6.2.1 Well Casing

The **casing** is a steel or plastic pipe installed during construction to prevent collapse of the borehole. It provides a connection to the groundwater and a pathway for bringing the water to the surface. The annulus space between the casing and sides of the hole must be sealed with **grout** to prevent pollutant seepage into the well along the well casing. The casing must terminate al least 12 inches above the ground surface or floor of a well house and the ground surface around the casing must be sloped away to prevent liquids from accumulating around the well, which may cause contamination of the groundwater.

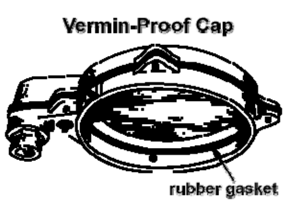
Figure 6.4 - Grout

The picture to the left is a submersible well with a plastic casing. The gray material is grout, which seals the opening between the ground and the casing. The electrical conduit holds the electrical wires from the power supply to the submersible pump. For safety purposes, the electrical conduit must be gray in color for identification between electrical conduit and plastic water pipe which is white in color. The conduit must also be tightly sealed to prevent a shock hazard and contaminants from getting down into the well casing.

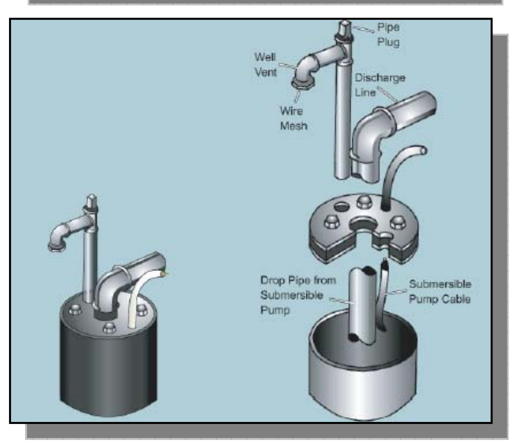
6.2.2 Well Cap



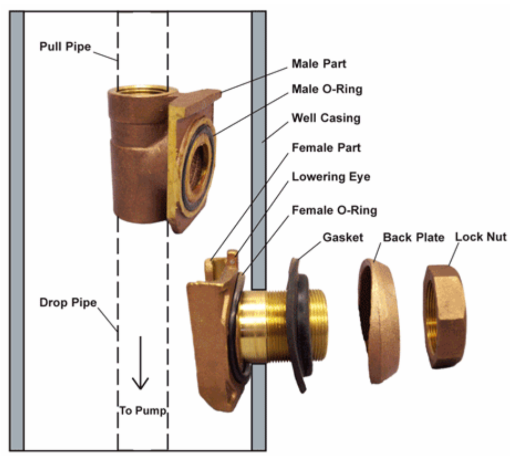
A **well cap** should be weatherproof and tightly sealed with a down turned and screened vent to prevent well contamination from dust, debris, insects, rodents and bird droppings. The vent allows air to enter the well during drawdown to prevent vacuum conditions.



6.2.3 Sanitary Well Seal



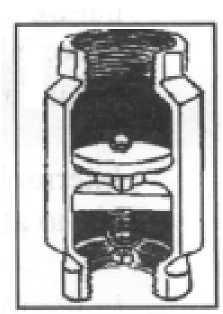
A sanitary well seal is used instead of a well cap on wells that have piping exiting at the top of the casing. It consists of a rubber gasket that is sandwiched between an upper and lower metal plate that all fits inside the top of the casing. The sanitary well seal has openings on the top for piping. Two-piece top plate sanitary seals are only acceptable for wells located in an approved well house. (*Minnesota Dept of Health, 2002)*



6.2.4 Pitless Units & Adapter

A pitless adaptor or pitless unit is used to create a frost proof connection between the well and the water service line. The water service line is attached to the fittings on the well underground, below the frost line to prevent freezing during cold weather. The water service line connects the well to the water distribution system.

6.2.5 Check Valve



The check valve is used to prevent water from flowing back down into the well when the pump has been shut off. If the check valve fails, the water flowing back down into the well will stir up the geological formation, which may cause silt, sand, or other materials to be present in the drinking water. (*Minnesota Dept of Health, Safe Drinking Water for Your Small Water System, 2000)*

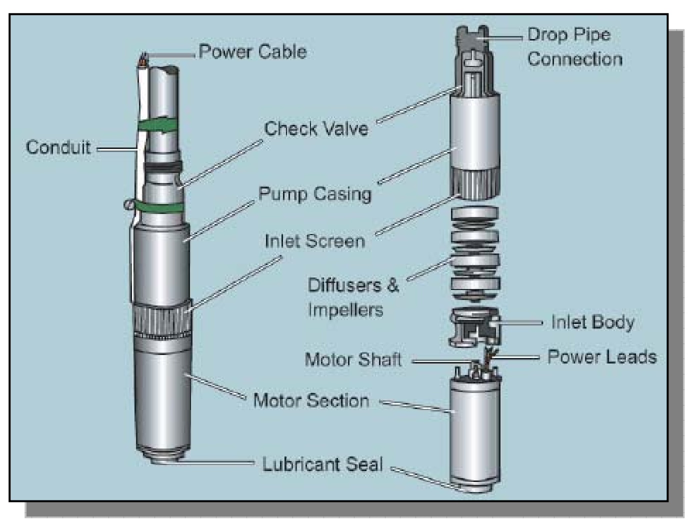
6.2.6 Water Service Line

The water service line is the water pipe that delivers the water from the well to the buildings being served.

6.2.7 Pumps

There are different types of pumps that force the water up from the groundwater to the distribution system. The most common types used in noncommunity systems are the submersible pump, jet pump and hand pump.

Submersible Pump – is designed to operate completely submerged under water in the well casing. See Figure to the right.



Jet Pump – is located on top of the well casing or offset from the well in a pump house or basement. It is connected to the well with piping and operates by forcing water through a jet or venturi, which creates a partial vacuum (suction) and draws water from the well into the pumping system. Figure on right.

Hand Pump – this consists of a cylinder on a pump rod, which moves up and down and forces water to the surface. They are commonly found in parks and other recreational settings.

6.2.8 Well Screen

Well screens are used in drift wells and in some rock wells. The purpose of a screen is to prevent sediment from entering the well while allowing water to enter the well. The slot sizes on screens vary according to how "fine" or "coarse" the sand and gravel material at the bottom of the casing are.

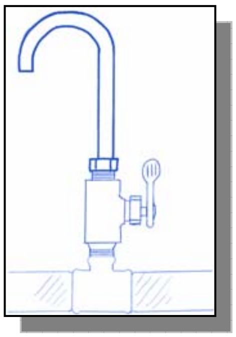


Figure 6.5 Sample Tap

6.2.9 Raw Water Sample Tap

A raw water sample tap allows for the collection of a water sample prior to any treatment that a facility may have. It is also used to test the quality of the well water itself. An approved tap should have a small diameter outlet in an accessible location at the pressure tank or as near to the well as possible. The spout is to be at least 8 inches above the floor, with no threads on the end and down-turned. The raw water sample should be collected after the pump kicks on to ensure you are getting water from the source, and not the distribution system.

6.2.10 Electrical Conduit

The electrical cable or wiring on the outside of the casing shall be protected by a rigid conduit from the well cap/seal to a point below grade. The rigid conduit must be securely attached to the well cap/seal and must extend below grade to the minimum depth required for the cable (18 inches below the ground surface). The conduit must be provided with an electrical bushing or fitting at the point where the cable enters and leaves the conduit. This bushing or fitting protects against cable damage due to abrasion. Types of conduit approved for submersible pump installations are rigid metal conduit (galvanized) or a rigid nonmetallic conduit which must be grey (color designated for electrical components), PVC plastic, and schedule 40 or 80. Conduit helps prevent contaminants (insects, mice, etc.) from getting into the well.

Black polyethylene (P.E.) pipe/tubing is not an approved electrical conduit material. (*MDPH Well Words. Division of Water Supply – Ground Water Quality Control Chapter. Vol.14 No.1. Feb 1994, page 8.)*

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CHAPTER 7
Water Storage & Pressure Tanks

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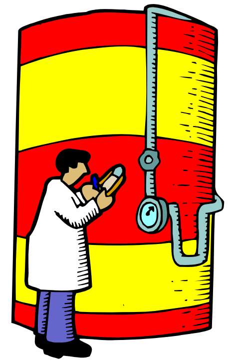
Water Storage & Pressure Tanks



7.0 Chapter Overview

The main purpose for water storage is to provide a sufficient amount of water for the daily demands so the pump does not have to operate every time the faucet is turned on and to help maintain adequate pressure throughout the distribution system. Water storage must also provide water for **peak demands**, which is the time of the day when the water is used the most (such as during lunch time, or when children are showering after gym class).

Other purposes of water storage may include meeting the needs for fire protection and industrial use. The major types of tanks are hydropneumatic (diaphragm or bladder), elevated storage, and ground storage tanks.

7.1 Types of Storage Units

There are three major types of storage tanks, however only pressure tanks will be described as they are the type typically seen at noncommunity public water systems:

- Pressure Tanks
- Elevated Storage Tanks
- Ground Storage Tanks

7.1.1 Pressure Tanks

These tanks can range in size from small household units to much larger industrial/institutional sizes. A pressure tank may be designed with or without a bladder that separates air and water in the tank. Figure 7.1 shows diagrams of different pressure tanks.

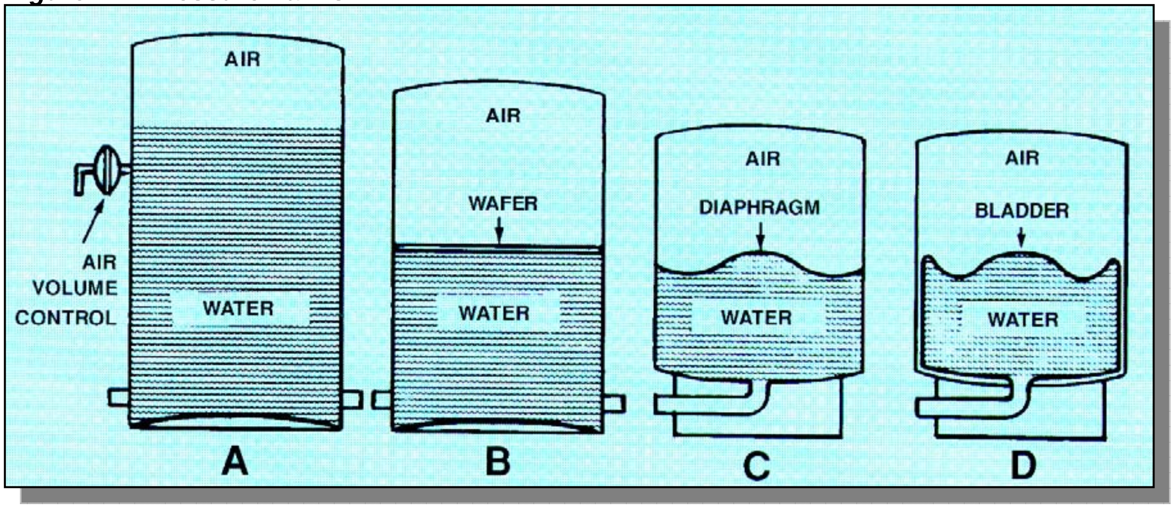
Air-to Water (No Bladder) Pressure Tanks

These tanks operate using a pressure-rated tank containing approximately two-thirds water and one-third air at full capacity. These tanks do not have a barrier between the water and air in the tank and may become "water-logged" if the air leaks out or is absorbed by the water. An air compressor is periodically used to replenish the air in the tank.

Bladder (Diaphragm) Pressure Tanks

This type of tank uses a bladder, or diaphragm, as a flexible separator between the air and water in the tank. The bladder prevents loss of air to the water thus eliminates the need for an air compressor. Very small tanks do not provide much storage but provide pressure and prevent excess pump cycling.

Figure 7.1- Pressure Tanks



<u>Key to Figure 7.1:</u>

A: Galvanized (steel) water storage tank

B: Galvanized tank with a wafer separating the air from water = less mixing of water molecules into air

C: Pressure tank

D: Bladder pressure tank

Hydropneumatic = "A water system, usually small, in which a water pump is automatically controlled (started and stopped) by the air pressure in a compressed-air tank"

Hydropneumatic pressure tanks can be used very successfully in well pump operations to maintain adequate pressure throughout distribution systems. Air must be added to A & B above. Many people believe these tanks are used for water storage, but they are for pressure purposes.

7.2 Routine Maintenance

Routine maintenance includes observing the pressure gauges to verify proper operation of the pressure tank. Typically, operating pressures are between 40 and 60 psi. A well pump installer will set the operating pressure when the water equipment is initially installed.

The tank storage room should be adequately vented to reduce the external corrosion of the tank which may be brought on by excess moisture. Tanks that lose air pressure and become water-logged must be repaired or replaced as the pressure is minimized and the pump runs whenever there is water demand. These tanks should be kept in a heated building to prevent freezing and should never be operated above the pressure rating of the tank shown on the manufacturer's plate. Tanks should also be equipped with a pressure relief valve.

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CHAPTER 8
Water Distribution System

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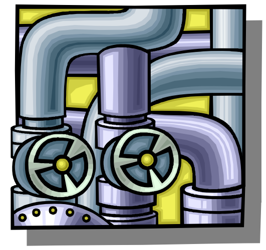
Water Distribution System



8.0 Chapter Overview

The distribution system consists of a network of pipes, valves, storage tanks, fire protection pipes, service lines, meters, and other **appurtenances**. Pipes transport or "distribute" the water throughout the facility and valves are needed to isolate portions of the system for cleaning, maintenance, repairs or adding on to the system. The **service line** is the piping that connects the source water to the building or the water supply from one building to another. It is critical that the distribution system is properly maintained and free of cross connections with unapproved water supplies that could allow contamination to be introduced into the drinking water system. **Continuous Positive Water Pressure** in the system under all conditions is critical to protect the distribution system from the entrance of contaminants.

8.1 Storage Facilities

Water storage facilities are used to provide a sufficient amount of water for daily average and peak demands on the water supply system, to help maintain adequate pressures throughout the entire system, to meet the needs for fire protection (Refer to chapter 5 for more detailed information on storage).

8.2 Distribution Pipe

Piping used to transport drinking water throughout the system must be of approved materials and sizes in order to deliver safe and sufficient amounts of water to the consumer. Pipe materials must meet the minimum requirements of the Michigan Plumbing Code for drinking water. Plastic, copper, ductile iron and steel pipe are commonly used for exterior water service lines. Plastic pipe must be marked with NSF-pw indicating that it is safe for carrying potable water.

Water distribution piping in buildings is usually copper or plastic with some old piping consisting of galvanized steel. Today, copper pipe must be jointed with lead free solder.

Polyethylene pipe (flexible black pipe) is not approved for use as distribution piping.

8.3 Meters

The primary function of a water meter is to measure the amount of water passing through it and provides many benefits to the water operator. A meter assists in informing the operator of water losses somewhere in the distribution system, of potential system problems, of exactly how much water is being used (or wasted), and to help determine when backwashing or filter media needs to be changed when certain water treatment devices are used. With proper operation, maintenance and monitoring of the water meter, a facility may be able to save money by heading off problems.

8.4 Valves

Valves should be installed at enough points throughout the water system to provide adequate isolations during repairs. Valves should be "exercised" or turned on a regular basis to ensure that they will work properly when needed. Some common valves are gate valves, ball valves, and globe valves.

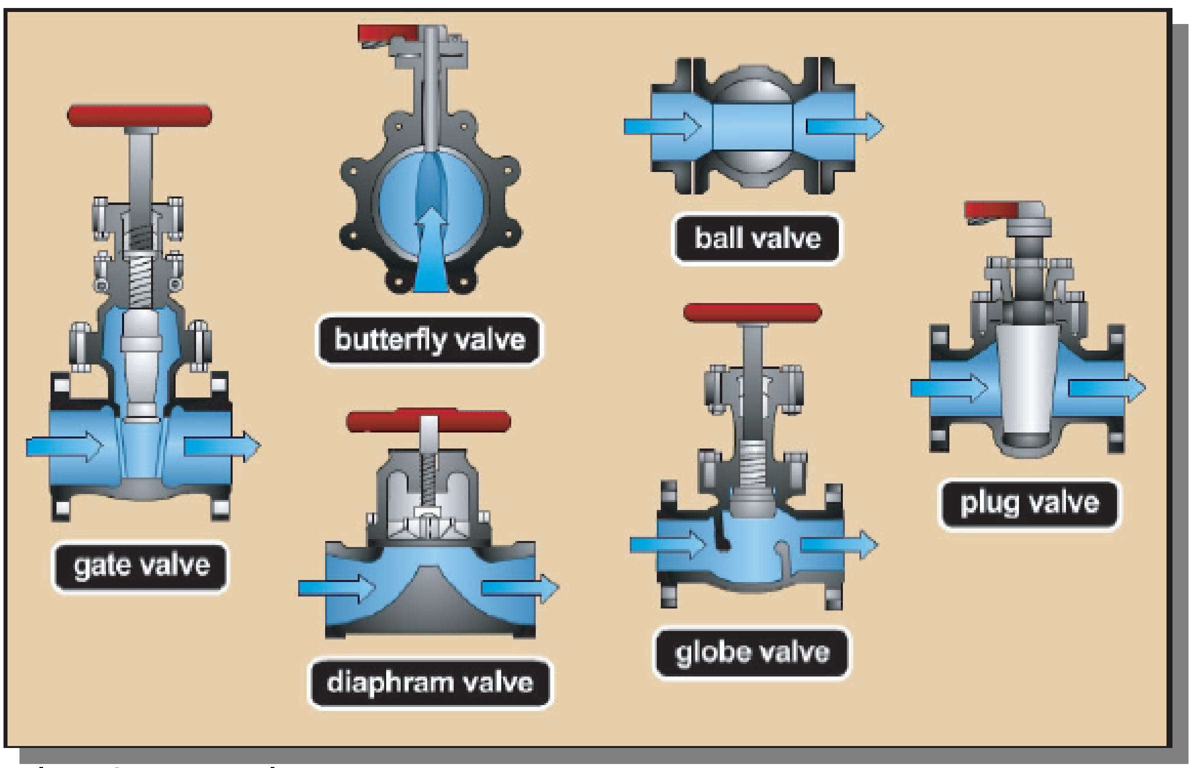


Figure 8.1 Water Valves

8.5 Water Quality in the Distribution System

The source of drinking water from a NCWS is required to meet all water quality standards before it is served to the public. Both the owner and certified operator of the facility must make sure that this safe source remains safe from contamination or pollution. Questionable or unsafe water may result in the distribution system if quality control at the source is not practiced. However, a facility may have a safe and approved source but the water in the distribution system may be contaminated if proper operation and maintenance of the distribution system is neglected.

Contaminates found in the distribution system water include chemical, physical, and biological substances. Sources of contaminant may have been introduced from the source water or from factors that may cause water quality problems including cross connections, corrosion, biological growth, high temperatures, unusual flows, amount of time the water is in the distribution system, dead ends, the age of the facility, and operational (or lack of) procedures, or when the system is depressurized with failure to chlorinate afterward.

8.5.1 Installations and Repairs

Improper installment of new water treatment equipment, other distribution system appurtenances, or piping may result in contamination of the distribution system water. Repair or replacement of leaking pipes without using approved materials or proper disinfection of the system after the work is done can also lead to water quality problems.

8.5.2 Water Equipment Contamination

If equipment in a distribution system, such as storage tanks, hot water heaters, treatment devices, is not being operated effectively and reliably, contaminants can build up and be passed into the distribution piping. For example, a chlorinator not properly operated or maintained could result in pathogenic organisms entering the distribution system. Per ***Rule 831(2)*** of the SDWA, before placing a new or reconditioned well or a well facility which is opened for maintenance or inspection into service, not less than 2 consecutive water samples for bacteriological analyses shall be collected and each analysis shall be non-detect for coliform. These samples must be taken a minimum of 24 hours apart.

8.5.3 Cross Connections

An unprotected connection between any part of a drinking water system and any source or system containing water or a substance that is not or cannot be approved as safe, wholesome, and potable for human consumption could result in the delivery of contaminated water to consumers. It is imperative for the operator to constantly monitor the system in the prevention of cross connections (refer to the Cross Connection Chapter in this Guide for more detailed information).

8.5.4 Corrosion

"Corrosion is the gradual deterioration or destruction of a substance or material by chemical action proceeding inward from the surface" *(Calf. Dept. of Health Services, Small Water System Operation & Maintenance, 2001)*. Corrosion of metal may occur either on the inside or outside of the surface and many factors influence the rate of corrosion such as water temperature, water velocity, if two different metals come in contact, and specific substances in the water. For example, higher water temperature, dissolved minerals, dissolved oxygen, and sulfate-reducing bacteria can speed up corrosion. Carbon dioxide in the water lowers the pH of water making it more corrosive. Monitoring for lead, copper, zinc, etc., in the water will inform the operator whether elevated levels are present that may cause future problems.

8.5.5 Seasonal Temperatures

The temperature of water has three major impacts on water quality. Higher temperatures speed the rate of chemical reactions and increase biological growth. Summer temperatures may intensify biological decomposition and require greater chlorine demand if a system is disinfecting the distribution lines.

8.5.6 Water Flow Rate

Changes in the flow rate of water through the distribution system could result in sediments being stirred up and stagnant water, both causing water quality problems. **Continuous positive system pressure** is necessary in order to prevent contaminants from entering the drinking water system.

8.5.7 Dead Ends

Dead end piping in the distribution system may cause major water quality problems since the water flow is very low, the time of contact of water with the pipe and any deposits, encrustations, or slimes is long, there may be an accumulation of organic matter containing nutrients which is a food source for bacteria, and there is low oxygen which may produce carbon dioxide, methane, and foul sulfide odors. Therefore, dead ends should be eliminated if possible.

8.5.8 Operation and Maintenance

Poorly performed water quality monitoring, failure to adequately flush the water system, insufficient surveillance of equipment, inadequate cross connection control, improper disinfection practices, disregard of hazards and threats to the water system, and lack of trained operators all contribute to potential water quality problems. As water supply system equipment and piping become older, more maintenance is required and more water quality problems may arise.

CHAPTER 9
Water Supply Treatment

NOTE: This chapter is important for certified operators who operate limited treatment or complete treatment facilities (D-5 or F-5 levels). However, a distribution system operator not treating to meet drinking water standards or not adding chemicals to drinking water may want to quickly glance through information on water softener units, if the facility is thinking about adding chemicals or any treatment to the water supply, or if the well or distribution system is in need of disinfection due to bacteria contamination or shutdown.

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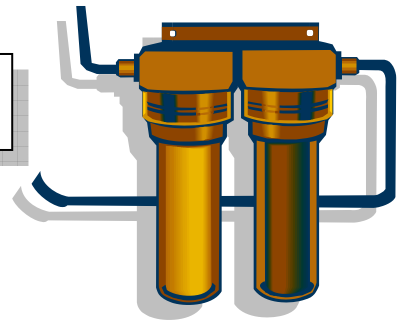
Water Supply Treatment



9.0 Chapter Overview

The majority of groundwater sources in Michigan provide quality water that meet federal drinking water standards, and do not need to be treated to remove contaminants. However, if the drinking water source is from surface water or a groundwater source that contains contaminants that pose a health risk, ***continuous treatment*** to remove the contaminants is necessary. If ***treatment for water quality purposes*** is required, persons responsible for the operation of the public water system must be knowledgeable in the operation, maintenance, and procedures involved in adding chemicals to the water and must demonstrate this knowledge by passing an operator certification examination. Treatment may also be used to improve the water's aesthetic characteristics such as reducing hardness or iron content. Treatment for water quality is the last resort; a safe source is always pursued first. This chapter is divided into two sections: Limited Treatment Systems and Complete Treatment Systems. The type of treatment system will dictate which level of certification the operator is required to have.

9.1 Taste & Odor Control Methods

Taste and odor problems in drinking water may be seasonal, occasional, infrequent, or persistent and complaints from consumers will vary depending on the individual's sight, smell and taste. Many substances causing objectionable taste, color, or odor in drinking water are considered secondary contaminants and are not required by law to be monitored and removed; however, in order to get consumers to drink the water, treatment may be warranted. Taste and odors can be the result of natural or manmade conditions that can exist in the source water or anywhere in the water supply system. Some natural causes include biological growths or minerals and chemicals in the environment. Some man made causes include municipal and residential wastewater, industrial wastes, chemical spills, agricultural wastes and urban runoff.

Some methods of treatment for taste and odor include many of the below mentioned treatments as well as aeration, oxidative, and adsorption processes. **The owner or certified operator *<u>must</u>* contact their LHD representative before the installation of any type of treatment, even though it might be for aesthetic reasons.** A permit, evaluation and approval may be needed.

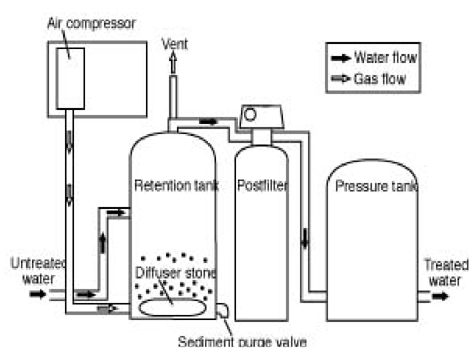


Figure 9.1 Aeration System

SECTION 1: LIMITED TREATMENT SYSTEMS

Public health related treatment of groundwater sources such as removal of nitrate or arsenic to meet a drinking water standard is required to be permitted and approved prior to installation and must have at least a D level certified operator. This is because if the treatment is not properly operated, the system could exceed a drinking water standard and that has public health implications.

Certain other treatment also has potential to impact public health thus also must be permitted and managed by at least a D level certified operator. These treatment systems typically inject a chemical into the drinking water such as chlorine, phosphate, or potassium permanganate. Even though the treatment could be used for aesthetic reasons, overfeed of a chemical or feeding the wrong chemical is a public health concern so it is imperative the system be operated properly.

Typical Treatment Requiring Permit and Level 5 Operator

- Removal of a contaminant to meet a drinking water standard
- Chemical addition to drinking water

NOTE: Other treatment is discussed in this section as an overview but if the treatment is not employed to remove a regulated contaminant to meet a drinking water standard or chemical injection is not used, a D level certified operator is not normally required.

9.2 The Disinfection Process

Water may carry biological life forms which can cause diseases. These life forms are called waterborne **pathogenic** organisms and include bacteria, viruses or intestinal parasites. Proper construction, operation, maintenance and monitoring help to protect the water supply from these pathogens, however, a breech in the system that introduces contaminants into the water supply may create a potential health risk. Disinfection is one treatment process that helps cleanse the water of potential pathogens that may have been introduced into the system as it destroys or inactivates pathogenic organisms.

Some examples of disinfection agents include chlorine, iodine, bromine, ozone, ultraviolet rays, and heat. Chlorine is typically used in small water supplies for new well construction or if disinfection of the existing well and distribution system is necessary. Liquid bleach with additives or solid compounds with stabilizers or binders should <u>not</u> be used in drinking water systems.

The chemical should also be safe and easy to handle and it should not make the water toxic or unpalatable. The chemical must be approved for drinking water purposes (NSF 60 certification). In addition, the concentration of disinfectant in the water must meet prescribed limits, be easy to monitor and the disinfection must provide residual protection against possible recontamination.

9.2.1 "Shock" Disinfection (Repair/Construction/New well)

Disinfection of a newly constructed well is required, as is disinfection to the well and distribution system if any repair work is done, because the "closed system" is opened to potential contamination. Shock disinfection may also be utilized if a bacteriological contamination is encountered. You must contact your LHD program coordinator before disinfection of a noncommunity public water well and ***the well disinfection process must be done by a licensed well driller or contractor.***

9.2.2 Continuous Disinfection

If well construction/location cannot provide a safe water source (i.e. groundwater under the influence of surface water) and continual treatment is required, biological contaminants are most effectively eliminated by disinfecting water through oxidation (e.g., chlorine disinfection or ozonation), and filtration. For each method the equipment must be specifically designed for the intended use and properly maintained to allow for effective filtration and contact time for treatment. Ultraviolet and ozonation are not permitted as stand alone disinfection methods to meet public health water quality standards. A chemical disinfectant residual must also be maintained in the distribution system. However, regular bacterial analysis of the treated water is also needed to ensure that adequate treatment occurs.

Chemical feed equipment must be automatic, require minimal maintenance, and treat all water in the distribution system. It should also be fail-safe so that no one can unknowingly use or consume contaminated water.

9.2.3 Chlorine

Chlorination is the most common method of disinfection used. Chlorine is good at eliminating coliform bacteria that might reach water in the distribution system after new construction or repairs. It also helps control other microorganisms that could produce slimes, tastes, or odors in the distribution system water.

Chlorine is also used as an **oxidant** in arsenic removal and as a post treatment disinfectant in the coagulation-flocculation, sedimentation, and filtration treatment process.

There are different forms of chlorine that may be used. Hypochlorites are available in solid (tablet) or liquid (pump-fed solution) forms. The use of gaseous chlorination at small water supplies may not be among the best disinfection options due to the hazardous nature of the material. Use of gaseous chlorine places greater demand on the need for isolated plant space, on providing trained and attentive operating staff and their protection from any hazards, and, possibly, on liability issues which may boost insurance costs for small public water systems.

<u>Small systems typically use either the liquid or solid forms of chlorine:</u>

Sodium Hypochlorite

(Liquid chlorine)

Calcium hypochlorite

(A powder form that mixes with water to form a solution)

Note: Chlorine gas is typically used by larger systems such as municipal water supplies.

9.2.4 Factors Influencing the Disinfection Properties of Chlorine:

- **pH** – chlorine disinfects better at a lower pH than a higher pH.
- **Temperature** – disinfection is more efficient the higher the temperature of the water.
- **Turbidity** – disinfection is less effective with suspended particles (turbidity) present.
- **Reducing Agents** – these materials react with chlorine and will use it up before any disinfection can occur.
- **Number & Types of Microorganisms** – the higher the amount of microorganisms, the greater the demand for chlorine.
- **Contact Time** – the longer the time chlorine is in the water the better the disinfection.

NOTE: Chlorine pellets should not be "dropped" into a well casing for disinfection as it has been found that they do not dissolve properly and may cause secondary problems.

9.2.5 Common Terms

Free Available Chlorine: The concentration of hypochlorous acid and hypochlorite ions in the water.

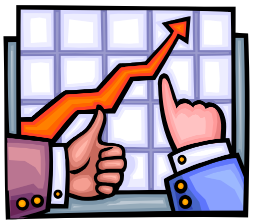
Total Chlorine Residual: The amount of chlorine remaining in the free and combined form after a certain contact time.

Free Chlorine Residual: The amount of chlorine that has not reacted with other compounds found in the water.

Combined Chlorine Residual: Is the amount of chlorine that has reacted with natural ammonia or organic nitrogen compounds in the water to form chloramines.

Chlorine Demand: The difference between the chlorine applied and chlorine residual. Usually, the amount of chlorine that has reacted with or is lost to other substances in the water and is not found as a free or combined chlorine residual.

9.2.6 Breakpoint Chlorination:



The highest disinfection ability of chlorine is when it is in the form of "***free available residual.***" Breakpoint chlorination is the process of adding chlorine to water until the chlorine demand has been satisfied and further addition of chlorine results in a chlorine residual that is "free" to kill or inactivate microorganisms.

Here is the process to get to that breakpoint:

1. Water naturally contains organic and inorganic materials which chlorine combines with to form chlorine compounds some of which do not have disinfecting properties. If you continue to add chlorine, you eventually reach a point where the reaction with organic and inorganic materials stops. At this point, you have satisfied what is known as the "***chlorine demand***".

2. Some chlorine reacts with water and produces some substances with disinfecting properties. The total of all the compounds with disinfecting properties plus any remaining free (uncombined) chlorine is known as the "***chlorine residual.***" The Chlorine residual can be measured with an approved test kit and indicates that all chemical reactions with chlorine have been completed and there is still sufficient "***free available residual chlorine***" to kill or inactivate any microorganisms present in the water supply. At this time, the **DPD** (diethyl-p-phenylene diamine) **titrimetric** and **colorimetric** methods are the two most common field tests for determining chlorine residuals. In the DPD colorimetric method, the chlorine residual can be determined by comparing the color development with known colored standards. A pinkish color will develop in the presence of chlorine.

3. "**Chlorine dose**"
   Chlorine dose is the amount of chlorine that must be added to the water to disinfect it.

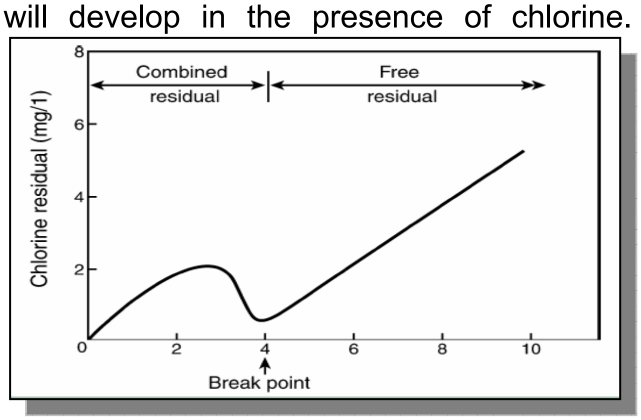


Figure 9.2 Breakpoint Chlorination

9.2.7 Operation, Maintenance & Safety Issues:

When chlorine is used as a disinfectant, chlorine residual must be maintained throughout the distribution system. Always be sure to measure the chlorine residual in the distribution system on a daily basis, especially at the farthest end of the system, and properly document the results.

It is also important to make sure the chlorine equipment is working properly; the pump, the inlet to distribution pipe is not clogged up, the strainer in the bottom of the solution container is not plugged, and there is enough chlorine solution in the container.

Chlorine can be hazardous to your health. Always take precautionary measures when handling chlorine. Wear protective clothing and breathing apparatus if necessary and wash your hands. If there is a spill, clean up immediately by using large amounts of water and if any is spilled on you, quickly wash all affected areas with water. Hypochlorite solutions are also very corrosive. There are specific regulations regarding the use of chlorine and chlorine disinfectant by-products mandated by federal law.

9.2.8 Positive Displacement Chemical Feeders:

A common type of positive displacement hypo-chlorinator is one that uses a piston or diaphragm pump to inject the solution. This type of equipment, which is adjustable during operation, can be designed to give reliable and accurate feed rates. The stopping and starting of the hypo-chlorinator can be synchronized with the well pumping unit by plugging it into an outlet that is energized when the well pump is on. A hypo-chlorinator of this kind can be used with any water system. However, it is especially desirable in systems where water pressure is low and fluctuating.

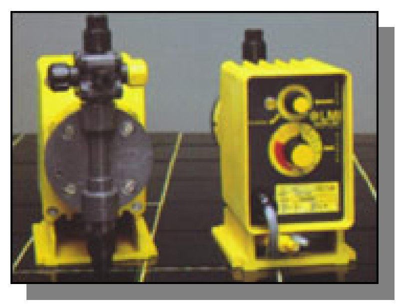


Figure 9.3 Chlorine Pump

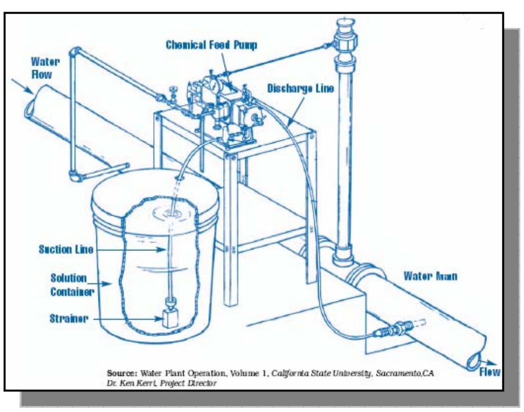


Figure 9.4 Simple Chlorination Setup

9.2.9 Chlorine Residual Testing

When continuous chlorination is used for disinfection, a residual of 0.2 to 0.5 ppm free chlorine must be maintained at all points in the distribution system. This will help ensure that effective disinfection is occurring at all points on the distribution system. In some cases, residuals will be higher than the 0.2 to 0.5 ppm range due to treatment specifications (such as surface water treatment). However, concentrations must not be higher than 4 ppm in the distribution system. Chlorine residual can be measured using a field test kit that uses the DPD analysis method. There are many chemical companies that manufacture chlorine residual testing equipment.

Operators of a chlorinated water supply are required to maintain a **Monthly Operation Report** on a form provided by the Department. (Appendix F-1).
Records are kept for chlorine residual on a daily basis with results entered immediately after each test.
A copy of the Monthly Operation Report shall be submitted to the local health department having jurisdiction over the facility.

It is REQUIRED that chlorine residual tests be performed and recorded at least once daily at a sample point on the distribution system which is representative of the water being used for drinking purposes.

9.3 Lead/Copper Corrosion Control

Corrosive water can cause serious problems to the water system and health of individuals. **Corrosion** is a gradual destruction of materials such as metal pipes due to a chemical action on the material from the water. The water becomes corrosive because of stray electrical currents or metals in the water that react with the metal of the pipe. Corrosion starts at the surface of a material and moves inward. It can occur on the interior or exterior of metal piping and equipment.

Factors that influence corrosion include physical factors such as the type of water system materials, stray electrical currents, an increase in water temperature, low flow velocity of water in the pipes (stagnant water areas), chemical factors such as alkalinity, pH, dissolved oxygen, hardness, chlorides, and metals in the water, and certain bacterial growth in the system.

The **Lead and Copper Rule** requires water systems to monitor and control corrosion to protect the public from harmful effects of lead, copper, or other toxic metals in drinking water. There are various methods that may be utilized to minimize system corrosion. Some examples include changing the water's characteristics, such as adjusting pH and alkalinity; softening the water with lime; and changing the level of dissolved oxygen. Chemical control depends on the original water quality characteristics. Ion exchange, Reverse osmosis, Lime softening, and Coagulation/filtration are possible source water treatment methods (SDWA Rule 604f). Some measures, like adding phosphates or silicates are used to provide a protective coating on the piping, which helps stop or reduce the leaching of lead and copper from pipes.

Replacement or removal of lead and copper service lines, pipes, fixtures and lead solder is also a method used to reduce the leaching effect of lead and copper from corrosive water.

9.3.1 Phosphate Treatment (sequestration treatment)

Phosphate and polyphosphate are general terms used to denote several types of phosphate compounds used in water treatment. In the water treatment industry, phosphate is mainly used for controlling iron problems, for the stabilization of lime-soda softened water, and for boiler feed water stocks. Phosphate is only effective in certain types of water and under certain conditions.

Phosphate combines with or sequesters dissolved iron and keeps it in solution. It does not remove iron from solution, like ion exchange or aeration, nor does it combine with precipitated ferric iron. This sequestering action of phosphate with iron will be less effective with an increase in time or temperature.

Phosphate can be applied to water by a positive displacement chemical feed pump which operates when the well pump operates. Disinfection is required following treatment with phosphate because phosphate can act as a nutrient for bacteria. Phosphate should be applied ahead of aeration or chlorination since it must be introduced before oxidation of the iron occurs. Only nontoxic solutions (ANSI/NSF approved products only) may be used and at the proper dosage. The dosage for water systems should always be kept below 10 ppm. (AWWA Limited Treatment Manual)

9.4 Iron and Manganese Removal

Iron and manganese are metals commonly found in the earth's crust, and are routinely found in groundwater. Neither is associated with any health concern, but both can cause aesthetic problems if present in high enough concentrations.

The most noticeable effect of elevated levels of iron and manganese is staining. Iron concentrations higher than 0.3 mg/l will cause brown stains and manganese exceeding 0.05 mg/l will cause black stains on plumbing fixtures, sinks, etc.

Iron and manganese may also promote the growth of bacterial slimes in the distribution system. These slimes are rust colored from iron and black from manganese. Foul tastes and odors are often associated with these slimes, and dirty water may occur if the slimes break loose. (AWWA Limited Treatment Manual)

9.4.1 Iron & Manganese Treatment

Iron and manganese may be treated in the same manner. The method most commonly used involves three steps; oxidation, detention and filtration. However, other methods such as greensand filtration and ion exchange may also be used. Arsenic may also be removed with the iron in these processes.

Steps to the Common Method of Treatment:

1. **Oxidation**

   Iron and manganese react with dissolved oxygen to form insoluble compounds in a process called **oxidation** which helps to filter them out of the water. There are different ways to obtain oxidation of these materials: aeration (adding air to the water); chlorination (chlorine will oxidize both); or the addition of **potassium permanganate**.

   If the water is oxidized properly, the iron and manganese will settle out of the water and can be removed by filtration. The dose of potassium permanganate must be carefully controlled as too little permanganate will not oxidize all the iron and manganese, and too much will allow permanganate to enter the distribution system and cause a pink color.

2. **Detention**

   A minimum detention time of 20 minutes should typically be provided in order to adequately allow for the oxidation reactions to take place.

3. **Filtration**

   The last step in the iron and manganese treatment process is to pass the water through filters where the insoluble iron and manganese are removed. Eventually, these filters will accumulate large amounts of the iron and/or manganese precipitates, which will cause a pressure loss through the filter and "***backwashing***" is necessary. In some cases, the iron and/or manganese may "***break through***" the filter before a significant head loss is developed. This may cause a dumping of excessive amounts of iron or manganese into the distribution system.

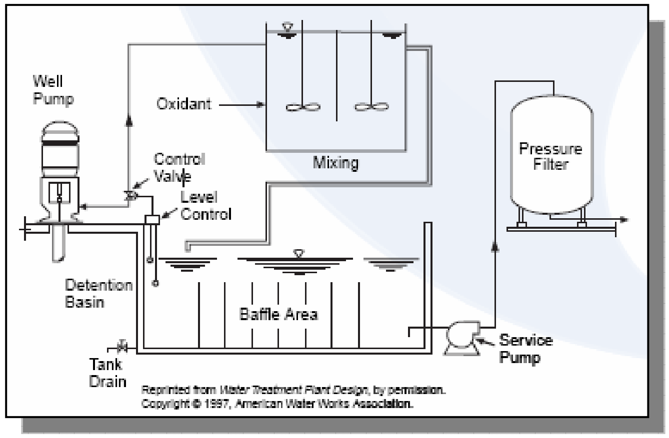


Figure 9.4 – Filtration System

9.4.2 Greensand Filtration

Iron and manganese can also be effectively removed by filtering the water through manganese-treated greensand which is a mineral capable of exchanging electrons and thereby oxidizing iron and manganese's to their insoluble, filterable states. Again, greensand filtration may also be effective for arsenic removal.

One major advantage of this type of treatment method over the aeration, detention, filtration method is that double pumping is eliminated.

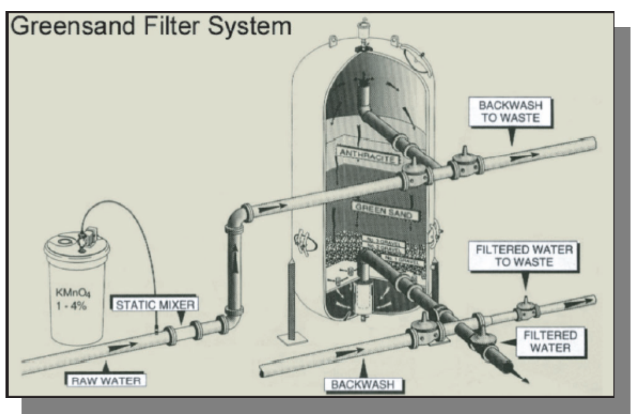


Figure 9.5 Greensand Filter

9.5 Ion Exchange

9.5.1 Iron and Manganese Removal

SMALL amounts of soluble iron and manganese may be removed using this process. In this case, sodium ions are exchanged for iron and manganese ions, however, this process is extremely expensive and the resins can easily become fouled with iron and manganese. Therefore, ion exchange is typically not utilized primarily as an iron or manganese removal technique.

9.5.2 Water Softening

Hard water is generally considered to be that which requires considerable amounts of soap to produce a foam or lather and that also produces scale in hot water pipes, heaters, boilers, and other units in which the temperature of water is increased. Hard water is often the cause of excessive calcium and/or magnesium in the groundwater. Noncommunity water systems that use a water softener to remove water hardness for aesthetic reasons are not required to have a D-5 level certified operator, however, use of a softener for removing a primary drinking water standard component will require a D-5 certified operator.

The **ion** (an electrically charged atom) exchange treatment process involves passing water through a media that has the ability to exchange **cations** (positively charged ion). As water passes over the media, non-hardness causing cations attached to the media are exchanged with hardness causing (calcium and magnesium) cations present in the water. This exchange continues until the media has been exhausted. The exhausted media is then regenerated and the softening process begins again.

The media is typically an artificial resin and the non-hardness exchange cation most commonly used is sodium. Sodium is used since it can be obtained at low cost from common salt.

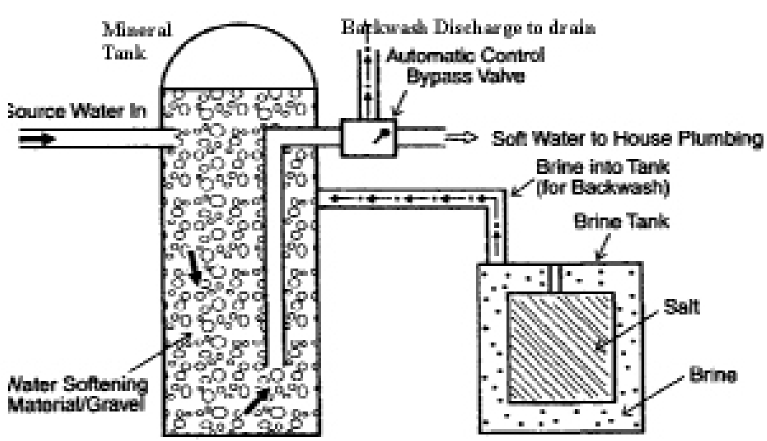


Figure 9.6 Ion Exchange
Diagram from the American Ground Water Trust

Operation of a Water Softener:

Most ion exchange softeners operate as pressurized systems with a downward flow of water through the exchange resin (media). The water enters the unit through an inlet distributor at the top, is forced by pressure through the exchange media where the hardness ions are exchanged for sodium ions, the flows into an under-drain structure and out to the distribution system.

Water leaving the softener contains nearly zero hardness. Such water is corrosive and aesthetically objectionable. In general practice, a portion of the raw water is bypassed to provide a blend of softened water and unsoftened water. The amount of water bypassed is typically adjusted so that the water entering the distribution system has a total hardness in the neighborhood of 80 to 100 mg/l.

The ion exchange process continues automatically until the supply of sodium ions in the resin is almost depleted. When this occurs, increasing numbers of hardness ions pass through the bed, un-removed, and the softener is termed "exhausted".

Backwashing a Water Softener:

Once the softener is exhausted, the unit must be taken out of service to clean and regenerate the resin which is accomplished in a three stage process.

1. ***Stage One***

   Water is reversed through the unit to loosen the resin and clean it.
   This takes approximately 5 – 10 minutes.

2. ***Stage Two***

   A brine (salt) solution is passed through the unit to regenerate the resin.
   This usually takes 45 – 60 minutes to "recharge" the resin with sodium ions.

3. ***Stage Three***

   Remaining waste products and excess brine are rinsed from the softener.
   The unit is basically placed in service except that the softener effluent (waste water) goes to waste instead of to the distribution system.
   This generally lasts between 20 – 40 minutes.

Upon completion of the backwash cycle, all of the calcium and magnesium ions should have been removed from the resin and replaced with sodium ions. It should be noted that the method of disposing of the softener backwash water is often a major consideration. Waste discharge must be disposed of properly to prevent environmental contamination and erosion. Softener backwash should not go into an on-site septic system as it may have a negative impact on the septic tank biological activity needed for treatment of waste and the drain line shall not terminate into a floor drain or sewer line. An air gap is required by law to separate the drinking water supply from the waste water system to protect public health.

9.6 Anion Exchange/Nitrate Removal

Nitrates can be removed using an **anion** exchange treatment unit that may look like a water softener on the exterior; however it uses a resin different than that of a water softener on the inside. The resin inside the anion system is selected to target nitrates in the water.

There are several types of anion exchange resins, each designed to remove specific contaminant(s). Another example would be an anion exchange system using a strong base "sulfate-selective" to reduce arsenic.

Reverse osmosis described in 9.7.2 is another treatment for nitrate removal, usually for very small applications.

Figure 9.7 Anion Exchange Treatment

9.7 Miscellaneous Treatment

9.7.1 Activated Carbon

Carbon material in this type of treatment reduces organic chemicals, such as those that can cause offensive tastes and odors by adsorption. **Adsorption** is the attraction and accumulation of one substance on the surface of another. It is primarily a surface phenomenon; the larger the surface area of the adsorber, the greater its adsorptive power. Activated carbon filters may be installed either to treat an entire system or just a single point of use (POU).

Bacterial growth in the media or the shedding of bacteria to the distribution system is a problem in carbon filters if they are not properly operated and maintained. Activated carbon filters have limited capacity, so frequent replacement of the filter media or cartridge is necessary or bacteria will slough off into the drinking water supply.

9.7.2 Reverse Osmosis (RO)

RO is a membrane process that can effectively remove nearly all inorganic contaminants such as nitrates and arsenic from water. In the RO unit, water passes through a synthetic, semi-permeable membrane that filters all pathogens and most organic and inorganic contaminants. This system uses pressure to force the water through the tiny pores in the membrane, trapping the contaminant on the membrane. These units must have a means of discharging filtered matter to a drain and this discharge line must be installed with an air gap so a cross-connection between wastewater and drinking water will not occur.

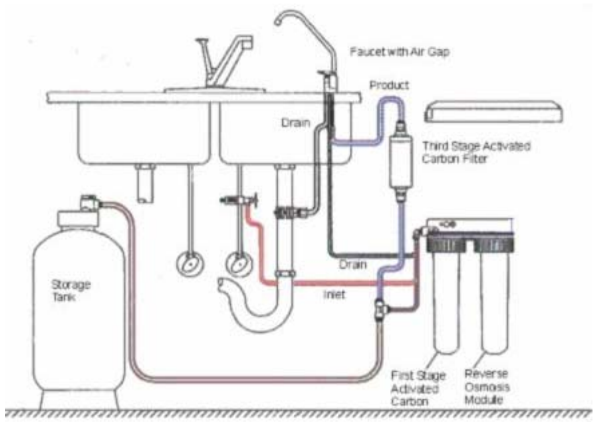


Figure 9.8 RO Treatment Diagram

Proper maintenance is critical to the use of an RO device (as it is with ANY treatment system) as the membrane will become plugged with contaminants. RO units are often installed to treat a single point of use fixture.

9.7.3 Cartridge Filtration

Cartridge filters are often used by small facilities to remove organic chemicals that can cause offensive tastes and odors. These devices may be installed to treat an entire system or a POU. As the system must be opened to exchange filters, care must be taken to routinely maintain all filtration devices to prevent bacterial growth.

9.7.4 Ozone

Ozone is a powerful oxidant with high disinfectant capacity. The pH and temperature of the water has an effect on the microorganism inactivation capabilities of ozone. Ozone disinfection of the drinking water is not widely used in noncommunity systems.

9.7.5 Adsorption Medias for Arsenic (As) Removal

Adsorption is contaminant removal from water by attachment onto the surface of a porous solid. These types of medias will be a popular choice for arsenic removal due to the ease of operation and their ability to remove both As (III) and As (V). However, these systems are much more efficient if the arsenic is in the (V) form. There are two common types of adsorption medias, iron based and aluminum based.

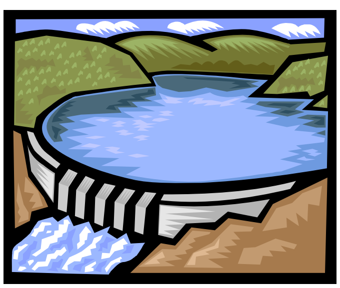
See ***Appendix F-2*** through ***F-8*** for arsenic & nitrate MOR forms.

SECTION 2: COMPLETE TREATMENT SYSTEMS

Act 399, Part 1, Rule 103 provides the definition of complete treatment.
"Complete treatment means a series of processes, including disinfection and filtration, to treat surface water or ground water under the direct influence of surface water, or to treat ground water not under the direct influence of surface water that uses precipitative softening, to produce a finished water meeting state drinking water standards."

A nontransient or transient noncommunity water supply with treatment meeting the definition of a complete treatment system is required to have a **Level F-5** certified operator:

9.8 Surface Water Treatment Rule (SWTR)



The SWTR affects all PWS's that use surface water or groundwater under direct influence of surface water and are defined as ***"Subpart H"*** systems in the SDWA. The purpose of this rule is to improve public health protection through the control of microbial contaminants, particularly viruses, Giardia, and Cryptosporidium. This rule establishes criteria under which filtration is required. Subpart H systems must provide filtration and disinfection or find an alternative safe ground water source.

9.8.1 Disinfection Requirements for Subpart H Systems

General information of chlorine as a disinfectant can be found above in section 6.1 "The Disinfection Process." Small drinking water systems using complete treatment processes typically will use liquid chlorine as a disinfectant.

Subpart H systems shall provide sufficient disinfectant ***Contact Time*** (**CT**) before the water enters the distribution system to assure adequate disinfection. "**CT**" refers to the product of the residual disinfectant concentration in mg/L, "C", and the disinfectant contact time in minutes, "T". The disinfectant contact time is defined as the time required for the water being treated to flow from the point of disinfectant application to a point before or at the first customer during peak hourly flow. There is a relationship between CT and percent inactivation (**log inactivation**) for a given disinfectant. Since the determination of percent removal of a microbiological contaminant is more technically demanding than the calculation of CT, CT is used as a surrogate for percent removal for a given disinfectant. Inactivation **contact time** (CT) values for the disinfectants listed in the SWTR were published by USEPA in the 1989 guidance for the SWTR.

Refer to Table IV-3 (p. 27511) of the SWTR to find CT values for free chlorine, ozone, chlorine dioxide, and preformed chloramines that correspond to 1-log removal of Giardia lamblia.

See Rule 611a of the SDWA for more specifics of Michigan's requirements.

9.8.2 Turbidity Monitoring Requirements

Turbidimeters (also referred to as "turbidity meters") detect the intensity of light scattered at one or more angles to an incident beam of light. Turbidimeters are in widespread use throughout the water industry and the turbidity data generated by these instruments is broadly recognized as a meaningful gauge of water quality.

Under the EPA SWTR, turbidity monitoring is specified as the default method for continuous indirect integrity monitoring of filtration membranes unless the state approves an alternate approach. There are two ways turbidity is measured: **Combined Filter Effluent** (**CFE**) and **Individual Filter Effluent** (**IFE**).

CFE monitoring frequency is at least ***every 4 hours*** (unless reduced by the state on an individual basis). Using IFE, filtrate turbidity must be monitored on each discrete membrane unit at a minimum frequency of once ***every 15 minutes***.

The **Maximum levels of turbidity (MCL)** are as follows:

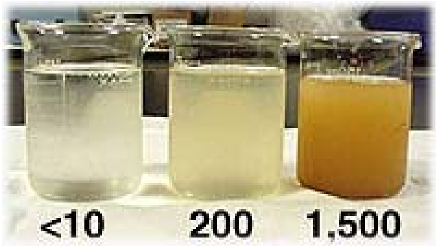
CFE 95% Value:	≤ 0.3 NTU
CFE Maximum Value:	**1 NTU**
IFE Monitoring:	0.15 NTU *

* Two consecutive readings exceed a control limit of ***0.15 NTU*** for any one unit would require that unit to undergo direct integrity testing and subsequent diagnostic testing, as necessary. Any such events that trigger direct integrity testing must be reported to the state on a monthly basis.

NTU = Nephelometric Turbidity Units

See Rule 611b of the SDWA for other filtration technology turbidity level requirements.

9.9 The Coagulation and Flocculation Process



These processes are used to remove particulate impurities such as solids that don't settle out of water (causing turbidity) and color from water which typically are found in surface water sources. Groundwater sources that are NOT under the influence of surface water do not use this type of treatment. **Turbidity** reduction is best achieved when the water is run through a series of chemical and physical treatment methods before reaching a filter. **Coagulation** is the process of getting particulates to stick together and **flocculation** is usually a two or three stage process of slow mixing which gets the particulates to become more visible. Flocculation allows the particles to get heavier which helps them settle to the bottom in the sedimentation part of the process.

9.10 The Sedimentation Process

Sedimentation is also a process utilized by surface water and groundwater sources under the influence of surface water in order to remove suspended solids. During this stage the particles of dirt settle to the bottom of the basin (becoming sludge) and the water is free to continue flowing to the filters for further "polishing." The sludge is periodically removed.

9.11 The Filtration Process

The process of **filtration** is to remove suspended solids from water by passing the water through a "bed" of sand, coal, or other granular substance or through a permeable fabric. The unwanted particles are trapped but the water passes through. Filtration is both a physical and chemical process. Some examples of filtration include Gravity Filtration, Pressure Filtration, Diatomaceous Earth Filtration, and Sand Filtration. If a filter media is used, it is selected based on what substance needs to be filtered out. Filtration is used along with the coagulation/flocculation and sedimentation processes and is the last stage in turbidity control. **Filtration** is the most commonly used treatment for reducing turbidity and microbial contaminant levels in domestic water supplies. Common drinking water filtration processes involve passing water through a filter media to remove suspended particulate material, larger colloidal materials, and, for some filter media, to reduce levels of smaller colloidal and dissolved contaminants.

Internet picture – EPA Water Filtration

Examples of suspended particulates include clay and silt, microorganisms, organic materials, and aluminum and iron oxide precipitates. Familiar filter media include silica sand, diatomaceous earth, garnet or ilmenite, and a combination of coarse anthracite coal overlaying finer sand. Filtration may be rapid or slow, depending upon the application, and may involve different removal processes, cleaning methods, and operation methods.

9.11.1 Approved Filtration Technologies

1. Conventional filtration treatment or direct filtration
2. Slow sand filtration
3. Diatomaceous earth filtration
4. Other filtration technologies (Bag, cartridge, etc. – not commonly used by small systems)

9.11.2 Conventional Filtration

Conventional filtration includes pre-treatment steps of chemical coagulation, rapid mixing, and flocculation, followed by floc removal via sedimentation or flotation. After clarification, the water is then filtered. Common filter media include sand, dual-media, and tri-media. Design criteria for specific sites are influenced by site-specific conditions and thus individual components of the treatment may vary in design criteria between systems. Conventional treatment has demonstrated removal efficiencies greater than 99% for viruses and 97 to 99.9% (rapid filtration with coagulation and sedimentation) for Giardia lamblia.

Conventional filtration is the most widely used technology for treating surface water supplies for turbidity and microbial contaminants, but may be less applicable to the smallest water system size category (those serving 25 to 500 persons) due to relatively high costs and technical complexity. Although conventional filtration has the advantage that it can treat a wide range of water qualities, it has the disadvantage that it requires advanced operator skill and has high monitoring requirements. Thus, small systems without access to a skilled operator should not use conventional treatment, given that waterborne pathogens are acute contaminants and that the disruption of chemical pre-treatment can lead to pathogen introduction into the distribution system.

9.11.3 Direct Filtration

Direct filtration has several effective variations, but all include a pre-treatment of chemical coagulation followed by rapid mixing. The water is then filtered through dual- or mixed-media using pressure or gravity filtration units. Pressure units, which are used primarily by small systems, have the advantage of not requiring re-pumping for delivery of the filtrate to the point of use. Gravity units have the advantage of allowing easy visual inspection of the filter medium during and after backwash. Direct filtration has the disadvantage that it requires advanced operator skill and has high monitoring requirements. Thus, small systems without access to a skilled operator should not use direct filtration, given that waterborne pathogens are acute contaminants and that the disruption of chemical pre-treatment can lead to pathogen introduction into the distribution system.

9.11.4 Slow Sand Filtration

Slow sand filters are simple, are easily used by small systems, and have been adapted to package plant construction. However, this technology is not commonly used by small systems.

9.11.5 Diatomaceous Earth (DE) Filtration

DE filtration, also known as pre-coat or diatomite filtration can be used to directly treat low turbidity raw water supplies. DE filters consist of a layer of DE supported on a septum or filter element. Problems inherent in maintaining the filter cake have limited the use of DE filtration and this technology is typically not used in small systems.

9.11.6 Membrane Filtration

Membrane filtration involves a thin layer of semi-permeable material capable of separating substances when a driving force is applied across the material. Membranes are manufactured in a variety of configurations, materials and pore size distributions. The selection of membrane treatment for a particular drinking water application would be determined by a number of factors, such as: targeted material(s) to be removed; source water quality characteristics; treated water quality requirements; membrane pore size; molecular weight cutoff (MWC); membrane materials and system/treatment configuration.

The membrane filtration process is increasingly employed for removal of bacteria and other microorganisms, particulate material, and natural organic materials. Pressure-driven membrane processes are **microfiltration** (MF), **ultrafiltration** (UF), **nanofiltration** (NF), and **reverse osmosis** (RO).

9.11.7 Microfiltration (MF)

MF is commonly used to remove Giardia lamblia and Cryptosporidium cysts in drinking water obtained from surface water. It is not an absolute barrier to viruses; however, when used in combination with disinfection MF appears to control these microorganisms.

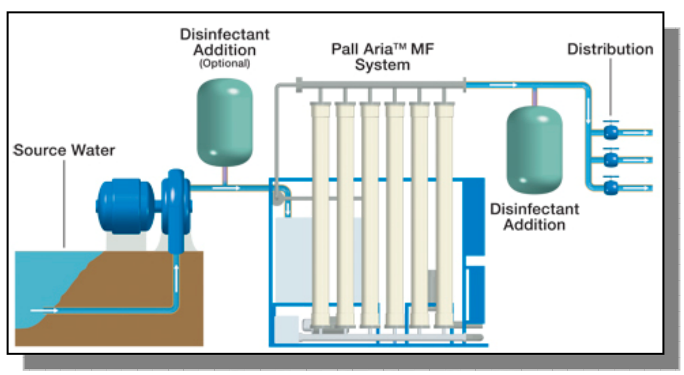


Figure 9.9 Microfiltration System

MF and UF utilize low operating pressures for the removal of particulates including pathogenic cysts. Due to typical MF membrane pore sizes and size exclusion (e.g., 0.1 to 0.2 micron, macro- molecular/micro-particle range); MF is effective for absolute removal of *Giardia* cysts and partial removal of bacteria and viruses, and when used in combination with disinfection appears adequate for removal/inactivation of these microorganisms.

Tests have been determined that MF filtrate turbidity may be kept below 0.2 NTU and typically at or below 0.1 NTU.

Pre-filtration and scale-inhibiting chemical addition may be utilized to protect membranes from plugging effects, fouling and/or scaling, and to reduce operational and maintenance costs. For the purposes of meeting the performance criteria under the SWTR and as a safety measure, a disinfectant is commonly applied following membrane treatment to protect distributed water quality.

9.11.8 Ultrafiltration (UF)

UF, characterized by a wide band of "molecular-weight cutoffs" (MWCO) and pore sizes, is used for removal of specific dissolved organics (e.g., humic substances, for control of disinfection byproducts in finished water) and for removing particulates. Due to typical UF membrane pore sizes and size exclusion capability (e.g., 0.01 micron, molecular/macromolecular range), UF is effective for absolute removal of *Giardia* cysts and partial removal of bacteria and viruses, and when used in combination with disinfection appears adequate for removal/inactivation of these microorganisms. Tests have also shown that filtrate turbidity may be kept consistently at or below 0.1 NTU).

> **Molecular Weight Cutoff** (MWCO) – a measure of the removal characteristic of a membrane in terms of atomic weight (mass) as opposed to pore size.

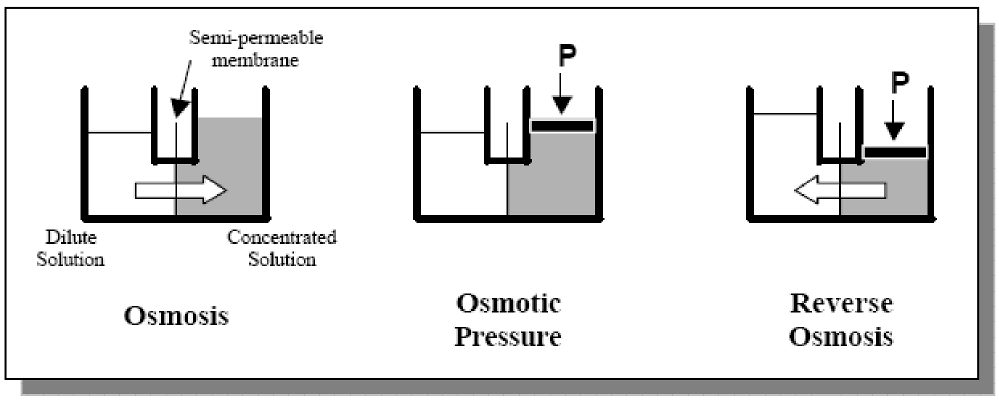
9.11.9 Nanofiltration (NF)

"NF and RO constitute the class of membrane processes that is most often used in applications that require the removal of dissolved contaminants. While NF and RO are sometimes referred to as "filters" of dissolved solids, NF and RO utilize semi-permeable membranes that do not have definable pores.

NF and RO processes achieve removal through the process of reverse osmosis, as described below. However, these membrane processes also represent a barrier to particulate matter. Osmosis is the natural flow of a solvent, such as water, through a semi permeable membrane (acting as a barrier to dissolved solids) from a less concentrated solution to a more concentrated solution. This flow will continue until the chemical potentials (or concentrations, for practical purposes) on both sides of the membrane are equal. The amount of pressure that must be applied to the more concentrated solution to stop this flow of water is called the osmotic pressure. An approximate rule of thumb for the osmotic pressure of fresh or brackish water is approximately 1 psi for every 100 mg/L difference in total dissolved solids (TDS) concentration on opposite sides of the membrane.

Reverse osmosis, as illustrated in Figure 9.10 is the reversal of the natural osmotic process, accomplished by applying pressure in excess of the osmotic pressure to the more concentrated solution. This pressure forces the water through the membrane against the natural osmotic gradient, thereby increasingly concentrating the water on one side (i.e., the feed) of the membrane and increasing the volume of water with a lower concentration of dissolved solids on the opposite side (i.e., the filtrate or permeate). The required operating pressure varies depending on the TDS of the feed water (i.e., osmotic potential), as well as on membrane properties and temperature." *(EPA Drinking Water website)*

Figure 9.10 Osmosis Model



Because semi-permeable NF and RO membranes are not porous, they have the ability to screen microorganisms and particulate matter in the feed water; however, they are not necessarily absolute barriers. NF and RO membranes are specifically designed for the removal of TDS and not particulate matter. Nonetheless, NF and RO are eligible for *Cryptosporidium* removal credit under the LT2ESWTR based on the demonstrated ability of these technologies to remove pathogens, as well as on the high probability that these processes can meet the requirements for membrane filtration specified in the rule.

The ability to maintain system integrity is one of the most important operational concerns associated with any membrane filtration facility, whether applied for compliance with the Long Term 2 Enhanced Surface Water Treatment Rule (LT2ESWTR) or for any other treatment objective. Because a membrane represents a physical barrier to pathogens and other drinking water contaminants, the means to ensure that this barrier remains uncompromised is critical for the ongoing protection of public health.

Due to typical NF membrane pore sizes and size exclusion capability (1nanometer range, e.g., organic compounds); NF is effective for removal of cysts, bacteria and viruses.

9.12 Membrane Information

The following section information comes from the ***USEPA Membrane Filtration Guidance Manual,*** EPA 815-D-03-008, June 2003

9.12.1 Membrane Modules

In general, MF and UF use hollow-fiber membranes, and NF and RO use spiral-wound membranes. The terms hollow-fiber, spiral- wound, and cartridge refer to the module in which the membrane media is manufactured. Normally, the membrane material is manufactured from a synthetic polymer, although other forms, including ceramic and metallic membranes, may be available.

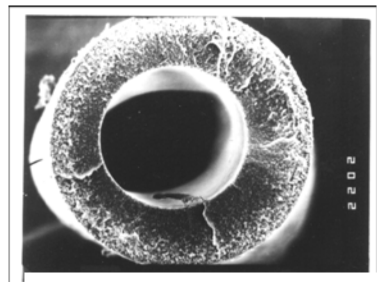


Figure 9.11 Hollow Fiber Cross-Section Photomicrograph

Figure 9.12 Spiral Wound Membrane Model

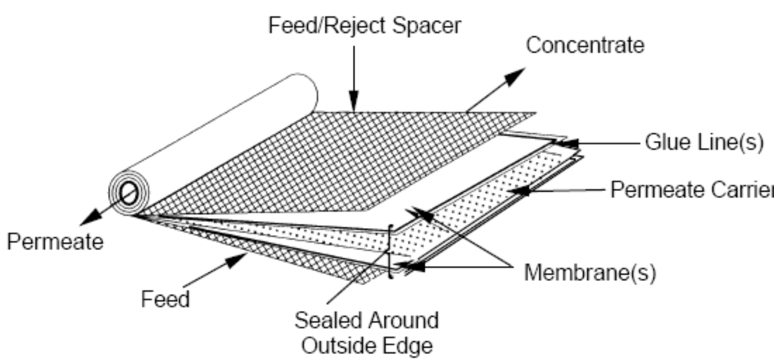
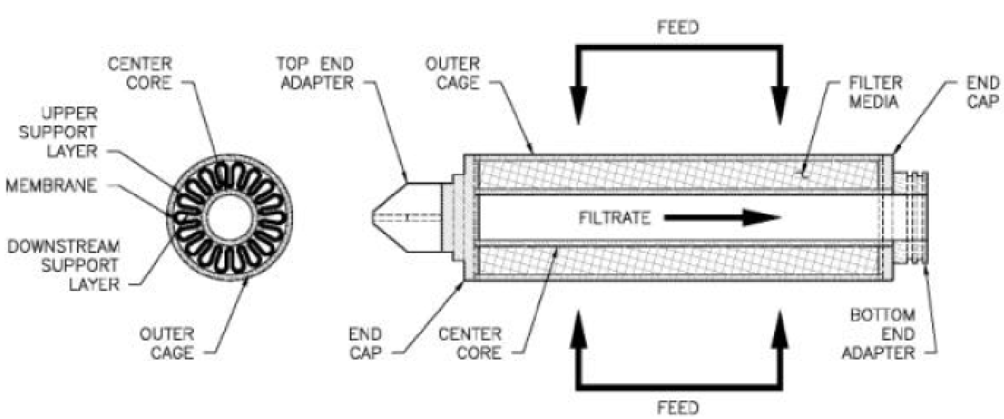


Figure 9.13 Membrane Cartridge Filter



9.12.2 Membrane Material

The material properties of the membrane may significantly impact the design and operation of the filtration system. For example, membranes constructed of polymers that react with oxidants commonly used in drinking water treatment should not be used with chlorinated feed water. Mechanical strength is another consideration, since a membrane with greater strength can withstand larger transmembrane pressure (TMP) allowing for greater operational flexibility and the use of higher pressures with pressure-based direct integrity testing.

Similarly, a membrane with bi-directional strength may allow cleaning operations or integrity testing to be performed from either the feed or the filtrate side of the membrane. Material properties influence the exclusion characteristic of a membrane as well. A membrane with a particular surface charge may achieve enhanced removal of particulate or microbial contaminant of the opposite surface charge due to electrostatic attraction. In addition, a membrane can be characterized as being hydrophilic (i.e., water attracting) or hydrophobic (i.e., water repelling). These terms describe the ease with which membranes can be wetted, as well as the propensity of the material to resist fouling to some degree.

Membrane filtration media is usually manufactured as flat sheet stock or as hollow fibers and then configured into one of several different types of membrane modules.

There are a number of general concepts that are applicable to all types of pressure-driven membrane filtration systems and which serve as the underlying basic principles for system design and operation. These concepts include flux, recovery, and flow balance (see the EPA *Membrane Filtration Guidance Manual,* page 70 for equations and calculation).

9.12.3 Membrane Integrity Testing

In order for a membrane process to be an effective barrier against pathogens and other particulate matter, the filtration system must be integral, or free of any leaks or defects resulting in an integrity breach. Thus, it is critical that operators are able to demonstrate the integrity of this barrier on an ongoing basis during system operation. ***Indirect integrity*** testing methods include: turbidity monitoring; particle counting and monitoring. ***Direct integrity*** testing methods include: air pressure tests; bubble point testing; and sonic wave sensing.

9.12.4 Direct Integrity Testing

A *direct integrity test* is a physical test applied to a membrane unit in order to identify and isolate integrity breaches. Direct integrity testing represents the most accurate means of assessing the integrity of a membrane filtration system that is currently available. In order to receive *Cryptosporidium* removal credit for compliance with the SWTR, the removal efficiency of a membrane filtration process must be routinely verified during operation using direct integrity testing. The direct integrity test must be applied to the physical elements of the entire membrane unit, including membranes, seals, potting material, associated valves and piping, and all other components which could result in contamination of the filtrate under compromised conditions. Chapter 4 in the EPA *Membrane Filtration Guidance Manual* explains integrity testing in more detail.

Although there are a number of types of direct integrity tests, the most common method is the ***pressure decay*** test, which measures the rate of pressure loss across the membrane relative to a maximum acceptable threshold.

9.12.5 Indirect Integrity Testing

Indirect integrity monitoring methods are not physical tests applied specifically to a membrane module or membrane unit, but instead involve monitoring some aspect of filtrate water quality as a surrogate measure of membrane integrity. Because the quality of membrane filtrate is very consistent and independent of fluctuations in feed water turbidity or particle levels, a marked decline in filtrate quality may indicate an integrity problem. Although indirect integrity monitoring is not as sensitive as direct testing for detecting integrity breaches, the indirect methods offer some significant benefits that make them an important and useful tool in an overall integrity verification strategy. These benefits include both the ability to be operated in a continuous, on-line mode and the non-proprietary nature of the indirect techniques, such that the same indirect method is similarly applicable to any membrane filtration system independent of manufacturer, configuration, or other system parameters.

While ***direct*** integrity tests can be extremely sensitive and thus can potentially verify high log removal values, most direct test methods require that the membranes be taken off-line (i.e., out of production mode) to undergo testing. Thus, these direct tests are limited to periodic application in order to minimize system down time. A failed periodic direct integrity test indicates that an integrity breach occurred at some time between the most recent direct test in which integrity has been verified and the failed test, but indicates nothing about integrity over the period between direct test applications. Continuous monitoring using ***indirect*** methods does provide a real-time indication of membrane integrity, albeit with less sensitivity in most cases. Consequently, the advantages of the direct and indirect integrity monitoring approaches are complementary, and both are critical elements of a comprehensive integrity verification program (IVP).

9.12.6 Membrane Failures

There are a number of potential modes of failure associated with membrane filtration systems that would result in an integrity breach. For example, membranes may become damaged via exposure to ***oxidants*** (chlorine), ***pH*** levels outside the recommended range, or other ***chemicals*** or operating conditions to which the membranes are sensitive. In addition, membranes may break or puncture as a result of ***extreme pressure, scratches*** or abrasions, or operational ***fatigue*** over time. Spiral- wound membranes can be damaged at glue lines if the pressure on the filtrate side of the membrane exceeds that on the feed side.

Factory imperfections such as glue line gaps or potting defects may cause integrity breaches, as well. ***Improper installation*** of membrane modules can also create integrity problems at o-rings or interconnections.

9.12.7 Membrane Filter Maintenance

One of the most critical aspects of employing membrane technology is ensuring that the membranes are intact and continuing to provide a barrier between the source water and the drinking water.

Filtration devices will eventually “clog up” and exhibit high head loss (pressure drop) after a given time period depending on the amount of suspended solids in the water. When a filter becomes overloaded and can no longer take up the impurities that are targeted for removal, these materials will “breakthrough” the filter and be released into the distribution system. In the case of filtration for substances that may cause adverse health affects, this breakthrough could be dangerous. Therefore, it is important for the operator to properly operate, monitor and maintain this treatment device. In general, membranes can be fouled by an accumulation of inorganic and organic compounds. Bacteria can also adhere to the membranes and create **biofilms**.

A change in operating conditions, periodic backwashing, and chemical cleaning are methods that may be used to control or get rid of fouling on the membrane. ***Several chemical cleaning techniques can be employed including chlorinated cleaning, however only certain membranes can withstand this method.*** An operator should always refer to manufacturer’s recommendations on the maintenance of equipment. Because other chemicals such as acids or caustics may also be used in the cleaning process, safety issues are also involved.

Water that goes out of the filter into the distribution system should be monitored closely for turbidity. **Backwashing** – is the process of reversing the flow of water through the filter media to remove the entrapped solids. Backwashing should occur when a filter reaches its maximum head loss, when a specific time period has occurred (based on manufacturers recommendation), or if breakthrough occurs. During this process filtration is stopped.

9.13 Basic Mathematics

The drinking water operator must be familiar with phrases such as gallons per day, cubic feet per second, pounds of chlorine, gallons per minute, and pounds per square inch. Much of the work involved with these phrases requires arithmetic and some algebraic calculation. The basic operations of arithmetic are addition, subtraction, multiplication and division. This section only highlights some basic mathematical information and calculations.

9.13.1 Algebra

Algebraic calculations basically deal with signs and symbols used to solving problems (or for solving the "unknown"). Frequently, the letter "x" is used to represent the unknown and parentheses ( ) are used to denote the multiplication function.

To solve for the unknown "x", two basic objectives are considered:

1. Get x to the numerator
2. Clear all other numbers from the x side of the equation to get "x" alone.
   Note: whatever is done to one side of the equation must be done to the other side.

9.13.2 Units of Measurement

There are two systems of measurement: (1) the English system, and (2) the metric system. Numbers can be assigned a particular unit of measurement to depict length, width, area, volume, etc. When conducting mathematical calculations of quantities, the quantities must be in the same units. If they are not, they must be converted to a common unit.

Common "units" or terms used in waterworks operations:

gpm	= gallons per minute	lb	= pound
gpd	= gallons per day	ppm	= parts per million
mgd	= million gallons per day	ppb	= parts per billion
cfs	= cubic feet per second	mg/l	= milligrams per liter
psi	= pounds per square inch		(mg/l is same as ppm)

Common conversions from one unit to another:

Multiply	By	To Obtain
Cubic Feet (ft^3 or cu.ft.)	62.4	Pounds (lbs) of water
Gallons of water	8.34	Pounds (lbs) of water
Feet of water (ft)	0.433	Pounds/square Inch (psi)

Note: ***Velocity*** (speed) of flow of water is often expressed as feet per minute (fpm) or feet per second (fps). The ***rate of flow*** (Q) indicates how much water is moving past a spot in a unit of time and is expressed as gallons per unit of time. Pump capacities are usually expressed in gallons per minute (gpm).

9.13.3 Solving Equations

Most of the arithmetic problems the operator will work with requires plugging numbers into formulas and calculating the answer. There are a few basic rules that apply to solving formulas:

1. Work from left to right
2. Do all multiplication & division above the line (in the numerator) and below the line (denominator); then do the addition and subtraction above and below the line.
3. Perform the division (divide the numerator by the denominator).
4. Complete all arithmetic within parentheses before working outside the parentheses.

9.13.4 Decimals

The decimal system is a way of counting or measuring using units that are powers of ten such as thousands, hundreds, tens, ones, tenths, hundredths, or thousandths. Whole numbers are written to the left of the decimal point. Fractions are written to the right of the decimal point.

Rules for rounding decimals:

1. Look to the right of the place to which you want to round.
2. If the digit to the right of that place is 5 or greater than 5, round up.
3. If the digit to the right is 4 or less than 4, do not change the number in the place you are rounding to.

9.13.5 Fractions

A fraction is an unexecuted division and involves a numerator and denominator separated by a "fraction bar". A fraction can be converted into a decimal by dividing the numerator by the denominator.

$$\frac{\text{numerator}}{\text{denominator}}$$

Examples: ¼ = 1 ÷ 4 = 0.25   2/3 = 2 ÷ 3 = 0.67

9.13.6 Percentage

Percent means parts per 100 parts. "Per" means divided by and a percent is the numerator of a fraction whose denominator is always 100. Percentage computations are frequently made by operators when calculating chlorine dosages and other chemical feed rates, pump and motor efficiencies and in other instances.

Examples: $\frac{50}{100}$ = 50% $\frac{2.5}{100}$ = 2.5%

Percentage problems:

<u>What is 16 % of 80?</u>

$$80 \times \frac{16}{100} = \frac{1280}{100} = 12.8$$

OR you could change 16% into a decimal & multiply it by 80:

0.16 x 80 = 12.8

<u>A 500 gallon tank contains 320 gallons. What percent of the tank is full?</u>

A percent means parts per 100 parts. Think of this example as "parts per parts". Relate the number of gallons in the tank to the total number of gallons available in the tank.

320 gallons in a 500 gallon tank is the same as:
320 gallons/500 gallons or 320 gal ÷ 500 gal
320 gal ÷ 500 gal = 0.64

Converting the decimal 0.64 to a percent gives us 64% (0.64 x 100%)

9.13.7 Computing Chlorine Injection

Injection of chlorine is calculated by parts per million (ppm) - that is, so many pounds of chlorine for every million pounds of water. Chlorinator adjustment is usually by pounds per day of chlorine and is calculated on the basis of how many million pounds of water are being treated in 24 hrs and adjusting 1 lb of chlorine for each million pounds of water.

When calculating the concentration of a chemical in water, the weight of the chemical is placed on the top part of the concentration formula and the weight of water (expressed in millions of units), is put on the bottom of the formula.

$$\text{ppm} = \frac{\text{lbs of pure chemical}}{\text{million lbs of water}} \qquad \text{mg/l} = \frac{\text{milligrams of chemical}}{\text{liters of water}}$$

The disinfection example problems on the following pages are from the MDEQ Limited Treatment Course *"Water Distribution and Limited Chemical Treatment Review Manual*" (2nd edition). This course is recommended for certified drinking water operators involved with water treatment.

Example 1: A chlorinator is set to feed 10 lbs of chlorine per day to a flow of 250 gpm. What is the chlorine does in ppm?

$$\frac{250 \text{ gal}}{\text{min}} \times \frac{60 \text{ min}}{\text{hr}} \times \frac{24 \text{ hrs}}{\text{day}} \times \frac{8.34 \text{ lbs}}{\text{gal}} = 3{,}002{,}400 \text{ lbs/day } (\sim 3 \text{ million lbs})$$

$$\text{ppm} = \frac{10 \text{ lbs}}{3 \text{ M lbs}} = 3.3 \text{ ppm}$$

Note: "million pounds" = M lbs. For the above calculation, the use of the conversion factor 8.34 lb/gal (the weight of water) s necessary.

Example 2: A facility chlorinates its drinking water. If 1.7 million gallons are pumped each day, how many pounds of 100% available chlorine are needed to produce 1.0 ppm?

1. Set up equation & substitute as needed.

$$\text{ppm} = \frac{\text{lbs of chlorine}}{\text{M lbs of water}} \qquad 1.0 \text{ ppm} = \frac{\text{lbs of chlorine}}{1.7 \text{ M gal} \times 8.34 \text{ lbs/gal}}$$

$$1.0 \text{ ppm} = \frac{\text{lbs of chlorine}}{14.2 \text{ M lbs of water}}$$

2. Now solve for the unknown pounds of chlorine.
3. Multiply both sides of equation by 14.2 M lbs.
4. Because "ppm" is lbs per M lbs, the M lbs cancel & left with lbs chlorine.

$$\frac{1.0 \text{ lb}}{\text{M lbs}} \times 14.2 \text{ M lbs} = 4.2 \text{ lbs of 100\% chlorine}$$

In most operations, 100% available chemical is not used, but some other concentration such as 5.25%, 10%, or 65% available chlorine is used. One way to think of the "percent available" of the compound (cmpd) is as follows. Because percent is "parts per 100 parts", "percent available" represents the amount of pure substance, in pounds, per 100 pounds of compound. For a 65% available chlorine compound, there is 65 lbs of pure chlorine in 100 lbs of compound. From this, it can easily be calculated to how many pounds of pure chemical is available provided it is known how many pounds of compound there is and what the "percent available" is.

Example 3: How many pounds of chlorine are in 4 lbs of a compound that has 65% available chlorine?

$$\frac{65 \text{ lbs pure chlorine}}{100 \text{ lbs of cmpd}} \times 4 \text{ lbs of cmpd} = 2.6 \text{ lbs pure chlorine}$$

Therefore, 2.6 lbs of pure chlorine are contained in 4 lbs of a compound that has 65% available chlorine.

Example 4: How many pounds of chlorine are in 5 gallons of compound that weights 10 pounds per gallon and has 10% available chlorine?

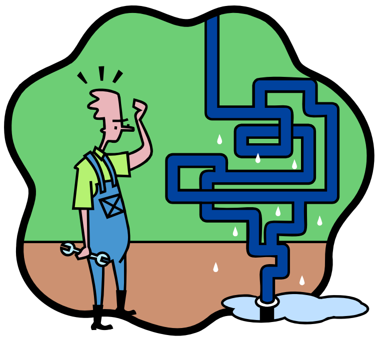
10% x 50 lbs = 0.10 x 50 lbs = 5 lbs of pure chlorine

Example 5: How many gallons of water must be added to 20 gallons of a 5 percent hypochlorite solution to produce a 1.5 percent hypochlorite solution?

$$\text{unknown - water added} = \frac{(\text{gal of hypo})(\%\text{ hypo}) - (\text{gal of hypo})(\%\text{ desired})}{\text{desired hypo }\%}$$

$$\frac{(20 \text{ gal}) \times (5\%) - (20 \text{ gal}) \times (1.5\%)}{1.5\%} = \frac{100 - 30}{1.5} = 46.7 \text{ gallons}$$

CHAPTER 10
Cross Connection Control



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Cross Connection Control

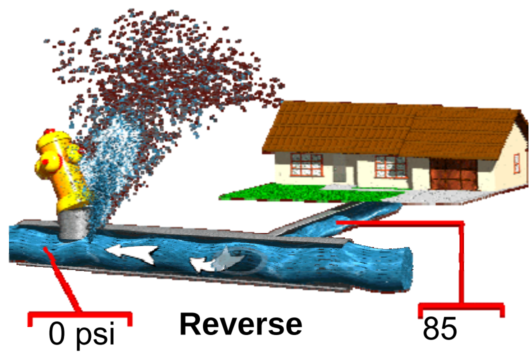
10.0 Chapter Overview

A cross connection is a direct connection of a potable water source with any system, equipment or fixture which contains **nonpotable** water. Cross connections can affect water quality and create health problems due to contamination from backflow.

Cases of illness, disease, and death have been documented as resulting from cross connections between potable water systems and non-potable water, sewage, and chemicals. Increased awareness and vigilance through cross connection prevention programs have reduced the number and severity, but “incidents” continue to occur.

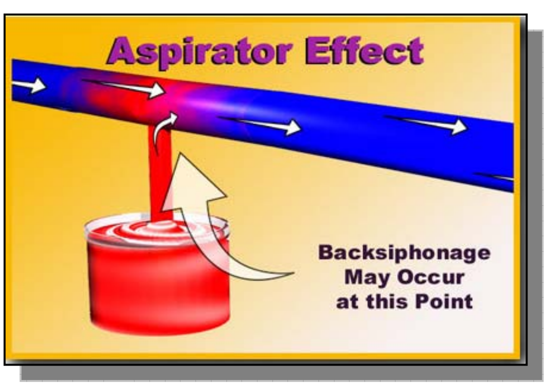
10.1 Backflow

Backflow is an undesirable reversed flow in a piping system. Backflow can be caused by backsiphonage, backpressure, or a combination of the two.



10.2 Backsiphonage Backflow

Backsiphonage backflow occurs when there is a partial vacuum (negative pressure) in a potable water supply system, potentially drawing contaminants into the water supply. The effect is similar to sipping a soda by inhaling through a straw.

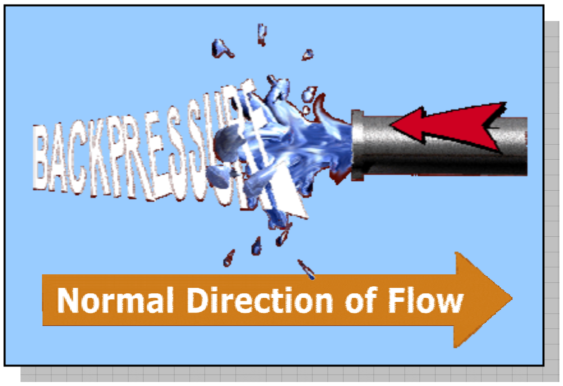


Heavy water demands, such as those created by fire fighting, repairs or breaks in municipal mains, and others, may create this back-siphonage situation. Under these conditions, hoses dangling in chemistry, biology, or photography laboratory sinks, janitors slop sinks, or other systems can provide the connection through which backflow (by back-siphonage) can occur.

10.3 Backpressure Backflow

Backpressure backflow occurs when the pressure of the non-potable system exceeds the positive pressure in the potable water distribution lines.

These situations may develop when a potable water supply system is directly or indirectly connected to heating systems, elevated tanks, pressure-producing systems, individual water supply systems, and the like. For example, if a boiler used in conjunction with a heating system is operating at 15 psi pressure and the potable water supply system is operating at 20 psi, and something happens to reduce the pressure in the potable water supply system, the water pressure from the boiler will exceed the system pressure. Since water flows from high pressure to low pressure, the backpressure situation would allow boiler water to flow into the potable system.



Prevention of cross connection contamination of the drinking water supply is the best management practice an operator can have. A water system should develop a sound program that eliminates health hazards caused by cross connections. Elimination of all direct connections between potable and nonpotable water is the best means of preventing cross connections.

10.4 Backflow Prevention Techniques

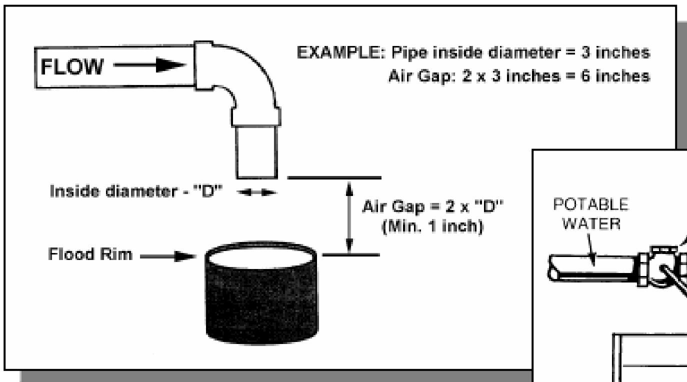
If a cross connection is discovered, its elimination first involves determining the means by which backflow might occur in that situation. If backflow can only occur by backsiphonage, then a particular backflow prevention device may be required. If, however, backflow could occur by either backsiphonage or backpressure, then that particular device may not be appropriate. Refer to the Michigan Plumbing Code and the DEQ Cross Connection Control Manual for specifics and appropriate use of devices. All approved backflow prevention devices must meet the Michigan Plumbing Code regulations and NSF/ASSE standards.

There are several basic ways to prevent or reduce the possibility of backflow in cross connections: air gaps, atmospheric vacuum breakers, hose bibb vacuum breakers, pressure type vacuum breaker assemblies, double check valve assemblies, dual-check valve with intermediate atmospheric vent, and reduced-pressure backflow prevention assemblies. The most reliable means of preventing backflow is an air gap.

10.4.1 Air Gap

An air gap is a *physical separation* of the potable and nonpotable systems by an air space. It cannot be used however for a direct connection to a pressurized system. An approved air gap must be at least 2 times the diameter of the water supply line but no smaller than 1 inch.

Typical Uses: Bathtubs, sinks, swimming pool fill inlets, fills for tank trucks and spraying equipment.



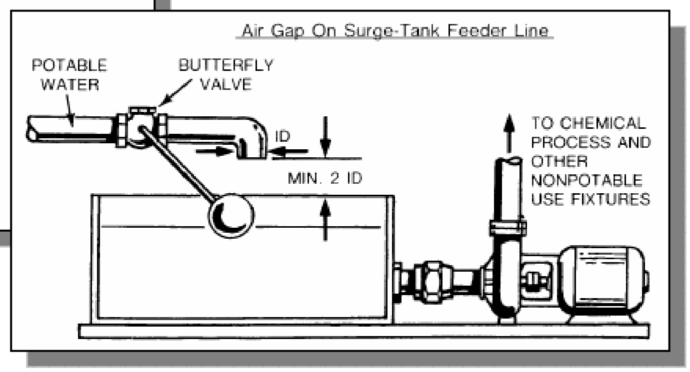


Figure 10.1 Air Gaps

10.4.2 Reduced Pressure Principle Device (RPZ)

This assembly provides protection against backpressure and backsiphonage. The RPZ can be used under continuous pressure and in high-hazard conditions. It consists of 2 independently acting internally loaded check valves separated by a reduced pressure zone.

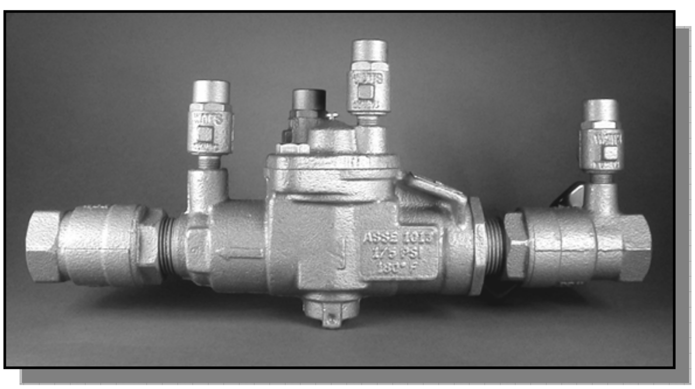


Figure 10.2 RPZ

Typical Uses: Plating shops, sewer plants, hospitals and chemical plants, treated boiler systems, etc.

Maintenance: Most RPZ failures are due to dirt and debris, therefore, keep the device clean.

Inspection: There are 3 test ports on the device used to check if the valves are properly working. The test should be done routinely by a licensed plumbing contractor and is based on the manufacturers' recommendation. Reliability of the device that it is protecting public health increases with regular inspection.

10.4.3 Atmospheric Vacuum Breaker (AVB)

AVBs allow air to enter the waterline when the pressure in the public system or the service line is reduced to 0 or below, however, since the vacuum relief valve is not internally loaded, the device must be installed on a discharge side of the shut off valve. AVBs should not be subjected to continuous flows for periods of more than 12 hours. They can be used in situations where **no chemicals** are added and are intended for **backsiphonage** potential only.

Typical Uses: Flush valve toilets, hose bibb outlet where a hose might be attached, dishwashers, janitor slop sinks, laboratory gooseneck faucets, beauty salon sinks, photo development machines.

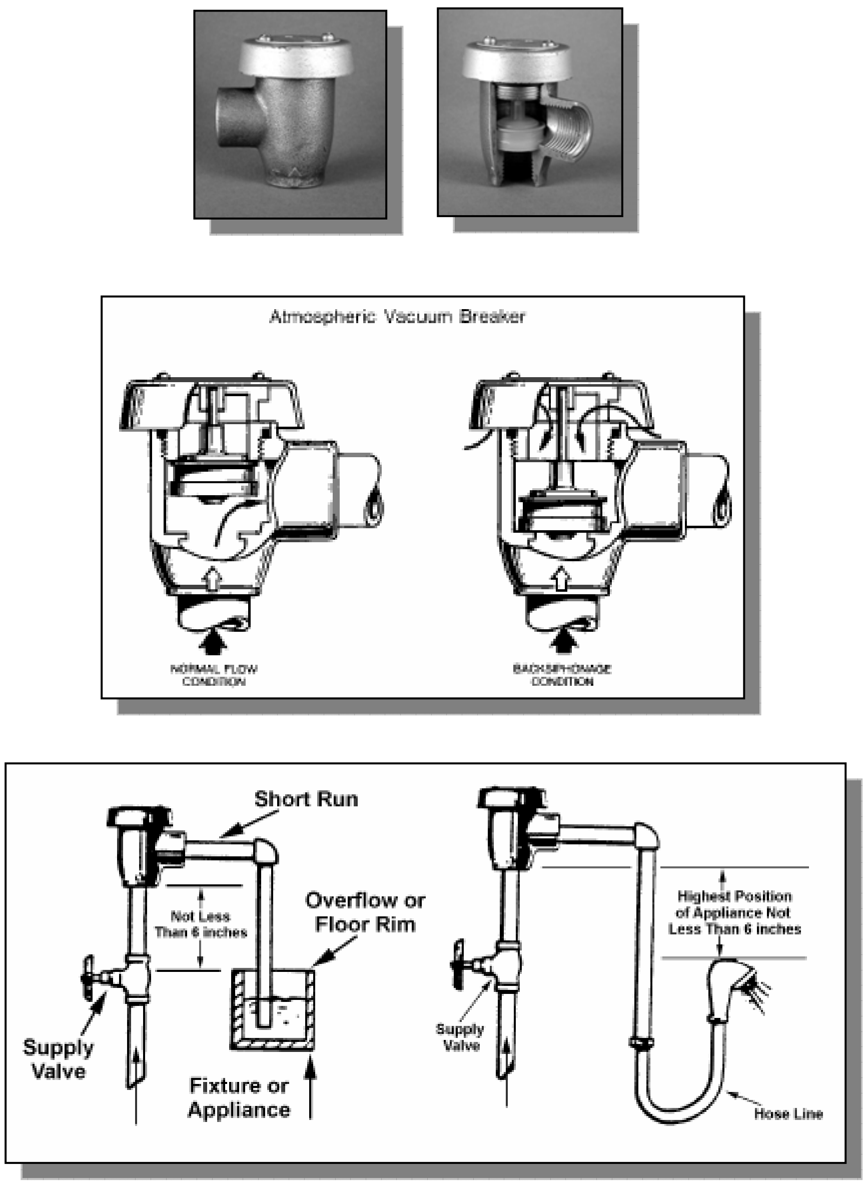


Figure 10.3 Atmospheric Vacuum Breakers

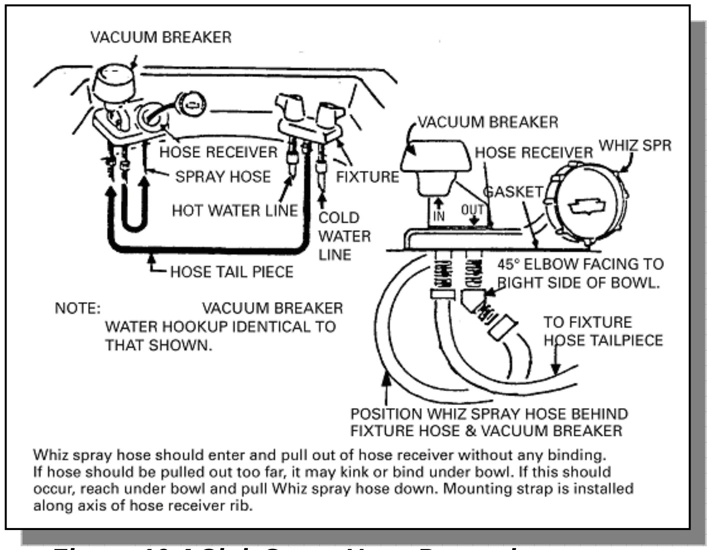


Figure 10.4 Sink Spray Hose Protection

10.4.4 Pressure Vacuum Breaker (PVB)

This device allows air to enter the waterline when the pressure in the public system or the service line is reduced to 0 or below. The device has a vacuum relief valve which is internally loaded, normally be means of a spring.

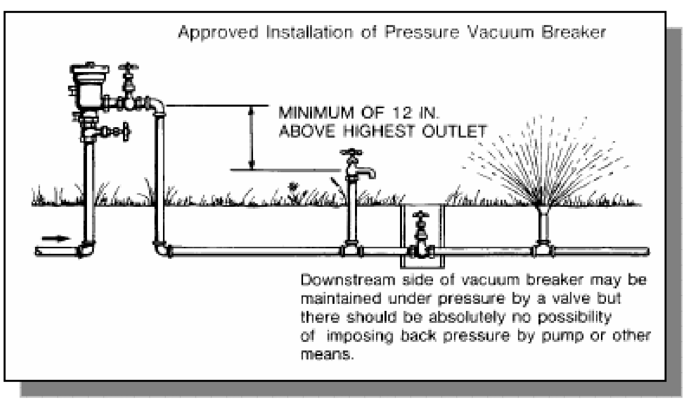


Figure 10.5 PVB

Typical Uses: Lawn sprinkler systems (no chemicals), photo developers.

Maintenance: Routine inspection according to manufacturers' recommendations. This device has 2 test ports that must be checked regularly to ensure its reliability.

10.4.5 Hose Bibb Vacuum Breaker

This device is used to protect primarily against back-siphonage at otherwise unprotected hose bibbs.

Typical Uses: Janitor slop sink, marinas, wash down hoses, swimming pools, and in general all hose uses.

Figure 10.6 Hose Bibb Vacuum Breakers

10.4.6 Double-Check Valve Assembly

These assemblies are used for a direct connection between two potable systems and therefore have very limited application. This device protects against backpressure and back-siphonage conditions <u>only</u> if the cross connection protection is from substances that <u>do not constitute a health hazard</u>.

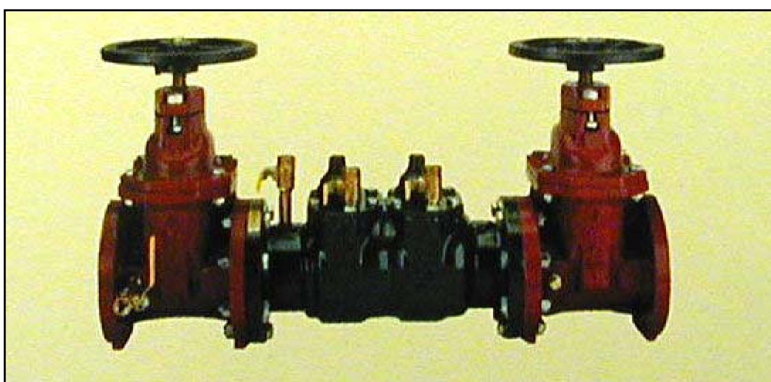


Figure 10.7 Double-check valve assembly

Typical Uses: Fire suppression systems with identical connections.

10.4.7 Dual-Check Valve with Intermediate Atmospheric Vent

This assembly is permitted for low or moderate hazard with small pipe sizes. It can be used to protect against backpressure and can be used under continuous pressure. A specific type made of stainless steel has also been developed for carbonated beverage application.

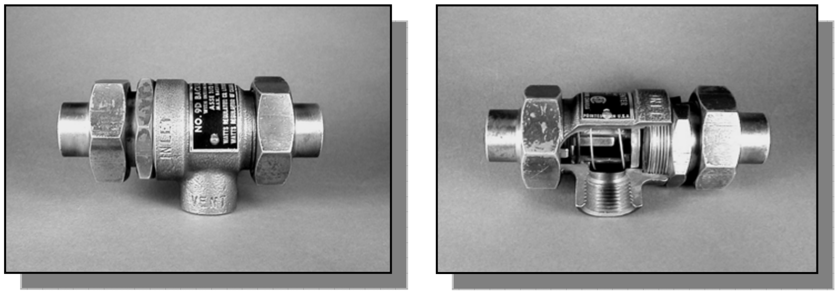


Figure 10.8 Dual-check valve atmospheric vent

Typical Uses: Domestic boilers (no treatment), heat exchangers (no treatment), carbonators (see info below).

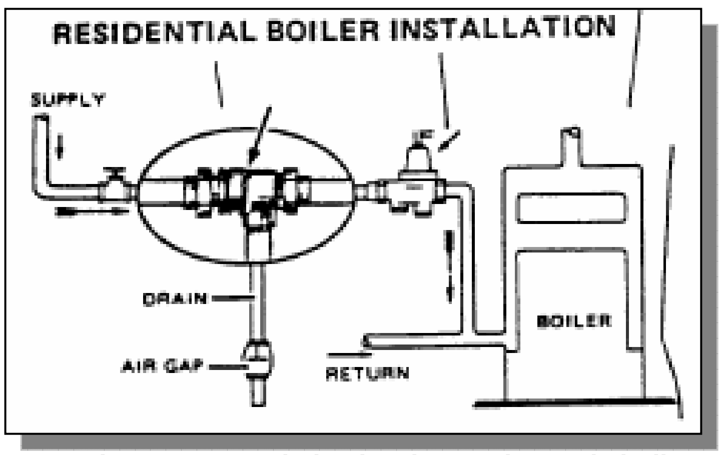


Figure 10.9 Dual-check valve on domestic boiler

Beverage Machine Carbonators:

The special backflow device for carbonators prevents the backflow of carbon dioxide gas and carbonated water into the water supply for vending machines, thus eliminating the hazardous reaction of carbon dioxide with copper tubing.

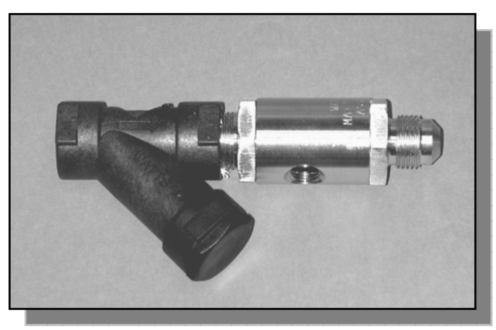


Figure 10.10 Backflow preventer for carbonator

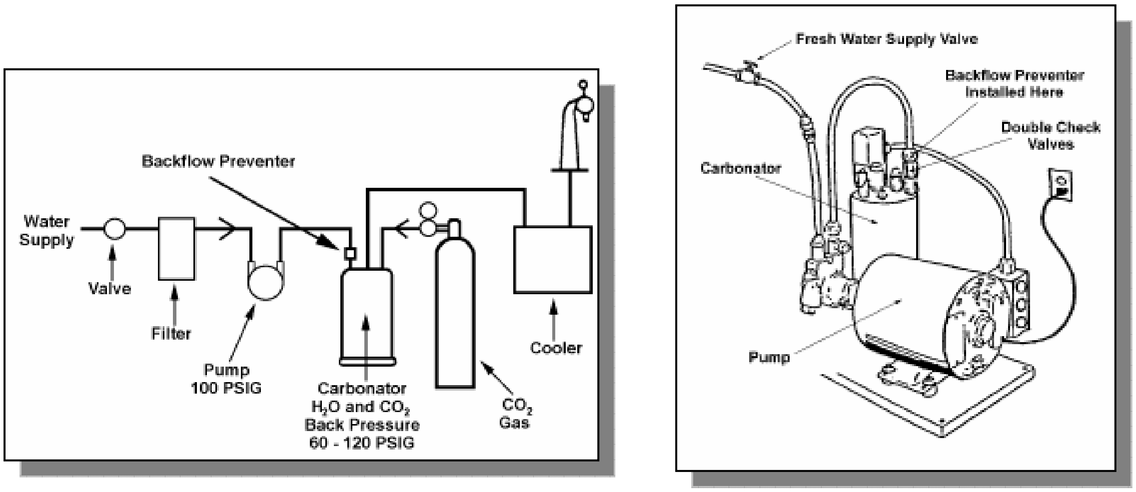


Figure 10.11 Beverage machine carbonators' backflow preventer installation position

Trap Primer:

Trap primers are installed to prevent floor drain traps from loosing their water seal by evaporation. Maintaining the water seal will prevent the backflow of sewer gas into the buildings or rooms where the trap is installed.

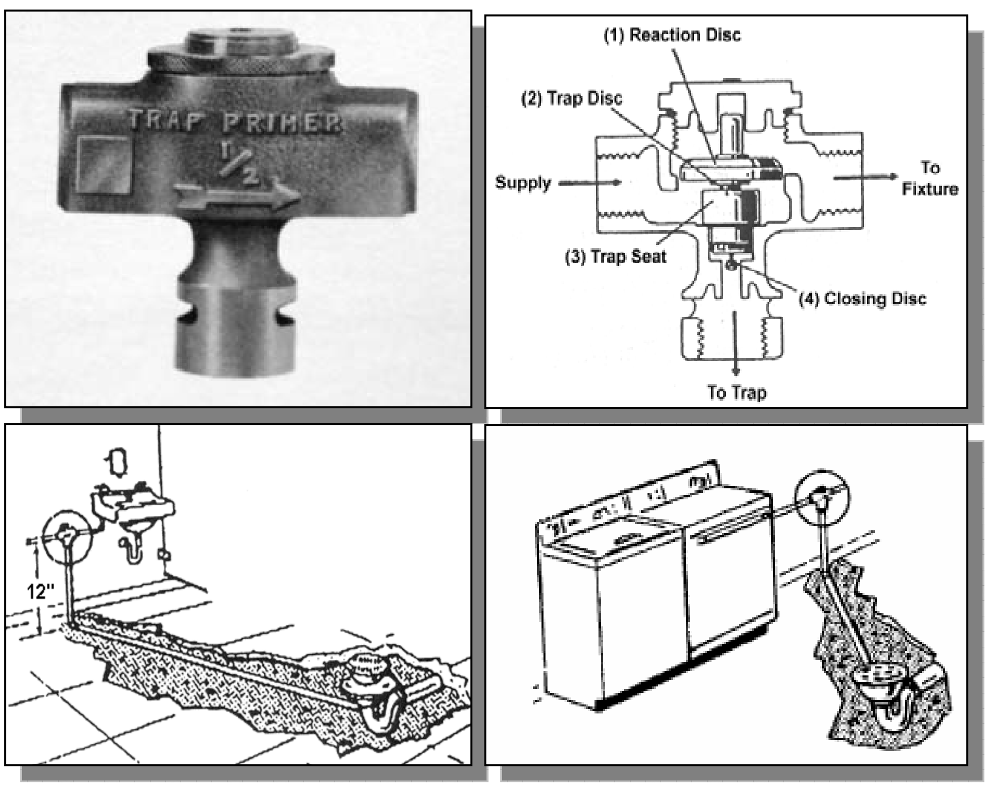


Figure 10.12 Trap Primer

Source of cross connection device pictures:
State of Connecticut Cross Connection Control Manual, Jan. 2003

CHAPTER 11
Safety & Emergency Issues

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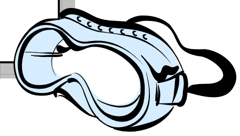
Safety & Emergency Issues



11.0 Chapter Overview

Everyone involved in the NCWS facility is responsible for maintaining a safe and secure environment. When tools are left lying around or when spills are left for someone else to clean up, accidents are possible. When a water pipe breaks or the well pump doesn't work, a plan must be in place to take care of the problem quickly. If the person in charge of the water system is not around, others need to know what to do and who to call in case of an emergency.

The federal government established minimum health safety standards under the Occupational Safety and Health Act of 1970 (**OSHA**). These standards require that every employer furnish employees with a place of employment that is free from recognized hazards that are likely to cause death or serious injury.

The Michigan Legislature created the Michigan Occupational Safety and Health Act, Public Act 154 of 1974 (**MIOSHA**), in order to better prevent workplace injuries, illnesses and fatalities in Michigan. These occupational safety and health standards promote safety and health training for the workplace.

11.1 Confined Space Rule

This MIOSHA rule is intended to provide protection to an employee from traumatic injury. A confined space is an area where the oxygen supply may be of insufficient quantity or that harmful gases may be present and includes, but is not limited to, a bin, silo, hopper, tank, manholes, or well pit. MIOSHA standards involve tests and procedures which must be followed before entry into a confined or hazardous space. Oxygen and gas detectors are to be used to check the air quality and personal protection equipment worn by the individual entering the confined space must be appropriate.

Statute authority
Refer to:
Michigan Occupational Safety and Health Act of 1974
R 408.10016 Work in confined or hazardous spaces

11.2 Protective Clothing

An assortment of personal protection equipment is available to protect a worker on the job site. This equipment can be very successful in preventing serious injuries and include items such as: hardhats, safety goggles, steel-toed safety shoes, face shields, gloves, safety belts, aprons, ear protection, and respiratory equipment. The owner of the facility is responsible for making sure certain equipment is available for the worker, but it is the workers responsibility to use the equipment.

11.3 Electrical Safety

When electrical equipment or motors are to be worked on, it is important that the person doing the work "locks out" and "tags" all electrical switches and is the person to remove the lockout device and tag. Remember when doing electrical work not to stand in water as it is a good conductor of electricity.

11.4 Handling Chemicals

A person must be very careful when handling chemicals. Many chemicals used in waterworks facilities may be acidic or corrosive and can cause severe skin burns, permenant eye damage, lung damage and even death. A Material Safety Data Sheet (MSDS), which describes the physical properties and the health and safety hazards associated with a chemical should be located at the water supply facility for each and every chemical used or stored there.

Chemicals such as hydrochloric acid (industrial name, muriatic acid) may be used to loosen incrustations from a well casing and well. This chemical is an acid and is very corrosive. If using an acid with water ALWAYS adde acid slowly to the water. ***NEVER ADD WATER TO ACID,*** A VIOLENT REACTION MAY OCCUR PRODUCING A LEATHAL GAS AND ACID COULD SPLASH ALL OVER YOU. Chlorine is often used for water quality treatment. Appropriate safety equipment such as protective eye goggles and rubber gloves must be used when handling any chemical.

11.5 Housekeeping Items

Of course, there are other items that a facility owner and operator must be aware of when it comes to safety issues. Along with MIOSHA rules and standards that must be followed, comes common sense that will help protect the health and safety of all persons who visit the establishment. Keeping work areas clear of debris, sidewalks and walkways in good condition, cleaning up water spills and messes are all things that should be done.

11.6 Contingency Plan

In the event of an emergency pertaining to the drinking water supply, it is necessary to act promptly and effectively to protect public health and welfare. In the context of this plan, emergencies could include complete loss of water pressure, contamination of water supply, and threats or observed vandalism to water system. Complete loss of water normally would require closure of the facility. Threats or contamination with unknown substances may also warrant such action. However, under certain situations where water is flowing but has been determined unsafe to drink by health authorities, it may be possible to operate the facilty with approval of the appropriate local or state agencies. If approved, operation for an interm period is dependent on providing an approved source of water for consumption and notification to the users to not consume the piped water in the facility.

A contingency plan includes information for immediate responses and may contain the following: an inventory of necessary standby personnel and equipment; obtaining an alternate source of water; public notification procedures; an inventory of contractors and suppliers; a method for notifying the local health department; and emergecny repair procedures.

See ***Appendix G*** for an example contingency plan form.

INDEX

CROSS REFERENCE – APPENDICES

Web Addresses:

www.michigan.gov/deqnoncommunitywatersupply

www.michigan.gov/deqoperatortraining

www.epa.gov/safewater

APPENDICES

APPENDIX A

PUBLIC WATER SUPPLY TYPE SUMMARY

Act 399, P.A. of 1976

Safe Drinking Water Act

"Public water supply" means a waterworks system which provides water for drinking or household purposes to persons other than the supplier of the water, except those systems which supply water to only one living unit. Public water supplies are classified into three types:

Type I

A community water supply providing year-round service units or serving not less than 25 residents.

1) Permits are required from the local heath department.
2) Engineering plans are required.
3) Examples: municipal water supplies, condominiums, apartment complexes, subdivision water supplies.

Type II

A noncommunity water supply which has no less than 15 service connections or which serves not less than 25 individuals on an average daily basis not less than 60 days out of the year.

1) Permits are required and issued by the local health department.
2) Construction details and sketch of well site are required.
3) Examples: schools, restaurants, industries, campgrounds, parks, motels.
4) See back of sheet for breakdown of different Type II water supplies.

Type III

All public water supplies which are not Type I or Type II public water supplies.

1) No MDEQ statewide permit required. Most local health departments require permits under local ordinances.
2) Examples: small apartment complex, small grocery store, small retail store.

A living unit is a house, apartment, or other domicile occupied or intended to be occupied on a day-to-day basis by an individual, family group, or equivalent.

A service connection is a direct connection from a distribution water main to a living unit or other facility for the purpose of providing water for drinking or household purposes.

Type II

A noncommunity water supply which has not less than 15 service connections or which serves not less than 25 individuals on an average daily basis not less than 60 days out of the year.

1) Permits are required and are issued by the local health department.
2) Construction details and sketch of well site are required.
3) Examples: schools, restaurants, industries, campgrounds, and parks.

Customer Type

Type II Nontransient

A Type II water supply that routinely serves the same 25 or more individuals on a daily basis at least 6 months per year.
Examples: schools, daycare centers, factories, offices and other work sites.

Average daily water production

Type IIa

Type II supplies with an average daily water production for the maximum month equal to or greater than 20,000 gallons per day.

Type IIb

Type II supplies with an average daily water production for the maximum month of less than 20,000 gallons per day.

Type II Transient

Any Type II (noncommunity) water supply which does not meet the definition for a Type II nontransient water supply.
Examples include motels and restaurants with less than 25 employees, medical offices, parks, campgrounds, churches, and marinas.

Average daily water production

Type IIa

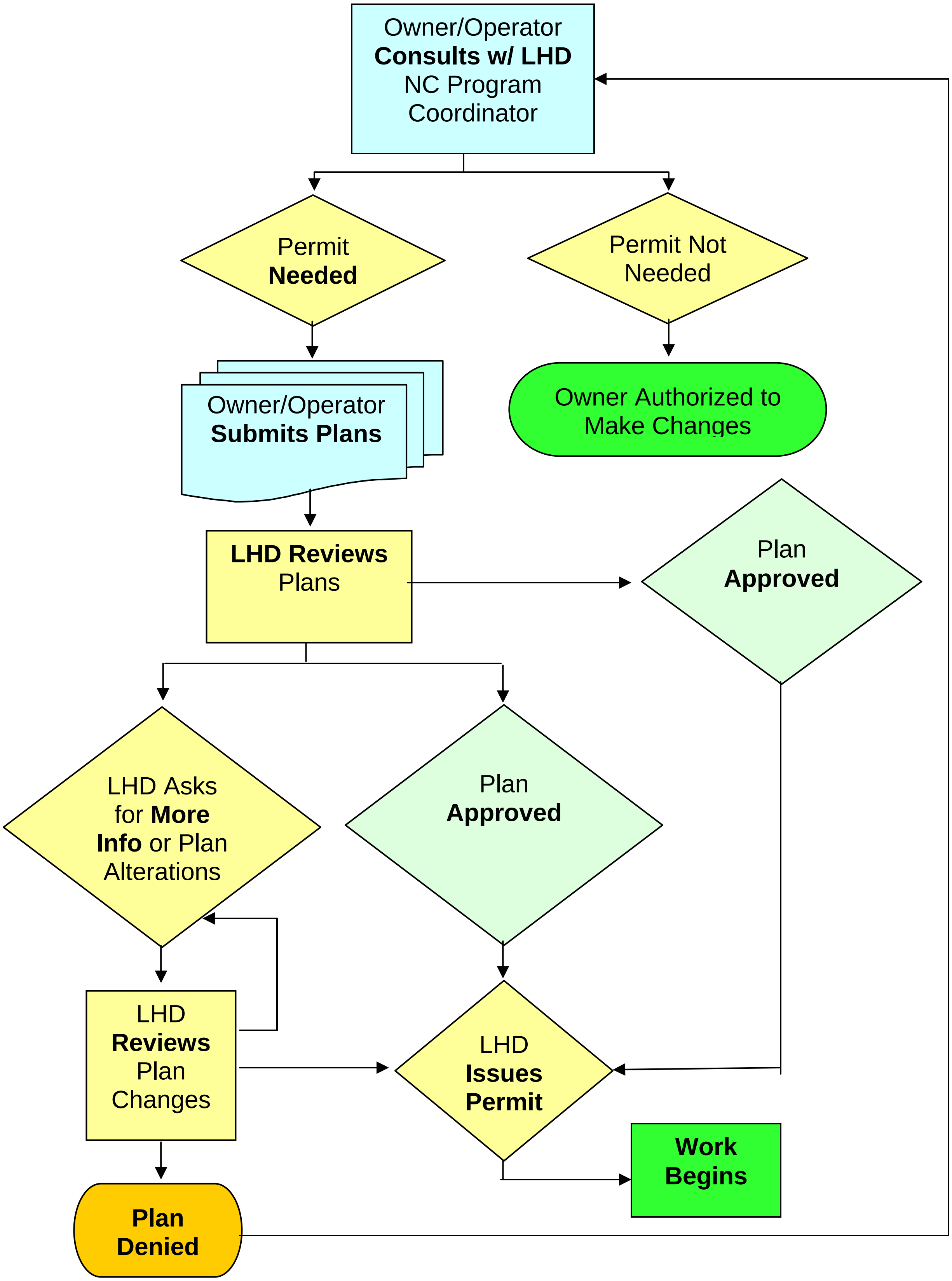
Type II supplies with an average daily water production for the maximum month equal to or greater than 20,000 gallons per day.

Type IIb

Type II supplies with an average daily water production for the maximum month of less than 20,000 gallons/day.

APPENDIX B

STEPS FOR WATER SYSTEM ADDITION/ALTERATION/REPAIR



APPENDIX C

EPA National Primary Drinking Water Standards

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

LEGEND

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

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

LEGEND

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

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

LEGEND

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

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

LEGEND

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

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

NOTES

1 Definitions

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

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

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

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

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

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

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

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

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

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

LEGEND

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

National Secondary Drinking Water Standards

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

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

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

APPENDIX D

EXAMPLE LABORATORY RESULT REPORT

Michigan Department of Environmental Quality
MDEQ/DWRP Drinking Water Chemistry Database

Sample Number: LLC03080

Analyzed by : Lansing Lab

Owner/Location Information:

MAINSTREET SCHOOL
1234 MAIN
LANSING MI - 48909

Sample/Collection Information:

WSSN :	2012345	Site Code :	2012345
County :	CLINTON	Water Source :	Public Non-Community Water Supply
Township :	DUPLAIN	Sample Reason :	Routine Monitoring
Section :	26	Sample Point :	Breakroom faucet
Well # :	002	Point Description :	Public System Well
Collection Date :	02/27/2008 15:30:00 PM	Collector :	Public Water Supply Operator
Arrival Date :	02/28/2008 07:51:14 AM	Collected By :	JOHN LEWIS

Case No.	Analyte	Result	Detect	Units	Method
TC-00-B	COLIFORM ORGANISMS PER 100ML	ND	-	-	SM 9223 B

Laboratory Comments :
No Comments entered for this Sample Number.

By authority of PA 368 of 1978 as amended. Print Date : 3/3/2008 Print Time : 2:09:32 PM

According to the laboratory analysis for this sample, no coliform bacteria were found (non-detected).

All the information in this area MUST be filled out completely and accurately or the results may not be credited to your facility and a monitoring violation could occur.

General MDEQ State Laboratory report interpretation information:

Sample number - The computer ID number for each analyte under a given test code.

Analyte - Name of the reported analyte/substance.

"RPT LIMITS" Reporting Limits are given as two values separated by a dash. The first value is the Reporting Quantitation Limit (RQL). Results below the RQL can't be reported with sufficient accuracy, and a qualitative result will be given. The second value is the estimated Method Detection Limit (MDL). Results found to be below the MDL will be reported as "ND" (Not Detected). A report of ND means there is no scientific evidence that any of the tested substance in the sample.

"MCL" The "Maximum Contaminant Limit" is a legal limit established under state and federal law. Public supplies should not exceed this limit for the given contaminant under federal/state regulation. While a "safety factor" is usually built into the limit setting process, safety can not be assured for any supply which exceeds the limit.

EXAMPLE LABORATORY RESULT REPORT

(Metals Analysis)

Michigan Department of Environmental Quality
MDEQ/DWRP Drinking Water Chemistry Database

Analyzed by : Lansing Lab

Sample Number: LLB77471

Owner/Location Information:

MAINSTREET SCHOOLS
1234 MAIN
LANSING MI - 48909

Sample/Collection Information:

WSSN :	2012345	Site Code :	2012345
County :	Clinton	Water Source :	Public Non-Community Water Supply
Township :	DUPLAIN	Sample Reason :	Routine Monitoring
Section :	26	Sample Point :	Breakroom faucet
Well # :	002	Point Description :	Public System Well
Collection Date :	09/11/2007 15:00:00 PM	Collector :	Public Water Supply Operator
Arrival Date :	09/12/2007 13:26:30 PM	Collected By :	John Lewis

Case No.	Analyte	Result	Detect	Units	Method
7440-36-0	ANTIMONY	ND	0.0006	MG/L	EPA 200.8
7440-38-2	ARSENIC (TOTAL)	ND	0.002	MG/L	EPA 200.8
7440-39-3	BARIUM	0.03	0.01	MG/L	EPA 200.8
7440-41-7	BERYLLIUM	ND	0.0004	MG/L	EPA 200.8
7440-43-9	CADMIUM (TOTAL)	ND	0.0003	MG/L	EPA 200.8
7440-47-3	CHROMIUM (TOTAL)	ND	0.01	MG/L	EPA 200.8
7439-92-1	LEAD (TOTAL)	0.001	0.001	MG/L	EPA 200.8
7439-97-6	MERCURY	ND	0.0001	MG/L	EPA 200.8
7440-02-0	NICKEL	ND	0.01	MG/L	EPA 200.8
7782-49-2	SELENIUM (TOTAL)	ND	0.001	MG/L	EPA 200.8
7440-28-0	THALLIUM	ND	0.0002	MG/L	EPA 200.8

Laboratory Comments :
No Comments entered for this Sample Number.

By authority of PA 368 of 1978 as amended. Print Date : 3/3/2008 Print Time : 2:53:24 PM

This column shows the laboratory results in mg/l.

General MDEQ State Laboratory report interpretation information:

Sample number - The computer ID number for each analyte under a given test code.

Analyte - Name of the reported analyte/substance.

"RPT LIMITS" Reporting Limits are given as two values separated by a dash. The first value is the Reporting Quantitation Limit (RQL). Results below the RQL can't be reported with sufficient accuracy, and a qualitative result will be given. The second value is the estimated Method Detection Limit (MDL). Results found to be below the MDL will be reported as "ND" (Not Detected). A report of ND means there is no scientific evidence that any of the tested substance in the sample.

"MCL" The "Maximum Contaminant Limit" is a legal limit established under state and federal law. Public supplies should not exceed this limit for the given contaminant under federal/state regulation. While a "safety factor" is usually built into the limit setting process, safety can not be assured for any supply which exceeds the limit.

APPENDIX E

Monitoring Violation Notice – Template NC-6

DRINKING WATER NOTICE

Monitoring requirements not met for [system]

We violated a drinking water standard. Even though this is not an emergency, as our customers, you have the right to know what happened and what we are doing to correct this situation.

We are required to monitor your drinking water for specific contaminants on a regular basis. Results of regular monitoring are an indicator of whether or not our drinking water meets health standards. During [compliance period] we [‘did not monitor’ or ‘did not complete all monitoring’] for [contaminant(s)] and therefore cannot be sure of the quality of our drinking water during that time.

What This Means

There is nothing you need to do at this time. The table below lists the contaminant(s) we did not properly test for, how often we are supposed to sample for [it/them] and how many samples we are suppose to take, how many samples we took, when samples should have been taken, and the date on which follow-up samples were (or will be) taken.

Contaminant	Required sampling frequency	When samples should have been taken
Coliform (example)	Twice per month	July 1, July 15, August 1

Steps We Are Taking

[Describe corrective action.] For more information, please contact [name of contact] of [system] at [phone number] or [location/address].

Please share this information with all the other people who drink this water, especially those who may not have received this notice directly (for example, people in apartments, nursing homes, schools, and businesses). You can do this by posting this notice in a public place or distributing copies by hand or mail.

This notice is being sent to you by [system]. State Water System ID#:_____________________

Date distributed:______________

DO NOT DRINK THIS WATER

Do Not Use Tap Water For:
Drinking
Soup, Juice, Coffee
Making Ice
Brushing teeth

Use Special Precautions For:
Hand Washing
Bathing
Showering

For your safety, until the problem is corrected, safe water is provided as follows:

____

E. coli bacteria were found in the [System Name} water supply on [date].

DO NOT DRINK THE WATER.
USE ALTERNATE SUPPLY OF WATER FOR CONSUMPTION AND OTHER USES AS NOTED

Potential Health Effects
Fecal coliforms and E. coli are bacteria whose presence indicates that the water may be contaminated with human or animal wastes. Microbes in these wastes can cause diarrhea, cramps, nausea, headaches, or other symptoms. They may pose a special health risk for infants, young children, some of the elderly, and people with severely compromised immune systems.

The symptoms above are not caused only by organisms in drinking water. If you experience any of these symptoms and they persist, you may want to seek medical advice. People at increased risk should seek advice about drinking water from their health care providers. Use commercially prepared had sanitizer/wipes for hand washing. Do not allow infants of young children to bath or shower in contaminated water since they may ingest it.

What happened? What is being done?

Bacterial contamination can occur when surface waters gains entry to the drinking water source, storage or distribution system (after construction, repairs, or damage to the well, tanks or piping).

We are working with the local health department to resolve this problem. We anticipate resolving the problem within [estimated time frame]. For more information, please contact «MsMr» «FirstName» «LastName», «Supply_Name» at «Phone» or [mailing address] or the [name of local health department].

CERTIFICATION: WSSN:

I certify that this water supply has fully complied with the public notification requirements in the Michigan Safe Drinking Water Act, 1976 PA 399, as amended, and the administrative rules.

Signature	Title	Date Distributed

Reminder to water supplier: A copy of this notice/certification must be sent to the LOCAL HEALTH DEPARTMENT.

For Monthly Operation Report forms specific to your treatment, contact your local health department representation or Michigan Department of Environmental Quality staff.

APPENDIX F

Department of Environmental Quality
Water Bureau
Drinking Water and Environmental Health Section
Noncommunity Unit

Chlorination Monthly Operation Report

Facility Name: ____ WSSN: __________________________

Certified Operator: _____________________________________ Month/Year: _______________/______

Chemical Added: ______________________________Manufacturer: ____________________________

Day	Quantity chlorine added	Sample location or problems/comments	Chlorine residual plant tap	Chlorine residual distribution	Coliform results raw	Coliform results treated	Analyzed by
1							
2							
3							
4							
5							
6							
7							
8							
9							
10							
11							
12							
13							
14							
15							
16							
17							
18							
19							
20							
21							
22							
23							
24							
25							
26							
27							
28							
29							
30							
31							

Signature of Operator: ____ Date: ________________

Completion of this form is required by Rule 325.11502 of Act 399, P.A. 1976

Instructions for completion of MOR: *(Chlorination)*

Day: The day of the month that system treatment system was checked.

Quantity chlorine added: Record when chlorine is added to tank and how much was added. (Chlorine must be approved as a drinking water additive meeting ANSI/NSF Standard 60.) Alternatively, chlorine tank can be weighed and pounds used recorded.

Sample location or problem/comments: This is the location where samples were collected, where chlorine residual tests were done or comments need to be made regarding a problem or concern; e.g., chlorinator malfunction.

Chlorine residual plant tap: Analyze and record a minimum of once a week at the sampling tap prior immediately after treatment.

Chlorine Residual distribution: Analyze and record a minimum of once a week at a sampling location out in the distribution system.

Coliform results raw: Record the coliform test results collected at the raw water sampling tap prior to any treatment.

Record results treated: Record the coliform test results collected at the designated treated water sampling tap located in the distribution system after treatment.

Analyzed by: Person making entry into the monthly operation report.

Operator signature: Certified operator attesting to the submitted information in the report.

Additional Comments____

Submit a copy of the MOR to the Local Health Department within 30 days after the end of the month

DEQ/WB 7/06

Michigan Department of Environmental Quality

Drinking Water and Environmental Health Section - Water Bureau

Arsenic Treatment Monthly Operation Report - Media Adsorption (With Chlorination)

Facility Name: ____ WSSN: ____________________

Certified Operator: __________________________#__________ Month/Year: _________/________

Chlorine Manufacturer/Trade Name______________________________ Concentration __________%

Day	Quantity Chlorine Added	Chlorine Residual PPM	Flow Meter Reading	Arsenic Untreated PPB	Arsenic Treated PPB	Inspection (check) / Comments	Analyzed by
1							
2							
3							
4							
5							
6							
7							
8							
9							
10							
11							
12							
13							
14							
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17							
18							
19							
20							
21							
22							
23							
24							
25							
26							
27							
28							
29							
30							
31							

Operator Signature:____Date___________

See back for instructions on completing form

Completion of this form is required by Rule 325.11502, 1976 PA 399

Submit a copy of this MOR to the Local Health Department within 30 days after the end of the month.

Instructions for completion of MOR: *Media Adsorption (With Chlorination)*

Quantity Chlorine Added: Record when chlorine added to tank and how much was added. (Must be approved as a drinking water additive meeting ANSI/NSF Standard 60.) Alternatively, chlorine tank can be weighed and pounds used recorded.

Chlorine Residual: Analyze and record a minimum of once a week.

Flow Meter Reading: Record at beginning and end of month.

Arsenic Untreated: Raw water arsenic level. Required once every 3 years.

Arsenic Treated: Treated water arsenic level. Required quarterly through a certified lab. Field test analysis required every month. Field test with quarterly certified lab test to verify field accuracy.

Visual Inspection: Daily check to verify pump operational & solution in tank, etc.

Comments: Record maintenance/or any unusual events e.g. manual backwash. See below for additional space.

Analyzed by: Person making entry and/or testing laboratory.

Operator signature: Certified operator attesting to the submitted information in the report.

Additional Comments____

Submit a copy of the MOR to the Local Health Department within 30 days after the end of the month

Michigan Department of Environmental Quality
Drinking Water and Environmental Health Section-Water Bureau
Nitrate Treatment Monthly Operation Report – Ion Exchange

Facility Name: ____________________ WSSN: ____________

Certified Operator: ______________ #________ Month/Year: ______/________

Day	Water Meter Reading	Pounds Salt Added	NO3 Untreated Mg/L	NO3 Treated Mg/L	Visual Inspection/Comments	Analyzed by
1						
2						
3						
4						
5						
6						
7						
8						
9						
10						
11						
12						
13						
14						
15						
16						
17						
18						
19						
20						
21						
22						
23						
24						
25						
26						
27						
28						
29						
30						
31						

Operator Signature: ______________________________ Date______________

See back for instructions on completing form

Completion of this form is required by Rule 325.11502, 1976 PA 399
Submit a copy of this MOR to the Local Health Department within 30 days after the end of the month.

Instructions for completion of MOR: *Nitrate Ion Exchange*

Water Meter Reading: Record weekly

Pounds Added Salt: Record pounds of salt when added

Nitrates Untreated: Record nitrate level of untreated water in milligram per liter (mg/l). Required annually in the quarter with historically highest nitrate levels.

Nitrates Treated: Record nitrate level of treated water in milligram per liter (mg/l). Required weekly with field test kit and quarterly at certified laboratory.

Visual Inspection: Daily to verify treatment unit operation/not bypassed/alarm/meter working, etc.

Comments: Record any unusual events. See below for additional space.

Analyzed by: Person that performed the field test or name of certified testing laboratory.

Operator signature: Certified operator attesting to the submitted information in the report.

Additional Comments____

Completion of this form is required by Rule 325.11502, 1976 PA 399
Submit a copy of this form to your Local Health Department within 30 days after the end of the month.

APPENDIX G

DRINKING WATER CONTINGENCY PLAN

Noncommunity Public Water Supplies

Water Supply Name ______________________________

Water Supply Serial Number (WSSN) ____________________

Contingency Plan Purpose: In the event of an emergency pertaining to the drinking water supply, it is necessary to act promptly and effectively to protect public health and welfare. In the context of this plan, emergencies could include complete loss of water pressure, contamination of water supply, and threats or observed vandalism to water system. Complete loss of water normally would require closure of the facility. Threats or contamination with unknown substances may also warrant such action. However, under certain situations where water is flowing but has been determined unsafe to drink by health authorities, it may be possible to operate the facility with approval of the appropriate local or state agencies. If approved, operation for an interim period is dependent on providing an approved source of water for consumption and notification to the users to not consume the piped water in the facility. This fact sheet is intended to outline procedures and contacts to address such emergencies. **If an emergency occurs, immediately contact your local health department for further instructions.**

1. **Facility Personnel**: List person(s) responsible for facility (owner or designee) and person(s) in routine charge of water system operation and treatment (certified operator) title and telephone number.

Name	Title	Phone

2. **Other Contacts**: List local and state contacts for notification of emergencies involving drinking water.

   Local Health Department contact: ____________________Telephone: __________

   Department of Environmental Quality - Water Division-Lansing:
   Telephone 517-373-1300:

   DEQ District Office: _____________ Name: ________________ Tel:____________

3. **Certified laboratory**: List local laboratory(s) and telephone number used by your facility for analysis of total coliform bacteria.

   ____

4. **Contractors**: List qualified contractors who may be used during emergencies.

   Water Well Drilling Contractor: ______________________________

   Plumber:______________________________________

   Other:

5. **Alternate Water Source**: List options for providing safe source of drinking water on a temporary basis:

   Purchase bottled water at: ___________________________ Quantity: ____________

   Method of dispensing water to individuals in sanitary manner: __________________

   Other Alternate approved source: ____

6. **Other consumptive water uses or equipment that may be directly connected to the potable water supply**. Indicate if any of the listed water uses are in the facility and thus need to be addressed.

Drinking Fountains to shut off:	Yes / No
Ice machines (discard contents):	Yes / No
Post mix soft drinks to disconnect:	Yes / No
A coffee machine, tea, juices, soups, vending, etc.	Yes / No

   Other: ____

Note: If the water supply loses pressure or cannot be used due to unsafe conditions, any equipment used for food service or consumption which is connected to the water supply will need to be disinfected per the manufacturers specifications.

7. **Public Notification**: Consumers are to be advised of a problem with the water and availability of an alternate source of water for consumption.

- Post public notice at sinks and any other potential drinking water outlets that can not be shut off. List locations to be posted:
  ____
  ____

- Retain copy of signed and dated public notice. List any other means to notify public. *(Schools/Child Care Centers/Children's Camps are recommended to provide notice to parents.)*
  ____
  ____

Consult your local health department for the required public notification language and format. **YOU MUST HAVE APPROVAL FROM YOUR LOCAL HEALTH DEPARTMENT PRIOR TO RESUMING USE OF YOUR WATER SUPPLY FOR CONSUMPTION.**