Basics

for Small Water Systems in Oregon

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FACT SHEET 1.1 - Drinking Water and Public Health Protection

1.1.1 - Background on Drinking Water Standards

The Safe Drinking Water Act (SDWA) is the primary federal legislation established to protect public health through regulation of the nation's public drinking water supply. Congress signed it into law on December 16, 1974. There were amendments made to SDWA in 1986 and 1996. The SDWA applies to each of the more than 170,000 public water systems in the United States

The SDWA gave the federal government, through the Environmental Protection Agency (EPA), authority to:

- Set minimum national standards for the levels of contaminants in drinking water.
- Require all public water systems to monitor for contaminants and report any identified contaminants.
- Provide protection for water sources such as rivers, lakes, reservoirs, springs and groundwater.
- Establish guidelines for the acceptable treatment technologies for reduction of contaminants from water.

The SDWA establishes primary and secondary drinking water standards for microbial and chemical contaminants that may be found in drinking water.

Primary drinking water standards are regulations that address waterborne contaminants that may cause illness or death and are set by EPA to minimize health risks posed by these contaminants. Primary standards set enforceable maximum contaminant levels (MCLs), or for some contaminants an action level.

- An **MCL** is the highest level at which a contaminant can occur (but cannot exceed) for the water to be considered safe to drink. Available technology, the cost of treatment, and sound science are all considered in setting these standards.
- An **Action Level** is set for some contaminants instead of an MCL. If the action level is exceeded, the water supplier is required to take additional steps. Depending on the contaminant, exceeding an Action Level

may require customer notification, additional testing and/or eventually require installation of equipment to reduce the contaminant.

The EPA also sets **secondary standards** for contaminants that affect the aesthetics of water but are not a public health threat. Secondary standards are not enforceable. Contaminants with these standards are usually minerals or gasses that cause water to taste or smell bad, or be discolored. For example, a water source that has high iron content will produce water that may be red in color or have particles of red floating in it. Although this makes the water less desirable to the consumer, it is not necessarily a health threat.

SDWA also gives state regulatory agencies the power to act as a **primacy agency** for enforcing the act's regulations. In the state of Oregon, enforcement of SDWA is the responsibility of the Oregon Department of Human Services Drinking Water Program.

Originally, SDWA focused primarily on treatment of drinking water as the best way to get safe drinking water to the tap. However, the 1996 amendments went further than simply treating water. The amendments addressed source water protection, operator training, funding for water system improvements and consumers' "right-to-know" through public information.

The regulatory system is designed to provide a **Multiple Barrier Approach** to protection. This includes source water protection, water treatment when required, distribution system integrity and public information. If one of these barriers is breached, the risk can be resolved at another barrier point to protect public health and safety.

1.1.2 – Acute vs. Chronic Health Effects

Drinking water contaminants can cause illness that we can classify based on how long it takes for symptoms to appear after exposure.

Acute effects typically occur within hours to weeks of exposure. Problems may result from consumption of very small amounts of contaminated water—even a single exposure. Acute effects most often result from microbial infections, but some chemicals (e.g., nitrate) can cause acute effects if present in high enough concentrations.

Chronic health effects such as cancer or organ damage generally result from prolonged exposure to low concentrations of drinking water contaminants, with the onset of disease occurring months to years after exposure. Chronic health effects are usually associated with chemical contaminants.

1.1.3 - Types of Contaminants: Microbial vs. Chemical

There are two primary types of contaminants, microbial and chemical.

Microbial contaminants include bacteria, viruses, and protozoa:

- **Bacteria** are single celled microorganisms of many different shapes and species that possess no well defined nucleus.
- **Viruses** are extremely complex molecules that have no independent metabolism and depend on living cells for reproduction. They do not live long outside of the human body, but while alive can withstand heat, drying and chemical agents.
- **Protozoa** are one-celled organisms within a cyst that can be difficult to treat. The most common protozoans are *Giardia Lamblia* and *Cryptosporidium*.

These organisms can enter a water system quite easily if proper treatment methods are not in place. Microbial contaminants that cause acute illness in humans are sometimes referred to as **pathogens** and nearly always originate in animal or human feces.

Microbial contaminants find their way into water systems at either the source, in storage or through the distribution system in a variety of ways:

- Groundwater wells may be contaminated by runoff, infiltration from animal wastes, septic tanks or poorly operated wastewater treatment facilities. Although shallow wells are most susceptible, even deep wells may be affected if they are not cased properly, or if the casing has deteriorated.
- Improperly screened vents and overflows or other openings on storage tanks may be an avenue by which microbial contaminants may enter a water system.
- Cross connections within the distribution system are another frequent source of contamination. These are connections between a public water system and a source of non-potable liquid, or gas including underground sprinkler systems, unapproved individual wells or other sources of water (springs, creeks, lakes, ponds).

Chemical contaminants of concern may occur naturally in water, as a result of human activity or may be created in the water treatment process. Chemicals have been seperated into four classes for regulatory purposes:

- **Inorganic chemicals (IOCs)** come from natural occurring mineral materials such as salts, iron and calcium as well as from industrial contamination. These chemicals may be present on rocks and in soil and can be carried into groundwater supplies by surface water that percolates into the ground.
- **Synthetic organic chemicals (SOCs)** are man-made, carbon-based compounds that are typically found in pesticides, herbicides and fungicides. Others are used in the making of plastics. Nearly all SOCs commonly found in water are from pesticides with a few notable exceptions (PCBs and dioxin).
- **Volatile organic chemicals (VOCs)** are man-made compounds that readily vaporize from water into the air at normal temperatures. They are commonly used as solvents, fuels, paints, or degreasers. They present a health risk not only from drinking contaminated water, but also from inhaling VOCs that escape from the water as it is used during showering or other home uses. VOCs also may be absorbed directly through the skin during bathing and showering. VOCs may cause cancer or damage to the liver, kidneys, nervous system, or circulatory system.
- **Radionuclides** can occur as a result of human activities or natural sources. Natural radionuclides are radium 226, radium 228 and radon. These are most common types found in groundwater sources. Man-made radionuclides can find their way to water systems as a result of scientific and industrial users of radioactive materials, wastewater discharge from nuclear power plants, discharges from the mining of radioactive materials and improper handling or storage of waste radioactive materials. Radon gas is most often present in granite formations.

1.1.4 - Waterborne Disease and Health Effects of Water Pollution

Waterborne disease and other health effects can be caused when microbial, or chemical contaminants enter the drinking water supply.

Pathogenic agents can cause a variety of illnesses in humans. The spectrum of waterborne illness is very broad, ranging from asymptomatic or very mild infection to life-threatening disease. Gastrointestinal symptoms (e.g., diarrhea and vomiting) are common manifestations for many of these pathogens. Some of the pathogens of particular importance in Oregon are listed in **TABLE 1.1.4**.

Laboratory methods exist to differentiate the various types of bacteria, but they are more difficult, time consuming, and expensive than the total coliform tests. Similarly, special water sampling procedures and equipment are required to sample for viruses and protozoa. As a result, these tests are not routinely conducted.

The most common test used to determine if bacterial pathogens are present in drinking water is a relatively easy and inexpensive test called the **total coliform test**.

Coliform bacteria are a classification of bacteria that are naturally occurring in the air, soil, and water as well as in the intestinal track of warm blooded animals. The water industry uses this test as an indicator of possible fecal contamination or the presence of other pathogens in the water system.

If present, a contaminant pathway may exist between a contamination source and the water supply. Because coliform bacteria stay in water longer than most disease causing organisms, the absence of coliform bacteria leads to the assumption that the water supply is microbiologically safe to drink.

Elevated levels of coliform bacteria suggest problems in the system. Sources of the problem may include runoff, infiltration, leaching, cross-connections, inadequate disinfection, and others. A positive test for coliform does not necessarily imply the presence of pathogens, but it suggests a potential for contamination of the water that demands immediate attention.

For more information on health effects of other microbial and chemical contaminants see EPA's web-site, List of Contaminants and MCL's http://www.epa.gov/safewater/mcl.html, or contact your local health department or the Drinking Water Program.

TABLE 1.1.4 - Common Microbial Contaminants and Potential Health Effects

Microbial contaminant	***Type of microorganism***	***Sources of contaminant***	***Potential health effects from ingestion through water***
Norovirus (Norwalk-like viruses)	Virus	Human feces Shellfish grown in polluted waters	Causes acute gastroenteritis. Is highly contagious. Symptoms include vomiting and diarrhea. Symptoms last one or more days.
Escherichia coli O157:H7(or, E. Coli O157:H7)	Bacterium	Animal or human feces	Symptoms include diarrhea and occasionally kidney failure. Symptoms last five to ten days.
Shigella	Bacterium	Human feces	Symptoms include diarrhea, fever and stomach cramps.
Giardia Lamblia	Protozoan	Animal or human feces	Symptoms include cramps, nausea, and general weakness. Symptoms may last two to six weeks, or longer.
Cryptosporidium	Protozoan	Animal or human feces	Symptoms include diarrhea, stomach pain, vomiting. Symptoms typically last one to two weeks.

Source: Center for Disease Control, Disease information web-site, http://www.cdc.gov/ncidod/dbmd/diseaseinfo/.

1.1.5 - Waterborne Disease Outbreaks in Oregon

Prevention of waterborne infections requires good separation of human and animal waste from drinking and recreational water sources. In Oregon and other parts of the developed world, sanitation and drinking water systems are generally well developed and adequately maintained, and waterborne disease is relatively uncommon. In developing countries, where sanitation may be poor or almost non-existent and safe drinking water is the exception rather than the rule, morbidity and mortality from these infections is common.

While drinking water is generally safe in Oregon, we cannot afford to be complacent. Safe water is only available because operators work hard and resources are invested to keep it so. Deferred maintenance, “accidents,” unusual rainfall events, mechanical failures - any number of things - can stress and sometimes overload even the best systems. When that happens, the potential for waterborne disease can go up very quickly.

Outbreaks of disease traced to drinking water have become fairly uncommon in the United States. Most outbreaks identified over the past 20 years, with a few notable exceptions,have been very small, and typically involve poorly maintained systems in rural areas.

Awareness of potential sources of contamination for your own system is important in preventing an outbreak or contamination event. A list of reported disease outbreaks in Oregon with identified causes is included in **TABLE 1.1.5**.

TABLE 1.1.5 - Reported Disease Outbreaks- Oregon Public Water Systems

Year	Location	Organism	No. of Cases	Water Source	Cause
1975	Crater Lake National Park	Enterotoxigenic *E. coli*	1,000	Spring	Inadequate chlorination; sewage contam.
1978	Century Drives Apts. (Linn Co.)	*Shigella*	34	Well	Source contamination
1979	Colton	unknown	300	Surface water	Inadequate chlorination; no filtration
1979	Government Camp	*Giardia*	120	Surface water	Inadequate chlorination; no filtration
1979	Zig Zag (Lady Creek) Cabins	*Giardia*	66	Surface water	Interrupted chlorination; no filtration
1980	Rockaway Beach	*Giardia*	63	Surface water	Inadequate chlorination; no filtration
1982	Corbett	*Giardia*	19	Surface water	Inadequate chlorination; no filtration
1984	Canyonville	*Giardia*	42	Surface water	Inadequate filtration
1984	Pacific City	*Campylobacter*	22	Surface water & wells	Inadequate chlorination; no filtration
1984	Willamina (Mill)	unknown	20	Surface water	Cross connection with fire system
1992	Jackson County (two outbreaks)	*Cryptosporidium*	3,000	Surface water; possibly spring also	Inadequate filtration; possible infiltration of spring water
1994	Florence (school)	unknown	10		Water cooler contamination (common spout)
1997	Grants Pass (campground)	*Giardia*	100	Well & spring	Rodent contam. of distribution storage tank
2005	Yamhill County (camp)	unk – pos tests for E.*coli 0157, shigella* & *campylobacter*	60	Surface water	Inadequate chlorination & filtration

Source: Oregon Waterborne Disease Outbreaks (1971-2000) CDC Database and DHS records.

UNIT 1: Essential Information and Considerations

FACT SHEET 1.2 - Basic Responsibilities of Water Suppliers

1.2.1 – Oregon Revised Statutes and Duties of DHS

1.2.2 – Responsibilities of Water Suppliers

1.2.3 – Classification of Public Water Systems

1.2.4 – Sampling and Reporting Requirements

1.2.5 – Public Notices

1.2.6 – Consumer Confidence Reports

1.2.7 – Water Operator Certification

1.2.8 – Emergency Response Plans

1.2.9 – Operations and Maintenance Manual

1.2.10 – Capacity Requirements for Public Water Systems

1.2.11 – Water System Survey

1.2.12 – Plan Review

FACT SHEET 1.2 - Basic Responsibilities of Water Suppliers

1.2.1 - Oregon Revised Statutes and Duties of DHS

Oregon's Department of Human Services (DHS) serves as the state's primacy agency for enforcing regulations under the Safe Drinking Water Act.

As the regulating agency, DHS has duties and responsibilities to protect public health and safety as outlined by the state legislature in ORS 448.150. These requirements include the authority to develop and adopt administrative rules which have the force of law. The rules are set forth in the Oregon Administrative Rules (OARs) Chapter 333-061. A copy is available on the Drinking Water Program's web-site or from your local health department.

By statute, DHS is obligated to conduct evaluations, investigate reports of contamination, and provide written report of findings to water suppliers. These activities are undertaken with the goal of protecting public health. The statute specifically charges the DHS with the following:

- Conduct periodic Water System Surveys of water systems and sources, take water samples, and inspect water system records to ensure the system is not creating unreasonable health risks to customers;
- Provide written report of evaluations (e.g., Water System Surveys, water samples, record inspections) to the local health administrator and to water suppliers;
- Require regular water sampling by water suppliers;
- Investigate any water system that fails to meet the water quality standards established by DHS;
- Investigate reports of waterborne disease pursuant to its authority and to protect the public health and safety;
- Notify the Department of Environmental Quality if water sampling data available to the DHS indicates/identifies an area of groundwater concern.

1.2.2 - Responsibilities of Water Suppliers

All public water suppliers have the important responsibility of providing a safe and reliable drinking water supply to their customers. Responsibilities are defined under OAR 333-061-0025.

These rules charge water suppliers to take all reasonable actions necessary to assure that maximum contamination levels are not exceeded and that requirements governing the operation and maintenance are observed. Overall responsibilities include, but are not limited to the following:

- Submitting plans to DHS prepared by a professional Oregon engineer before undertaking construction of new water systems or making major modifications to existing water systems;
- Collecting and submitting routine water samples for analysis at the required frequencies and report these results to the Department at the required frequencies;
- Taking corrective actions and notifying customers and the general public in the service area when results indicate maximum contaminant levels have been exceeded, as well as notifying customers when reporting requirements are not being met;
- Maintaining monitoring and operating records that must be available for review during inspections;
- Following up on complaints relating to water quality from users and maintaining records and reports on actions taken in response;
- Maintaining an active cross connection control program;
- Maintaining pressure of at least 20 pounds per square inch (psi) at all service connections at all times; Meeting water system operator certification requirements.

1.2.3 – Classification of Public Water Systems

Rules outlined in OAR 333-061 spell out specific requirements for public water systems (PWSs). Requirements vary based on water system classification. Water systems are classified by source and grouped into one of two categories:

- **Surface water** which includes groundwater systems which have been determined to be under the direct influence of surface water **(GWUDI)**, and;
- **Groundwater systems**.

Public water systems are also classified by number of people served and whether the same population is served occasionally versus year-round. The four primary classes of public drinking water systems are:

- **Community Systems (C)** A public water system which has 15 or more service connections used by year-round residents, or services 25 or more residents year-round. (e.g., cities, towns, mobile home parks, residential developments, prisons, etc.).
- **Non-Transient Non-Community Systems (NTNC)** A public water system that is not a community water system, but that serves at least 25 of the same persons over 6 months per year (e.g., schools, work sites, hospitals, etc.).
- **Transient Non-community Systems (TNC)** A public water system that serves an average transient population of 25 persons or more daily, 60 days a year (e.g., parks, restaurants, campgrounds, etc.)
- **State regulated**. **(NP)** A public water system which serves 4 to 14 service connections or serves 10 to 24 people.

Operational and sampling requirements may vary, depending on the classification of a particular system.

A general summary of sampling requirements by system classification is included in the resources section of the Need-to-Know Fact Sheet Library. Keep your system classification in mind as you review the following operational duties and basic rules.

1.2.4 - Sampling and Reporting Requirements

All public water systems are required to collect microbiological and chemical samples at varying frequencies depending on system classification. Sample results are among the first in a series in the water system's line of defense to detect system upsets and potential hazards. Sampling plans must be developed. Samples must be taken and sent to a state-certified lab for analysis.

Not only must there be follow through on sampling, but ***water suppliers are also responsible for reporting results to the Department*****.** Results are required to be submitted no later than ten days following the end of the required monitoring period. It is the water supplier's responsibility to work with the lab to assure that results are reported to the Department in a timely manner.

Any coliform bacteria sample which indicates coliform "present" or other analytical result that exceeds maximum contaminant levels (MCL) must be reported to the Department within 24 hours or by the next business day. If a coliform bacteria sample result indicates fecal coliform or *E. coli* present, the Department must be notified immediately.

1.2.5 - Public Notice

Public notification helps ensure that consumers will always know if there is a problem with their drinking water. Water systems are required to issue public notice when the system fails to comply with the following: Maximum Contaminant Levels (MCLs), treatment techniques, scheduled variance or permit, monitoring and reporting requirements, or testing procedures. Special language and basic information must be included in notices.

Requirements for timeliness of notification and method of posting (e.g., radio, posting notices, hand delivery of notices) vary depending on potential impact to public health.

Public notice templates are available from the Drinking Water Program website or from your local health department.

1.2.6 - Consumer Confidence Reports

Consumer Confidence Reports (CCRs) are reports that contain information on the quality of the water delivered by the systems, and characterize in an accurate and understandable manner the potential risks (if any) from exposure to contaminants detected in drinking water.

All community water systems are required to deliver a CCR to their customers annually. Reports must be delivered by July 1 following the reporting year. The water supplier must also submit a certification form to the Department due October 1. The certification form verifies the report was distributed; the information is correct and consistent with data submitted to the Department.

A CCR is intended in part to assist the consumer in making informed decisions about their drinking water.

Required components include but are not limited to:

- General water system information;
- Source information (including availability of Source Water Assessment if completed);
- Definitions and explanation of acronyms;
- Concentrations of “most recent” detected regulated contaminants;
- Detections of unregulated contaminants;
- Violations of standards;
- Special language for arsenic, nitrate, lead, cryptosporidium and radon;
- Variances and exemptions;
- Mandatory statements to be included on all CCRs.

A summary of required components is included in the resources section of the Need-to-Know Fact Sheet Library. Guidelines and templates, as well as a copy of the CCR certification form are available on the Drinking Water Program web-site, or from the Department.

1.2.7 - Water Operator Certification

General operating and maintenance requirements outlined in the state rules (OAR 333-061-0205 to 0272) require all public water systems to employ operators with proper certification to assure continuous production and delivery of potable water. Operators of all community and non-transient non-community water systems must meet certification requirements based on system size and complexity specified in state rules.

Small systems with less than 150 connections and using groundwater sources are classified as "small groundwater systems."

To comply with requirements for small groundwater systems, systems must employ operators that meet one of the following certification requirements:

- Complete Department-approved training on small groundwater system operation and water treatment processes, as applicable. or
- Achieve a passing score on a Department-approved written exam. (This may be available at a later date).

***All small system groundwater operator certificates expire every third year on July 31*.** Certificates can be renewed with evidence of completion of the approved small water operator training course. The course is offered around the state throughout the year. It will also be made available online or via CD Rom applications. See the Department's web site or contact the Department for the course schedule or information on accessing training.

1.2.8 - Emergency Response Plans

What is an **Emergency Response Plan (ERP)**?

An ERP is a living document that outlines contacts, public operating procedures and actions to minimize impact or potential impact to the drinking water supply from a natural disaster, accident, or intentional act. It helps water suppliers react to emergency situations more quickly.

Having a plan can make a difference in minimizing damage or hazards and can assist in getting a system back to normal operation in a timely manner. All public water systems serving less than 3,300 persons are required to have a current ERP by June 30, 2005. Reviews and updates must be made at least every five years; however, keeping a plan current is essential.

For small systems, part of developing an ERP includes completing a security vulnerability assessment. Once completed, small systems are required to submit a statement to DHS certifying the ERP is complete and staff is trained to implement the plan. A general fact sheet and guidelines for small systems are available on DHS' website (See the resources section).

1.2.9 - Operations and Maintenance Manual

All public water systems must maintain a current Operations and Maintenance Manual. The manual must be updated at least every five years.

Maintaining an updated manual ensures that operations knowledge is retained, even with staff changes. Procedures must include but are not limited to the following:

- Source operation and maintenance;
- Water treatment operation and maintenance;
- Reservoir operation and maintenance;
- Distribution system operation, maintenance and repairs;
- Standard operating procedures for certified operators;
- Record keeping.

When completed, water systems must send a statement to DWP certifying the plan is complete and staff is trained. A fact sheet addressing this requirement is available on the Drinking Water Program's website.

1.2.10 - Capacity Requirements for Public Water Systems

A **capacity assessment** is a comprehensive review of a public water system's technical, managerial, and financial **(TMF)** ability to deliver safe and reliable water to the public.

New community, non-transient non-community, and transient non-community public water systems (constructed after October 1, 1999) must submit information providing evidence of TMF capacity as part of the plan review process. Factors evaluated include appropriate permitting, water rights, plan review, land use requirements, initial sampling tests, certified operator, rate structure, and billing procedures.

Capacity assessments are also conducted for systems qualifying for Drinking Water State Revolving Loan Fund. Any identified deficiencies must be corrected prior to allocation of funds.

In addition, all existing community, non-transient non-community, and transient non-community systems will receive capacity assessments from, or with the assistance of the Department.

1.2.11 - Water System Survey

A Water System Survey will be conducted on all public water systems, by state or county health department staff approximately every 3 years for surface water systems or every 5 years for groundwater systems. A Water System Survey is a detailed inspection and documentation of a water supplier's water system from the beginning (the source) to the end (the distribution system) and everything in between.

The purpose of this survey is to identify any potential and existing health hazards. Water systems are evaluated for significant deficiencies in well construction, disinfection, treatment, storage, distribution, monitoring compliance, management, and general operations. Any noted deficiencies must be corrected.

1.2.12 - Plan Review

Plans, a plan review fee and a land use compatibility statement from the local planning authority, must be submitted to and approved by the Department prior to construction of a new water system or major additions or modifications to existing systems. “Major additions or modifications” mean changes of considerable extent or complexity including, but not limited to, projects involving water sources, treatment facilities (such as filtration and disinfection), finished water storage, pumping facilities, transmission mains and distribution mains. Plans are usually not required for main replacement of the same length and diameter of piping.

For community water systems, plans must be prepared by a professional engineer licensed in Oregon. The engineering requirement may be waived for non-community systems or for non-transient, non-community systems where the project involves only plumbing on private property. It is always best to check with the Department to see what types of plans and fees are required before initiating a project. OAR Chapter 333 contains Construction Standards that are applicable to these projects.

Certification that a project was completed in accordance with the approved plans will complete the plan review process. If significant changes are made during the course of the work, a set of as-built plans documenting compliance with the Construction Standards will be submitted to finalize the plan review process.

UNIT 1: Essential Information and Considerations

FACT SHEET 1.3 - Source and Wellhead Protection

1.3.1 – Understanding Source and Wellhead Protection

1.3.2 – Mechanisms and Potential of Contaminant Threats

1.3.3 – Well Construction and Aquifer Protection Concerns

1.3.4 – Well Drilling Standards

1.3.5 – Finding a Well-Drilling Contractor

1.3.6 – Using the Source Water Assessment Tool

1.3.7 – Benefits and Incentives for Creating a Drinking Water Protection Plan

FACT SHEET 1.3 - Source and Wellhead Protection

1.3.1 - Understanding Source and Wellhead Protection

Amendments made in 1986 to the federal Safe Drinking Water Act (SDWA) require all states to develop **Wellhead Protection Programs (WHPP)**.

The goal of a state WHPP is to, "protect wellhead areas within their jurisdiction from contaminants which may have any adverse effect on the health of persons."

A WHPP provides an organized approach to effectively protecting the drinking water supply. Wellhead protection involves several key elements:

(1) Identifying a WHP zone;

(2) Determining susceptibility of the area around the water source;

(3) Developing an inventory of potential contaminant sources and land use activities;

(4) Developing a management strategy to reduce the risk of contaminants entering the source;

(5) Contingency planning for natural disasters or other emergencies affecting water supply;

(6) Developing procedures for planning and siting of new wells;

(7) Gathering supporting information and documentation;

(8) Developing a public education program.

Oregon's WHPP is part of the state's overall **Drinking Water Protection Program (DWPP)** that includes both groundwater and surface water systems. Drinking water protection is often referred to as source water protection. The DWPP is jointly administered by the Oregon Department of Environmental Quality (DEQ) and the DHS.

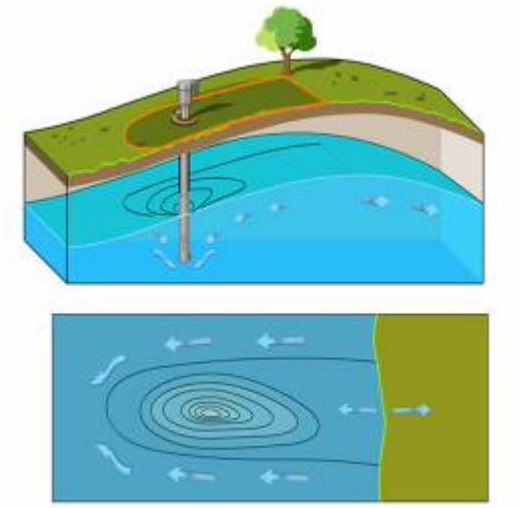
1.3.2 - Mechanisms and Potential of Contaminant Threats

There are many variables to consider when beginning a DWPP including, geology, well(s) depth(s) and slope or flow direction of groundwater. In Oregon, the WHPA is referred to as the **Drinking Water Protection Area (DWPA)**.

The **water table** is the upper surface of the saturated zone (top of the water surface underground). Groundwater tends to move from areas where the water table is high to areas where it is low.

Pumping wells can have a significant influence on the direction and rate of groundwater flow because the drawdown they produce changes the shape and slope of the water table.

When a well is turned on, it lowers the water table in its vicinity and intercepts water that flows in from higher water tables towards the well. This water can move sideways as well as up or down in response to differences in gravity, elevation and pressure.



This creates a "**capture zone**" above or in the aquifer (see illustration above), which is the part of the aquifer that supplies water to the well. Any water or contaminant that is in the capture zone will move towards the drawdown area.

It is not necessary for a contaminant to actually reach the groundwater itself; the percolating water is capable of transporting it to the aquifer.

The area on the ground surface where a contaminant, if released, may be transported by the flow of groundwater to a well or a well field is known as the **DWPA**.

Once the capture zone is delineated (or determined), possible contaminants within the capture zone must be identified, assessed and mitigated if necessary.

DWPA contaminants of concern include, microorganisms (bacteria, viruses, Giardia, etc.), inorganic chemicals (nitrate, arsenic, metals, etc.) and organic chemicals (solvents, fuels, pesticides, etc.).

When investigating the protection area, some potential contaminant sources such as landfills, gas stations and agricultural areas are easy to spot.

Awareness of not-so-obvious potential contaminants such as septic systems, lawn fertilizers, pesticides, storm water runoff and auto repair shops is very important.

It is also important to note that very small amounts of some chemicals can contaminate large quantities of water.

1.3.3 - Well Construction and Aquifer Protection Concerns

Because so much can be done to limit or reduce the risk of contamination during new well siting and construction, a DWPP includes developing procedures for planning and siting new wells. Such procedures include:

1. ***Finding the best location***. A well must meet desired capacity with good quality water that requires minimal treatment.

2. ***Research***. The amount of water in an aquifer depends on topography, geology, annual rainfall and distance to other water sources. Check with local well drillers, neighboring property owners or well logs for the desired area.

3. ***Well logs***. Well logs are part of well reports that are required by Oregon law and prepared by well drillers. The logs provide information regarding geological conditions and yields as well as details about well design and construction. The Oregon Water Resources Department (WRD) (*www.wrd.state.or.us*) has most of the well logs for wells drilled since 1955 on file. DHS asks that well logs for an area be submitted during the planning stage to allow them to make recommendations regarding the construction and sealing of the well.

New wells or springs outside an existing DWPA or obtaining water from a different aquifer not included in an existing delineated DWPA require a provisional delineation.

A preliminary potential source contamination assessment also must be conducted for each site. These assist in choosing the best long-term site.

If the well will be drilled in an existing DWPA, a provisional delineation and preliminary potential source contamination study must be conducted and needed modifications must be made to existing plans.

Once a source has been found, it is important to estimate water needs. To estimate water needs, determine peak day demands. Peak demand usually occurs at the beginning of the day or in the evenings.

Peak demand estimates should include conditions similar to a long hot summer day, when other activities such as irrigation and automobile washing are likely. Oregon WRD has an easy-to-understand guide to estimating water use for various home and farm activities. Domestic systems require storage tanks to stockpile water for use during periods of high demand.

Wells should be located in pollution free areas. Local well drillers who have knowledge of and experience with state regulations should be able to help site a well. If possible, a well should be located close to where it is needed and near a source of electricity.

State standards also dictate wells must be located:

- Away from septic systems, stock yards or other sources of contamination;
- At increased distances in highly permeable areas (sand and gravel);
- With drainage running away from the well;
- Far enough from other buildings to allow maintenance practices;
- In an area not prone to flooding;
- A reasonable distance from neighboring wells;
- A safe distance from property lines.

The Oregon Utility Notification Center (800-332-2344) must be notified at least two business days before any well-digging begins.

1.3.4 - Well Drilling Standards

WRD sets well drilling standards designed to protect public health and groundwater sources. A copy of well construction standards (OAR 690-200 through 690-230) can be found on WRD's web site. If site conditions do not allow for construction (or abandonment) of a well in a suitable location, a water purveyor must obtain a "*special standard*" from the WRD.

Prior to drilling a new well, public water systems are also required to notify DHS and obtain approval for their construction plan (OAR 330-061-0060). DHS may set additional standards regarding the construction of the well.

1.3.5 – Finding a Well-Drilling Contractor

Licensed and bonded well-drilling contractors can be found through:

- The departments web site (*www.wrd.state.or.us*);
- The Oregon Ground Water Association;
- Phone books;
- Neighbors;
- WRD's central office.

It is extremely important to check well-drilling contractors' references.

1.3.6 - Using the Source Water Assessment Tool

Until recently, costs associated with acquiring information needed to develop drinking water protection plans were a water system's responsibility.

Amendments made in 1996 to the Safe Drinking Water Act lifted the burden from water systems by requiring states to conduct **Source Water Assessments (SWAs)** for federally recognized public water systems that fall under state regulatory authority. In Oregon, groundwater system assessments are conducted by DHS and surface water system assessments are conducted by DEQ. SWAs include three primary elements:

(1) *Delineation.* Identification of the area that directly overlies that part of the aquifer supplying drinking water to the well or spring.

(2) *Inventory.* An inventory of potential contaminant sources in the area.

(3) *Susceptibility.* Identification of the areas most susceptible to contamination from those sources.

SWAs are an important tool to support water systems and communities that decide to move to the next phase of protection. Once potential contaminant sources are identified in a WPHA, a plan should be developed to control existing and future activities that may contaminate source water.

It is important to understand that the purpose of a DWPP is to reduce the risk of contamination, and, with few exceptions, DWPP is not incompatible with most land uses. The best approach to protecting drinking water supplies is to involve property owners early in the plan development process. Respecting their concerns and communicating to them the importance of protecting drinking water through **"Best Management Practices" (BMPs)** that reduce the risk of contamination is vital to a successful and implemental plan.

A public water system should have a **contingency plan** that outlines actions to take and backup supply options in the event of a contamination

incident and/or loss of supply. Options may include utilizing another nearby water source or forging an agreement with a neighboring water system.

Once the three primary elements of the DWPP have been completed, the *"protection phase"* of the program must be carried out by water system personnel and the community. The protection phase includes:

- Assembling a local Drinking Water Protection Team;
- Reviewing the SWA and enhancing it if necessary;
- Developing a plan to reduce identified risks of contamination;
- Developing a contingency plan to address potential loss of the drinking water supply during an emergency;
- Certifying (optional) and implementing the Drinking Water Protection Plan.

Prior to moving to the protection phase, DEQ and DHS recommend reviewing the SWA in detail to clarify the presence, location, operational practices, actual risks, etc., of identified facilities and land use activities. The inventory outlined in the SWA should be regarded as a preliminary review of potential sources of contamination within the drinking water protection area. Community resources should be used to perform an "enhanced inventory" to refine the primary list of potential contamination. When developing a protection plan, screen out contaminant sources that pose little or no threat to the drinking water source.

For example, if land use practices or activities within the protection area already operate in a manner to reduce risks of contamination, re-evaluation of practices may not be necessary. The protection plan objective is to address activities and practices that pose moderate or high risks to a public water supply.

The final step is to have DEQ certify the plan. A written plan report must be submitted to DEQ for certification. The report should contain:

- An introduction describing how the planning process was initiated in your community, background information on the local area and government entities and roles within the protection area;

- Delineation of the Drinking Water Protection Area;
- An inventory of potential contaminant sources that describes the inventory process;
- Management actions to address potential contamination sources;
- A description of the emergency contingency plan;
- Procedures for planning and siting of new public water system wells or springs;
- Public participation efforts used in the development of the plan.

Send the report to:

Oregon Department of Environmental Quality

Water Quality Division, Drinking Water Protection Coordinator

811 SW 6th Avenue

Portland, OR 97204

More steps detailing how to develop a Drinking Water Protection Plan are outlined in Oregon Wellhead Protection Guidance Manual (1996).

The manual, along with other pertinent information, can be viewed at: *www.deq.state.or.us/wq/dwp/dwphome.htm*

Limited technical assistance for systems that choose to voluntarily develop protection plans is available through DEQ and DHS.

For more information and help, contact DEQ/DHS Drinking Water Protection Specialists:

- Sheree Stewart
  503-229-5413
  stewart.sheree@deq.state.or.us
- Sue Gries
  503-229-6210
  gries.sue@deq.state.or.us
- Tom Pattee
  541-726-2587, ext. 24
  tom.pattee@state.or.us

1.3.7 - Benefits and Incentives for Creating a Drinking Water Protection Plan

Development of a certified DWPP is voluntary, so why go the extra effort? Benefits and incentives for developing a plan include:

Prevention of contamination - Preventing contamination from happening is more cost effective than investigation and treatment costs associated with a contamination event. The Oregon DEQ and DHS compared the estimated cost of prevention (less than $15 per resident) to the actual cost of investigation and treatment (more than $1500 per resident) in a small Oregon community (population 330) impacted by volatile organic contaminant that exceeded the drinking water standard.

Reduced monitoring requirements - Routine monitoring for organic chemicals (e.g., fuels, solvents and pesticides) must take place at least once every three years. Cost of monitoring is approximately $1750.00/source. A state-certified plan may allow a system to reduce monitoring from once every three years to once every six years. Such a reduction can mean a substantial savings for small systems or systems with multiple separate sources.

Access to special funding for implementation of protection strategies - Water systems in the process of developing or implementing drinking water protection strategies have access to loan funds of up to $100,000 through the State's Drinking Water Revolving Loan Fund. .

Additional credit when applying for funding from the Drinking Water State Revolving Loan Fund - Water systems applying for loans for capital improvements through the state revolving fund are awarded credit for developing drinking water protection plans.

Availability of Source Water Assessment Reports that contain much of the baseline information needed to develop a plan - DEQ and DHS have issued over 1,500 Source Water Assessment Reports to Oregon public water systems. These reports are the foundation for developing drinking water protection plans. They identify important areas, locate potential contaminant

sources, and define areas where the drinking water is most susceptible. Water Assessment Reports are a valuable source of information that naturally leads to development of protection strategies.

UNIT 1: Essential Information and Considerations

FACT SHEET 1.4 - Identifying and Correcting Significant Deficiencies

1.4.1 - What is a Significant Deficiency?
FIGURE - Significant Deficiencies / Drinking Water Regulation Violations

1.4.2 - What is a Water System Survey?

1.4.3 - Utilizing Information from the Water System Survey / Addressing Deficiencies

FACT SHEET 1.4 - Identifying and Correcting Significant Deficiencies

1.4.1 - What is a Significant Deficiency?

A **significant deficiency** is any condition in a water system that creates a reasonable threat of water contamination or a water outage. It could be a physical condition, a flawed operational procedure or a missing planning element that puts the system at risk.

Public water system operators must be able to identify significant deficiencies. This requires knowledge of the water system, common sense, accurate information and on-going diligence. If a significant deficiency is identified, it is an operator's responsibility to take the steps needed to correct the problem.

All water systems should have the authority (via rules, regulations, ordinances or resolutions) to make the necessary corrections.

A **Water System Survey** is one tool that helps identify the presence of significant deficiencies. Water System Surveys are conducted either by the DHS or your local health department staff and are further described in 1.4.2 below.

Types of deficiencies to look for in groundwater systems include:

- Well construction deficiencies;
- Spring/other source deficiencies;
- Disinfection deficiencies;
- Treatment deficiencies;
- Finished water deficiencies;
- Distribution system deficiencies;
- Monitoring compliance;
- Management deficiencies.

A summary of the most common significant deficiencies is shown in **FIGURE 1.4.1**.

FIGURE 1.4.1 - Significant Deficiencies / Drinking Water Regulation Violations

(√ if item has been resolved)

Deficiencies related to surface sources:

- ❑ Turbidity standards not met
- ❑ Turbidimeters not calibrated per manufacturer or at least quarterly
- ❑ Incorrect location for compliance turbidity monitoring
- ❑ No auto-dial call-out alarm or auto-plant shut-off for low chlorine residual (H >3300 population) or high turbidity when no operator is on-site
- ❑ For conventional or direct filtration: Settled water turbidity not measured daily
- ❑ For conventional or direct filtration: Turbidity profile not conducted on individual filters at least quarterly
- ❑ For cartridge filtration: No pressure gauges before and after cartridge filter
- ❑ For cartridge filtration: Filters not changed according to manufacturer
- ❑ For diatomaceous earth filtration: Body feed not added with influent flow
- ❑ For membrane filtration: No particle counting or equivalent
- ❑ For membrane filtration: No integrity testing at least weekly

Well Construction deficiencies (not enforceable until Groundwater Rule):

- ❑ Sanitary seal and casing not watertight
- ❑ Does not meet setbacks from hazards
- ❑ Wellhead does not terminate above grade
- ❑ No raw water sample tap
- ❑ No treated sample tap, if applicable

Spring / other source deficiencies (not enforceable until Groundwater Rule):

- ❑ Spring-box not impervious durable material
- ❑ No watertight access hatch / entry
- ❑ No screened overflow
- ❑ Does not meet setbacks from hazards

Disinfection deficiencies:

- ❑ DPD type test kit not used
- ❑ Free chlorine residual not maintained
- ❑ Chlorine not measured and recorded as required
- ❑ Minimum CT requirement not met all times
- ❑ No means to adequately determine flow rate on contact chamber effluent line

- ❑ No means to adequately determine disinfection contact time under peak flow and minimum storage conditions
- ❑ Failure to calculate CT values correctly
- ❑ pH, Temperature, and chlorine residual not measured daily at first user
- ❑ For UV: Bypass around UV system
- ❑ For UV: Lamp sleeve not cleaned
- ❑ For UV: Lamp not replaced annually
- ❑ For UV: No intensity sensor with alarm or shut-off

Treatment deficiencies:

- ❑ Non-NSF approved chemicals
- ❑ Corrosion control parameters not met

Finished water storage deficiencies:

- ❑ Hatch not locked
- ❑ Roof and access hatch not watertight
- ❑ No flap valve or equivalent over drain
- ❑ No screened vent

Distribution system deficiencies:

- ❑ System pressure < 20 psi
- ❑ Cross-connection:
- ❑ No ordinance or enabling authority (CWS)
- ❑ Testing records not current (CWS)
- ❑ No certified inspector (CWS, > 300)

Monitoring Compliance:

- ❑ Monitoring not current
- ❑ MCL violations
- ❑ No approved written coliform sampling plan

Management deficiencies:

- ❑ No operations and maintenance manual
- ❑ Emergency response plan not completed
- ❑ No Certified Operator at required level
- ❑ No written protocol for non-DRC operators
- ❑ Major modifications not approved (plan review)
- ❑ Master plan not current (> 300 population)
- ❑ Annual CCR not submitted

Source: DHS-Drinking Water Program

1.4.2 – What is a Water System Survey?

A **Water System Survey** is a detailed water system inspection conducted by staff of the DHS or the county health department. The survey evaluates all parts of the system, starting with the source, pumping, treatment, and storage facilities, on through the distribution system to service connections. The surveys are used to identify and correct sanitary deficiencies and are indispensable for ensuring the delivery of safe water on a sustainable basis.

Inspections for all public water systems are generally conducted every five years for systems using groundwater and every three years for those using surface water. Areas of inspection for groundwater supplies include:

- Catchment area at the wellhead;
- Potential sources of pollution;
- Sanitary seals;
- Whether wellhead terminates above grade:
- Raw water sample tap

The well house or pumping station is a key part of the survey for groundwater systems. The pumping station should be enclosed within a secure building that will prevent entry of natural and manmade contaminants. The survey will address such questions as:

- Can the building be locked?
- Is the pumping station well lit in the evenings?
- Is there an alarm or security system?
- If chemicals are present, are there signs stating this?
- Are unapproved chemicals stored in the building?
- Is the chemical feed system (if any) safe from vandals?
- Is the general housekeeping appropriate?

The Water System Survey will also include an inspection of the distribution system. Because much of this system is buried and can't be seen, it is important to check file records or with local officials to document the types, sizes and life expectancy of all pipes and valves located underground.

In a distribution system, an important concern for a water system operator is cross

connections that can contaminate water supplies. Distribution system questions to consider include:

- Are backflow devices installed on properties with unapproved sources of water?
- Are backflow devices installed on properties with known cross connections?
- Are fire hydrants inspected regularly?
- Are only trained individuals using the fire hydrants?
- Is a flushing program in place?
- Are all water meters protected (box for customers, locked for master meters)?
- Are valves exercised and maintained?

If there are storage facilities, concerns include:

- Are storage tank vents and overflow pipes screened?
- Are storage tank hatches locked and sealed?

Are storage facilities regularly inspected and cleaned as needed?

1.4.3 – Utilizing Information from the Water System Survey / Addressing Deficiencies

Once a Water System Survey has been performed, all deficiencies or potential deficiencies must be addressed. A plan to resolve or correct deficiencies including a schedule to execute the plan must be developed.

Surface water systems and groundwater systems under the influence of surface water (GWUDI) must respond to DHS within 45 days with a plan that outlines how and when any identified deficiencies will be resolved.

If a system fails to do so, it must issue a public notice to users advising of that failure and then must submit the plan and timetable as originally required. Failure to do so may result in a fine for non-compliance.

UNIT 1: Essential Information and Considerations

FACT SHEET 1.5 - Identifying and Resolving Cross-Connections

1.5.1 - What is a Cross-Connection?

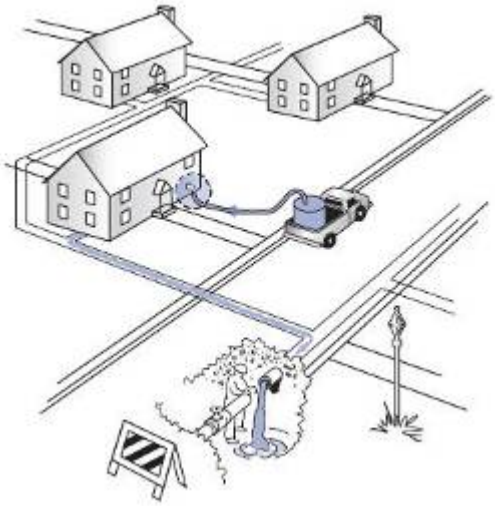
1.5.2 - Oregon Cross-Connection Control / Backflow Prevention Program

1.5.3 - Evaluating for Cross-Connections

FACT SHEET 1.5 - Identifying and Resolving Cross-Connections

1.5.1 - What is a Cross-Connection?

A **cross-connection** is any actual or potential connection between a potable water supply and non-potable water or other substance. A cross-connection may contaminate the water supply by backflow.



Backflow refers to the reversal of the normal direction of flow in piping. Backflow is caused by:

- Backpressure, flow of non-potable water or other substance into the water system from connections that are higher pressure than the water system; or
- Backsiphonage, siphoning of non-potable water or other substance into the water system due to negative pressure or reduced pressure in the water supply piping.

Backflow may be created by many situations. Under normal working pressures most cross-connections occur when the water from the unknown source is at a higher pressure than the pressure in the water system. This could occur when a customer uses a private well or booster pump or when there's a drop in system pressure caused by a large break in the line, or when the lines are being flushed, or by fire trucks pumping large amounts of water for fire fighting. The reduced pressure can also produce a siphon which can draw water out of chemical tanks, air conditioners, hot water heaters or any appliance with a submerged inlet that is not protected to prevent backsiphonage.

There are numerous, well-documented cases where cross-connections have been responsible for contamination of drinking water. For example, in 1999 in Texarkana, Arkansas backflow from the air conditioning system at a local school entered the school's waterlines because the heat exchanger operated at a higher pressure than the municipal

water system and the heat exchanger was either not properly protected or the backflow assembly prevention failed. Fortunately, discoloration of the water was observed early and the school was instructed not to drink or use the water and no one became ill.

Preventing and addressing cross-connections is an important factor in protecting the water supply from possible contamination. At a minimum, all public water suppliers must be familiar with the dangers of cross-connections and should exercise careful surveillance of their systems.

1.5.2 - Oregon Cross-Connection Control / Backflow Prevention Program

In Oregon, the Cross-Connection Control/Backflow Prevention Program is administered by DHS.

By state law, public water system operators are required to prevent cross-connections from existing within their systems. If an actual or potential cross-connection exists, installation of an approved backflow prevention assembly is required. Water systems can meet these requirements by conducting ongoing evaluations for cross-connections as described in section 1.5.3 below.

All community water systems are also required to carry out a local cross-connection program. In addition to ongoing evaluations, this includes:

(1) ***Enabling authority****.* All community water systems must have a rule, by-law, resolution, or an ordinance covering cross-connections. The document should make clear how the system will assure compliance with cross-connection requirements. The document should also state what steps the system will take to identify cross-connections, what will happen when cross-connections are discovered, the process by which each backflow assembly will be installed and tested, how testing will be documented and how non-compliance will be handled. The resolution or ordinance should include authority to inspect suspected cross-connections, as well as the clear authority to discontinue water service to customers who do not eliminate a cross-connection where possible, or fail to install or annually test backflow devices.

(2) ***Testing program and record keeping****.* A mechanism should be established to ensure that all backflow assemblies within the system are tested and maintained by a state certified tester on an annual basis. These records should be kept for a period of ten years. Records listing all connections within a water system that could have

potential cross-connections should also be kept for as long as the conditions exist.

(3) ***The Cross-Connection Annual Summary Report*** is required for all community water systems in Oregon. In it, community water systems must report the progress of their cross-connection control program to DHS. This report is supplied by the state and must be filled out by the system's cross-connection inspector. It is due each year before the last business day of March for the previous year's reporting period of January 1 to December 31.

For more information including regulations, forms, a list of approved backflow assembly devices, available cross-connection related training courses, and list of certified backflow assembly testers visit the DHS web site at: *http://www.oregon.gov/DHS/ph/crossconnection/*

Or, contact:
Michael Perry
Michael.Perry@state.or.us
(971) 673-1220

1.5.3 - Evaluating for Cross-Connections

All public water systems should be in the practice of conducting evaluations for cross-connections. Smaller systems (less than 300 connections) may contract with a certified cross-connection inspector or perform the work themselves with guidance from DHS.

The first step in the evaluation process is to determine what types of customers receive water service. If strictly residential, it should be determined if any of the connections has another source of water such as a private well, swimming pool, pond, or water-using equipment such as medical equipment, photo labs, etc. If there are any commercial or industrial connections, determinations must be made as to whether alternative water sources or any physical, biological, or chemical contaminants are being used in such a way that with the right hydraulic conditions could enable them to enter the water system.

Some types of service connections that could potentially contaminate water systems through a backflow incident are:

- Wastewater treatment plants or pumping stations;
- Domestic booster pumps;
- Hospitals, clinics or mortuaries;
- Fire-fighting systems (building sprinklers);
- Irrigation systems;
- Private groundwater wells or other alternate sources of water;
- Swimming pools, hot tubs or ponds;
- Car washes;
- Photo labs.

Water system operators must investigate properties within the system where potential cross-connections are suspected.

Where an actual or potential cross-connection is identified, installation of a backflow prevention assembly is required. The assemblies must be tested at least annually by a state certified backflow assembly tester or if they are moved or repaired.

UNIT 2: Sampling & Reporting

FACT SHEET 2.1 - Understanding Standards

2.1.1 - What are Drinking Water Standards?

2.1.2 - Maximum Contaminant Levels / Important Standards

2.1.3 - Action Levels

2.1.4 - Trigger Levels for Further Testing

2.1.5 - Interpreting Test Results / Units of Measure

2.1.6 - Other Useful Standards

FACT SHEET 2.1 - Understanding Test Standards

2.1.1 - What are Drinking Water Standards?

Standards are set for contaminants that are known to occur in water, are detectable in water and may cause a health or aesthetic problem.

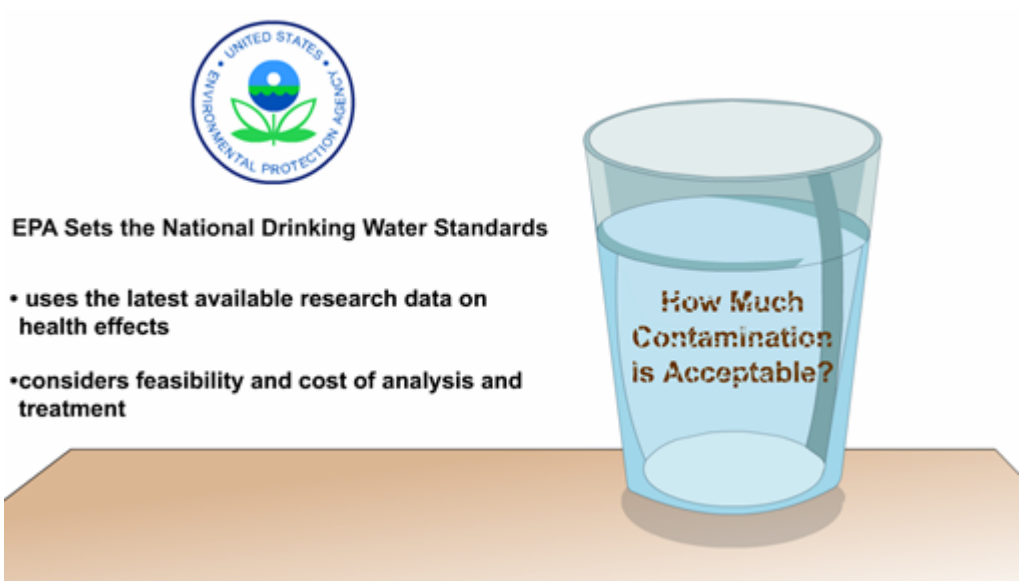
Drinking water standards limit the amount of contamination to a level considered “acceptable”.

The US Environmental Protection Agency (USEPA) is the federal agency responsible for setting national drinking water standards.

When setting standards, USEPA uses the latest available research data on health effects and also takes into account the feasibility and cost of analysis and treatment.

USEPA sets these standards, but it is up to the Oregon Department of Human Services (DHS) to enforce them in their role as the primacy agent. It is the responsibility of the water supplier to ensure that finished water, any chemicals used and equipment meet the appropriate standards.

Following are some of the different types of test standards used in Oregon.



2.1.2 - Maximum Contaminant Levels / Important Standards

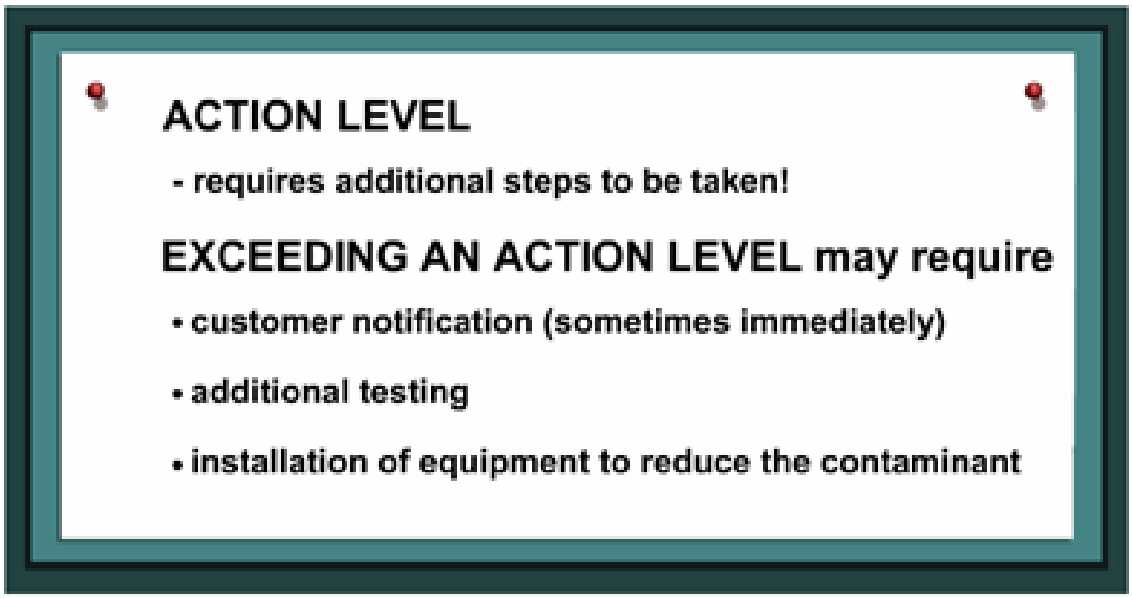
Two types of drinking water standards are used for testing: primary and secondary. **Primary standards** are set for contaminants that may cause health problems. It is mandatory that public water systems adhere to the primary standards.

Maximum Contaminant Levels (MCLs) are established for primary standards. An MCL is the maximum amount of contaminant that can be present in water, and still be considered safe to drink.

Maximum Contaminant Level Goals (MCLGs) that are solely based on health effects. These goals are not a requirement but are there to help water systems identify contaminant levels below which there are no known health risks.

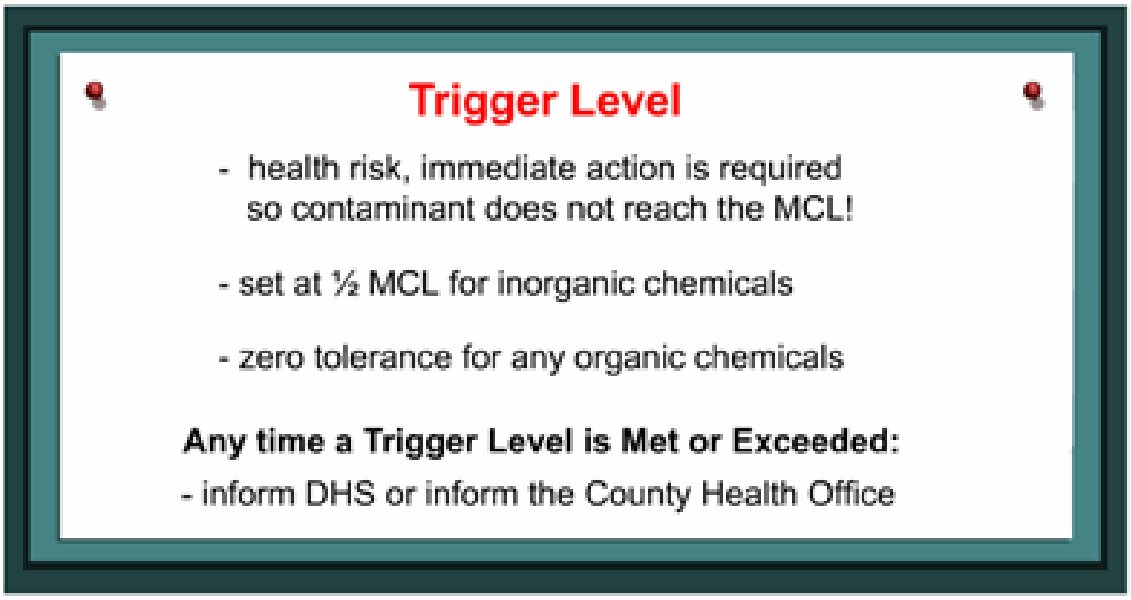
Secondary standards are created for water contaminants that cause aesthetic problems such as bad taste, discoloration or odor. Secondary standards are also known as **Secondary Maximum Contaminant Levels (SMCLs).** These standards are not enforceable.

2.1.3 - Action Levels



Instead of an MCL, some contaminants have a limit called an **Action Level** that, if exceeded, requires the water supplier to take additional steps. Depending on the contaminant, exceeding an Action Level may require customer notification (sometimes immediately), additional testing and/or eventually require installation of equipment to reduce the contaminant.

2.1.4 - Trigger Levels for Further Testing



In addition to standards, the USEPA has also identified **Trigger Levels.** The Trigger is a test result that shows a contaminant level greater than one-half the MCL for any inorganic chemicals, and any detection whatsoever for any volatile organic chemicals (VOCs) or synthetic organic chemicals (SOCs).

The water supplier must notify DHS or the relevant county health authority if a test result is at or above a trigger level.

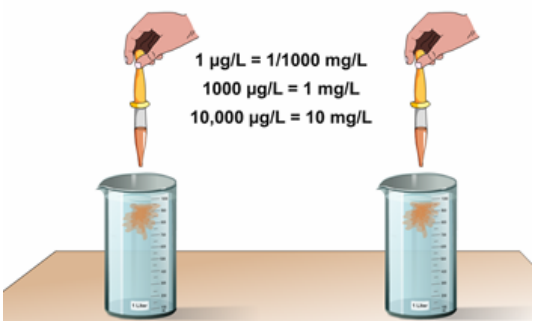
Because of the associated health risks, more frequent testing will be required for any analyte that exceeds the trigger level.

2.1.5 - Interpreting Test Results: Units of Measurement

All drinking water test results and standards have a unit of measurement associated with them. Most tests indicate units of weight of the contaminant per volume of water. The most common unit is the **milligram per liter (mg/L)**, which expresses the weight, in milligrams, of a contaminant in every liter of water (A liter is slightly more than a quart.). Some laboratories prefer to use **parts per million (ppm)**, which is the same measurement as milligrams per liter of water (i.e., 1 ppm = 1 mg/L).

Some contaminants that can be measured in extremely small quantities are reported in **micrograms per liter (µg/L),** which are identical to **parts per billion (ppb)** (i.e., 1 ppb = 1 µg/L).

Concentrations expressed in mg/L (or ppm) can be converted to µg/L (or ppb) by multiplying by1,000. Also µg/L (or ppb) can be converted to mg/L (or ppm) by dividing by 1,000.



For example:
4 ppm is the same as 4 mg/L; which is the same as 4000 µg/L; which is the same as 4000 ppb.

2000 ppb is the same as 2000 µg/L; which is the same as 2 mg/L; which is the same as 2 ppm.

Although most water quality measurements are expressed in these units, some tests — such as those for bacteria and radiation — use different units. These special units are described in later sections of this unit.

2.1.6 - Other Useful Standards

There are a variety of U.S. organizations, composed of various professional and stakeholder organizations that develop appropriate drinking water standards to ensure reliability, quality of products, and to protect the public health.

The National Sanitation Foundation, the American National Standards Institute, and the American Water Works Association (AWWA) are three of the better known organizations that produce standards for chemicals, pipes and equipment that comes into contact with potable water.

Any water system equipment must be certified by NSF or ANSI as being appropriate for potable water. Typically, the appropriate standard number will be printed on the side of the pipe or on the equipment data plate.

The NSF Water Distribution Systems Program is responsible for certifying drinking water treatment chemicals and drinking water system components to ensure that these products do not contribute contaminants to drinking water that could cause adverse health effects. The NSF standards are:

- **NSF/ANSI Standard 60: Drinking Water Treatment Chemicals -- Health Effects**: the nationally recognized health effects standard for chemicals used to treat drinking water.
- **NSF/ANSI Standard 61: Drinking Water System Components -- Health Effects:** the nationally recognized health effects standard for all devices, components and materials which come in contact or are used to provide drinking water.

UNIT 2: Sampling and Reporting

FACT SHEET 2.2 - Sampling and Reporting Requirements for Small Groundwater Systems

(Contains edited excerpts from 40 CFR 141.201)

2.2.1 - Overview of Sampling and Reporting Requirements

2.2.2 - Coliform Sampling FAQs

2.2.3 - Inorganic Chemical Sampling FAQs

2.2.4 - Organic Chemical Sampling FAQs

2.2.5 - Radionuclides

2.2.6 - Disinfection By-Products (DBP)

2.2.7 - Regulatory Changes

2.2.8 - Using the DHS Website & Templates

FACT SHEET 2.2 - Sampling and Reporting Requirements for Small Groundwater Systems (Contains edited excerpts from 40 CFR 141.201)

This fact sheet summarizes sampling and reporting requirements for small groundwater systems. It also addresses why certain tests are needed, testing requirements and test taking methods. In addition to knowing what tests to take and when, understanding correct sampling techniques is very important. If a sample is collected improperly, results may not accurately reflect water quality, *and could require multiple retake samples -- a waste of both time and money.*

2.2.1 - Overview of Sampling and Reporting Requirements

Why test?

By law, all public water systems are required to regularly test water quality. State and federal requirements determine the type and frequency of tests. Water testing provides information to both water suppliers and their customers concerning the overall quality of the drinking water, and also detects water quality problems that need to be addressed.

Failure to conduct these mandatory tests could result in:

- Customer health problems;
- A compliance violation(s);
- Financial penalties against the water supplier.

Testing responsibility is usually not understood by customers, and is therefore often unappreciated. You, as an operator or owner, should make a strong effort to educate your customers, board and council or commission on the importance of the water quality testing program and your efforts to comply.

Who can test drinking water?

It is the responsibility of the **Water Supplier** to see that samples are taken in accordance with federal and state requirements. Basically, anyone familiar with recommended procedures may collect the various samples. Most often this is the operator, or someone trained by the operator.

What must be tested?

Depending on your water system classification (community, transient, etc.), various tests are required at specified frequencies. Among the tests that must be conducted by small groundwater systems are:

- Microbial or Coliform;
- Inorganic Chemicals;
- Organic Chemicals: Volatile Organic Chemicals (VOCs) and Synthetic Organic Chemicals (SOCs);
- Radiological.
- Disinfection By-Products (DBPs)

Specific information about these contaminants and required sampling procedures are included in this document.

How often do I test?

Knowing which water quality tests to take and when to take them can be confusing. The number of required tests may be impacted by each water source's susceptibility to contamination, water quality history, compliance with previous monitoring requirements and waiver status. There is also a long list of required tests to perform.

The frequency of microbial testing depends on the populations served. For example, community groundwater systems serving populations of less than 1,000 must take one routine coliform sample per month. Generally, non-community systems must take quarterly samples. Your particular sampling schedule has been determined by your system classification.

Chemical sampling frequencies vary greatly by contaminant. Some chemical tests are required annually, while others require a single test during a three-year period. Depending on your test results, compliance with previous monitoring requirements, susceptibility to contamination and development of a **Drinking Water Protection Plan and Program**, some tests could be waived for the following two periods of a nine-year compliance cycle, at which time the whole procedure would start again.

Detailed descriptions of monitoring requirements can be found in the Oregon Administrative Rules (OAR 333-061-0036).

For Oregon public water

systems, a summary fact sheet available from DHS and included in the reference section of the Need-to-Know Fact Sheet Library (See Section 2.2.8 for further information).

What laboratory can I use?

All water quality tests must be sent to a **State Certified Laboratory** for analysis**.** Using a certified lab assures the water supplier, customers and DHS that tests are being analyzed following accepted laboratory practices and that results are dependable.

A list of certified labs throughout the state of Oregon is included in Unit 3, Section 3.9.8 – *State Certified Laboratories*.

Do I need to report results?

YES. Once tests are taken, the next step is to ***report the results to DHS***. The water supplier is responsible for assuring results are reported to of required chemical tests is DHS no later than 10 days following the end of the required monitoring period. The water supplier may choose to report results to DHS directly, or may make arrangements with their lab to report the results to DHS in a timely manner.

When a maximum contaminant level is exceeded, results must be reported to DHS more quickly. In addition, water suppliers may be required to submit **public notice** to consumers. (See 2.3 – *Public Notification Requirements* for more information.)

All community water systems also must report the results of any tests that show detections of regulated contaminants to customers in an annual **Consumer Confidence Report (CCR)**. The rationale for a CCR is that consumers have a right to know what is in their drinking water. (See 2.4 – *Consumer Confidence Reports* for more information.)

2.2.2 - Coliform Sampling FAQs

Why test for coliform bacteria?

Coliform bacteria commonly occur throughout the environment. They are used as an **indicator organism** to determine the potential for the presence of disease-causing (**pathogenic**) organisms in water.

If coliform bacteria are present, a contamination pathway presumably exists between the bacteria source and the water supply. Disease-causing bacteria may use this pathway to enter the water supply.

Since coliform bacteria stay in water longer than most disease-causing organisms, the absence of coliform bacteria leads to the assumption that the water supply is microbiologically safe to drink. Results from coliform bacteria tests are normally expressed as “Present” (P), or “Absent” (A).

When a coliform test is positive, additional tests for fecal coliform bacteria and *Escherichia coli* (*E. coli*) are conducted. **Fecal coliform** are a smaller group of bacteria within the coliform bacteria type specific to the intestinal tracts of warm-blooded animals. ***E. coli*** is a type of fecal coliform bacteria commonly found in the intestines of animals and humans. A positive *E. coli* result is a strong indication that human sewage or animal waste has contaminated the water. Fecal coliform and *E. coli* bacteria levels are expressed as the number of colonies per 100 ml of water.

Which coliform samples must be taken, and when?

For **community** water systems using groundwater, **bacteriological testing —** also known as a "bacti" or **total coliform (TC)** test — must be conducted every month. The number of monthly samples depends on the size of the system. Community systems serving populations of up to 1,000 must conduct one **routine sample** per month.

For **non-community** water systems using groundwater that serve populations of less than 1,000, routine samples are required quarterly. Monthly samples are required for all non-community systems using groundwater that serve populations greater than 1,000.

The drinking water standard requires that ***no coliform bacteria are present in public drinking water supplies and bacteriological testing cannot be waived.***

It is strongly advised that TC samples be taken within the first two weeks of the month, in case coliform is detected. Doing so allows for **repeat samples** to be taken within the same month or monitoring period, which is a federal requirement. It is important to properly identify on the laboratory form the type of sample collected.

In all, there are **four (4) types of microbial samples**:

1) Routine Samples
Regular TC samples are collected on a monthly (or quarterly) basis. Collection procedures, including sample sites, should be in accordance with an approved **Coliform Sampling Plan** (see following sections of this document for more information on a Coliform Sampling Plan).

2) Repeat Samples
Samples are collected following a "coliform present" routine sample result. If a system routinely collects one TC sample per month or quarter, the number of repeat samples taken is four. (These sites should be identified on the TC sample site plan.) If a system takes two or more routine samples per month, the number of repeat samples is three for every "coliform present" sample result.

3) Special Samples
Samples are collected for other reasons. For instance, a "special" sample would be collected after repairs to the system and before it is placed back into operation; or a sample collected at a wellhead prior to a disinfection

4) Temporary Routine
See basic definition of Routine Samples. Temporary Routine Samples are different in that they are required during the month following a positive routine sample. They represent a temporaty increase in number of required Routine Samples.

Where should coliform samples be taken?

Routine coliform samples should be taken in locations representative of the water system. This means that the samples should be representative of the *entire* water system in the course of a

A system's Coliform Sampling Plan shows the general water system layout and identifies locations where routine and repeat samples are taken.

Depending on the complexity of the water system, such as dead end lines or pipe run where little water is used, this could mean identifying anywhere from one to perhaps eight locations, even in a small system. Samples should be taken at a different location each month to ensure testing is done throughout the system.

Should the operator go on vacation, or become unavailable, someone else should be able to read the plan and properly continue the sampling. An outline of information to include in a sampling plan is highlighted in the "Coliform sampling plan template for small public water systems" included in the references section and available from the DHS.

What is a coliform sampling plan?

The coliform sampling plan guides the water operator in selecting routine sampling sites to ensure that sampling and coliform testing is conducted at representative points throughout the system. It takes into account various pressure zones, etc., and regular intervals, and, in the event of a positive routine test result, establishes repeat sampling sites for monitoring. The plan helps assure proper sampling is conducted even when staff assignments change.

The size and complexity of the plan will be dependent upon the structure and composition of the water system. These plans must be submitted to DHS or your local county health department upon request. They must also be made available for review during any site visit or Water System Survey.

Most small water systems will have relatively simple plans because their structure and composition are not complex.

Water systems without distribution systems, such as those supplying schools and single building facilities, are still required to develop a sampling plan.

In most cases, the plan is a relatively short and simple document with a small number of identified sampling sites. The sampling plan is a tool water systems use to identify the most representative points at which to collect microbial samples.

A thorough plan will promote economy in coliform sampling and minimize poor site selection and techniques that contribute to false positive results. All community water systems must develop a coliform sampling plan.

A plan with the following components is recommended:

1. A map of the distribution system showing:

- All water sources and their entry points into the distribution piping;
- The area served by each water source (if not combined prior to distribution);
- Treatment facilities (filtration, disinfection, etc.);
- Storage tanks and reservoirs;
- Pressure reducing stations;
- Booster pump stations;
- Pressure zones;
- Routine sampling sites;
- Repeat sampling sites;
- Interconnections and critical valves;
- Pipe material and size (if known);
- Location of blow offs / flushing points.

2. Background information on the system and key contacts including:

- Water system name;
- The seven digit water system ID number (41-12345);
- The name of each water source;
- Storage/reservoir volume;
- Treatment plant description--process utilized, source(s) treated, location, etc.;
- Pump stations;
- Total population served;
- Total number of service connections;
- Number and area of pressure zones with population and service connections in each zone;

- Lab contact information including hours and process for bottle pickup and drop off;
- Local county health department, or DHS contact for more information.

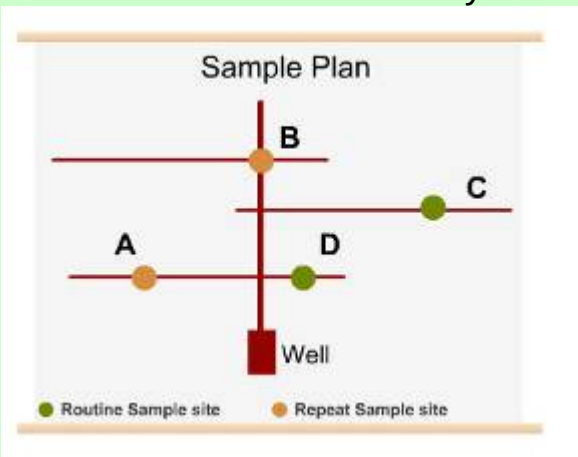
3. A narrative description of the sampling plan including the following information:

- Minimum number of routine samples required per monitoring period;
- The location of all routine sampling sites needed to cover all areas in the distribution system. The location of these sites must be on the map of the system and the specific location (address) must be listed in this section;
- DHS recommends selecting from 3 to 4 times the number of sites needed to meet minimum testing requirements (i.e., if you take 1 sample per month, identify 3 to 4 sites in the system so you can rotate through the system);
- Monthly rotation cycle; typically a system has more sampling sites than required for monthly samples and will rotate among those sites. A description of the rotation schedule must be included. It is desirable to rotate through each sample site from 3 to 4 times per year;
- Note the location of at least one site upstream and one downstream within five service connections of each routine sample site. These will come into play because systems collecting one sample per monitoring period are required to collect four repeat samples upstream and downstream of the initial site following a positive routine. Systems collecting two or more samples per month must collect three repeat samples for every positive coliform test result;
- Systems collecting fewer than five routine samples per month must collect five routine samples in the month following a coliform detection in a routine sample (even if the repeat samples were all negative).
- A brief narrative on the sample collection technique. Many instances of false positive test results occur due to improper collection technique. An excellent sampling plan is of little value if the personnel collecting samples are not properly trained. Follow the directions the laboratory provides with the sample container. If the system chlorinates, measure and record the free chlorine residual on the lab slip each time a coliform sample is collected;

- A schedule of the distribution line flushing program. This maintenance procedure is vital in reducing the possibility of coliform and biofilm buildup. Systems with dead-end lines should practice distribution line flushing on a regular schedule;
- The name and phone number of the sampling plan preparer;
- The date the plan was prepared.

Selecting routine and repeat sites

The purpose of routine coliform sampling is to assure that the water delivered to all users meets drinking water microbial standards. It is essential that the entire system be routinely monitored since coliform contamination can occur anywhere in the system.



Careful selection of sampling sites is extremely important. They should be located throughout the distribution system, represent varying conditions that occur and be chosen with consideration for the complexity of the water system. It is also important to identify potential areas of concern that may adversely affect the microbiological quality of the water, and include those areas in the sampling plan. Examples of these areas are:

- Cross connection hazards;
- Varying population densities;
- Low pressure zones;
- Deteriorating water mains;
- Shared use connections;
- Low velocity water movement areas;
- Any other areas of concern.

Customers' faucets and specially installed sampling taps are the two most commonly used sampling sites; either is acceptable. Many water suppliers use special taps for coliform sampling sites. These are connected directly to the distribution piping. They can be a simple riser pipe with a faucet connected to the distribution main or a more sophisticated manufactured sampling station that is installed at the water meter or into the distribution main.

Special sampling taps are preferred by some utilities because they are more accessible to the sample collector and are not influenced by conditions within customers' plumbing systems.

Sampling at a customer's faucet may not accurately reflect the conditions of the distribution system due to conditions in the customer's plumbing that are not under the control of the water supplier. However, in many cases, this is the only way to collect a sample. If this is the case, DHS recommends that each faucet be carefully examined to assure suitability.
Some examples of undesirable conditions are:

- Swivel-type faucets with a common control valve for hot and cold;
- Faucets with leaky packing material around the stem;
- Faucets that supply areas where bacterial contamination is highly probable, such as janitorial sinks or commercial cleaning sinks;
- Faucets close to or below the ground surface;
- Faucets that point upward;
- Faucets with internal threads in the spout;
- Samples collected through a garden hose or other faucet attachment;
- Faucets with aerators (remove aerators prior to sample collection);
- Drinking fountains and bubblers;
- Yard Hydrants.

How should coliform samples be taken?

Using the proper sampling technique is extremely important in obtaining accurate water quality information. A coliform sample that is collected improperly may indicate contamination of the water supply when, in fact, it is safe. Learning proper sampling techniques will help ensure accurate test results and

eliminate the cost of additional unnecessary sampling. If you have any questions about proper sampling procedures, please contact your laboratory, county health department or DHS.

Carefully follow these 3 steps when collecting a coliform sample:

I – Select a sampling site
II – Fill out a laboratory form
III – Take the sample and send it in to the lab

I – Select a sampling site

Select a sampling site where water is commonly taken for consumer use or a dedicated site in the distribution system. These are typically faucets or "hose-bibs." (These sites may already be identified in your sample site plan.)

- Do not take samples outdoors when it is raining or when the wind is blowing excessively. These events can easily contaminate a sample. Once you have selected a sample site, it should be incorporated into your sample site plan.
- The sampling point should be a non-swivel faucet; bacteria often grow in the swivel part.
- If it is a faucet with an aerator, remove the aerator, screen and gasket.
- If an outside faucet is used, disconnect any hoses or other attachments. It should be a faucet that does not leak around the packing or valve mechanism. Leaking faucets can promote bacterial growth and leaking water could drip into the sample bottle and contaminate your sample.
- The faucet may initially be sanitized by using a solution of one (1) ounce of 5% bleach per one gallon of water (*do not* use excess bleach as this may falsify results). However, this step is not necessary.
- *Do not* use fire hydrants, yard hydrants or drinking fountains as sampling points! They usually have a small hole in the underground pipe to allow for drainage, and this is a great source of coliform bacteria.
- *Never* dip sample bottles in reservoirs, spring boxes or storage tanks in order to collect a sample. First, these are not representative of the distribution system. Second, water running around your hand into the sample bottle will probably test positive.

II – Fill out a laboratory form

Before taking a sample, fill out a laboratory form. It's a good idea to do this before your hands get wet.

Complete the following information:

- PWS ID number (it begins with 41-)
- Water system name, address, city and phone number
- Collection date and time
- Type of sample: routine, repeat, special or temporary routines (refer to previous discussion of definitions)
- Name of person collecting sample and sample location
- If your system chlorinates, enter the free chlorine residual. The residual should be measured just prior to the time of sample collection.
- Complete the section for the return address where the report is to be sent.

III – Take the sample and send it in to the lab

- Use only laboratory-provided sample bottles that are specifically for bacteriological sampling. These bottles are sterile and should not be rinsed before sampling. A chemical, usually sodium thiosulfate, is placed in the bottle by the lab and is used for chlorine deactivation. *Do not* rinse the bottle.
- Flush the line thoroughly. *Vigorously run water through the faucet for three to five minutes*. Allow the water to run until there is a noticeable change in the temperature. This colder water is more representative of the quality of water being provided. Use this time to fill out the paperwork and, if your water is chlorinated, also conduct a chlorine residual test.
- *Reduce the water flow to a slow, steady stream.*
- Don't open the sample bottle until the moment you are going to fill it. Uncap the sample bottle, being careful not to touch the inside of the bottle with your fingers or other objects. Hold the lid opening down, but *never set the lid down* while taking the sample.
- Fill the sample bottle to the fill mark which is usually at the shoulder of the bottle. Leave an air space in the top of the bottle. Do not overfill.
- Replace the cap immediately making sure it is tight and does not leak.
- Package the sample for delivery to the laboratory. Be

sure to include the lab form. The sample should be kept cool at all times.
- Mail or deliver the sample to the lab immediately. Samples over 30-hours old will not be analyzed by the laboratory. If the sample is too old or leaks in transit, the lab should notify the water system contact to collect another.

What action is needed if a sample is positive?

Repeat samples are required if any routine sample is positive for total coliform.

When notified by the laboratory of a positive sample, the water supplier must:

- Notify DHS or the County health department within 24 hours
- Take repeat samples within 24 hours

For systems collecting ONE Routine sample per month:

A total of **FOUR REPEAT** samples are required from the following locations:

- The same tap as the original unsatisfactory routine sample.
- An active service within five active connections upstream from where the original unsatisfactory sample was taken.
- An active service within five active connections downstream from where the original unsatisfactory sample was taken.
- Another location, such as at the source or right after the storage tank, which will provide useful information for determining a possible source of contamination. If you do not have a tap at the source or storage tank, choose another active service.

In the month following the initial positive test, a system must take five routine samples, even if the all the initial repeat samples were negative.

Note: It is not an MCL violation unless a repeat test shows the presence of either total coliform or fecal coliform bacteria.

Typical Coliform Sample Form. Shown on next page

DHS oregon department of human services
MICROBIOLOGICAL ANALYSIS
Public Water Supplies
Drinking Water Program

PWS#: 4 1

PWS Name: _____

Address: _____

City, County: _____

Phone: _____ **Fax:** _____

Return address for report:

Name : _____

Address : _____

City, State, Zip : _____

Bottle#: _____

☐ Results do not meet NELAC Standards-see page 2

Lab Sample ID#: _____

Sample Collection Date/Time: ____ / ____ / ____ ____ : ____ ☐ **AM** ☐ **PM**
Month Day Year Hour Min

Collected By: _____

Sample Point: _____

Address: _____

Sample Type: ☐ **Routine** ☐ ***Repeat** ☐ **Special** ☐ **Temporary Routine** ☐ **Source Water**

Chlorinated?: ☐ **No** ☐ **Yes** **Free Chlorine:** _____ **mg/L**

***If Repeat, Date of Initial Positive:** ____ / ____ / ____ (Month Day Year) ***Original Positive ID#:** _____

LAB USE ONLY

Sample Received Date/Time: ____ / ____ / ____ ____ : ____ ☐ **AM** ☐ **PM**
Month Day Year Hour Min

Initials: _____ **Temp:** _____ **°C**

Evidence of cooling? ☐ **Yes** ☐ **No**

Analysis Start Date/Time: ____ / ____ / ____ ____ : ____ ☐ **AM** ☐ **PM**
Month Day Year Hour Min

Initials: _____

ORELAP Method(s):
Check all that apply.

☐ **Chromocult ®** ☐ **Coliscan ®** ☐ **ColiTag ®** ☐ **m-ColiBlue ®** ☐ **MI agar** ☐ **Readycult ®**

☐ **SM 9221 B (MTF) +** ☐ **E or** ☐ **F**

☐ **SM 9221 D (P-A M) +** ☐ **E or** ☐ **F** ☐ **SM 19th Ed.** ☐ **SM 20th Ed.**

☐ **SM 9222 B (MF) +** ☐ **9221E or** ☐ **9221F or** ☐ **9222G**

☐ **SM 9223** ☐ **Colilert ®** ☐ **Colilert-18 ®** ☐ **Colisure ®** ☐ **Other:** _____

Test Results:

Total Coliforms: ☐ **Present** ☐ **Absent**

***E. coli*:** ☐ **Present** ☐ **Absent**

Analysis Complete Date/Time: ____ / ____ / ____ ____ : ____ ☐ **AM** ☐ **PM**
Month Day Year Hour Min

Analyst: _____

Review by: _____ ____ / ____ / ____
Month Day Year

Reported By: _____ **Report Date:** ____ / ____ / ____
Month Day Year

Sample Invalidation:
☐ **over 30 hours**
☐ **leak**
☐ **heavy non-coliform growth**
☐ **other** _____

Test results relate only to the parameters tested and to the samples as received by the laboratory. Test results meet all requirements of NELAC unless otherwise noted. This report shall not be reproduced, except in full, without written consent of this laboratory

Send results to: **DHS-DWP P.O. Box 14350, Portland OR 97293-0350**
Phone (971) 673-0416

2.2.3 - Inorganic Chemicals (IOCs) Sampling FAQs

Why sample for inorganic chemicals?

Inorganic chemicals (IOCs) are substances usually of mineral origin, but are also by-products of agriculture and industry. They include salts, metals and minerals. Many pose health risks and are primary contaminants.

There are also a number of inorganic chemicals sometimes referred to as secondary contaminants. Monitoring for secondary contaminants is not required as they do not usually pose health risks, but they may affect taste, odor and quality of a system's water or interfere with water treatment.

How often must IOC samples be taken?

*All community and non-transient non-community systems must initially conduct IOC tests in each three-year period***.** If your system has a history of three rounds of testing with **no** Maximum Contaminant Level violations, you may apply to DHS for a reduction in testing to once every nine-year cycle.

For a list of IOCs that must be tested see the DHS fact sheet on routine chemical monitoring for your system type in the reference section.

Several inorganic chemicals have different sampling frequencies and procedures, including nitrate, arsenic and lead and copper which are discussed separately below.

What are the health effects?

Nitrate.

Although nitrate is listed as an IOC, it has different test requirements. ***All public water systems except purchasing systems must test nitrates annually*****.** Sensitive populations, including infants less than 12 months old, pregnant women and people with certain blood disorders, are prone to methemoglobinemia (blue-baby disease) when consuming water with high levels of nitrates. Nitrate originates from fertilizers and animal or human waste. It is a concern in areas with intensive agriculture or residential areas with large concentrations of septic systems.

Nitrate may be reported as either nitrate (NO3) or nitrate-nitrogen (NO3-N). Be sure to determine which type of nitrate is being measured. The nitrate-nitrogen (NO3-N) MCL is 10 mg/L.

Arsenic.

Arsenic is odorless and tasteless. It enters drinking water supplies from natural deposits in the earth or from agricultural and industrial practices.

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.

The standard for arsenic has been revised to reflect growing awareness of potential health effects at levels previously considered safe. Your system's sampling schedule for arsenic may change depending on sampling history and any levels of arsenic detected. Check with DHS or your county health department representative for your individual system's sampling requirements.

Lead and Copper.

Both lead and copper have serious health effects and come from similar sources in a system. Lead is particularly harmful to a fetus and small children where it interferes with proper nervous system development. It may also cause premature birth, reduced birth rate, seizures, behavioral disorders, brain damage and lowered IQ in children. Long-term exposure to lead (in excess of the drinking water standard) has been linked to cancer, stroke and high blood pressure in adults. Copper also has serious health effects and may cause severe stomach cramps and intestinal illness.

Lead and copper in the drinking water system usually originate from plumbing system corrosion. Where the water supply is corrosive, homes with copper or galvanized pipes, lead solder joints and brass plumbing fixtures are at risk of increased concentrations of lead and copper. Signs of corrosion include metallic taste, bluish green stains in sinks and bathtubs, and in severe cases, small leaks in plumbing systems.

Lead and Copper Sampling Requirements

Lead and copper have special sampling requirements (OAR 333-061-0036) that are different from most inorganic chemicals. Initial testing establishes further lead and copper testing requirements for each water system. Community and non-transient, non-community water system should have completed initial testing, which involves collecting two rounds of samples in consecutive six-month periods of a calendar year. The number of samples collected in the initial testing period depends on the size of the system:

- Systems with a population of <100 are required to take 5 samples.
- Systems with a population of 101 to 500 must take 10 samples.
- Systems with a population of 501 to 3300 must take 20 samples.

If the results of the initial testing did not exceed the action level for either lead or copper at the 90th percentile, then the number of samples may be reduced by half and the frequency may be reduced to annual or every 3 years, depending on the results of the initial rounds. There is no reduction for systems taking only five samples.

High risk contamination sites include single family structures or any building containing copper pipes with lead solder constructed between Jan 1, 1983 to June 30, 1985, or that may have had any type of lead piping.

What is the lead and copper sampling procedure?

1. Request sample kits from the laboratory. Read the instructions.
2. Test samples are taken from inside homes or buildings, and must be taken as a “first draw.” This means the water in the facility must sit in the pipes for a minimum of six hours. Most operators instruct their customers how to take a sample and have them place the sample by the front door. If everyone in the house has gone to work or school, another option is to have the sample taken in the afternoon when the first person returns home.
3. The person who collects the sample should fill out a simple chain of custody.
4. The sample must be collected from a kitchen or

bathroom ***cold water*** faucet. Water should ***not*** be run prior to sampling. Place the open sample bottle below the faucet, gently open the cold water tape and fill a one-liter bottle.

5. Fill out the lab slip paperwork, place it in the sample kit and return it to the lab.

2.2.4 - Organic Chemicals (VOCs & SOCs) Sampling FAQs

Why sample for organic chemicals?

Organic chemicals are a group of more than 100 mostly man-made chemicals. They can occur in drinking water sources due to industrial activity, landfills, gas stations or pesticide use. Many organic chemicals are carcinogenic (cancer causing), so they often have very low drinking water standards, usually measured in µg/L or ppb (micrograms per liter or parts per billion).

Generally, organic chemicals are grouped into two major categories:

- **Volatile Organic Chemicals (VOCs).** VOCs are man-made compounds that, at normal temperatures, readily vaporize from water into the air. They present a health risk not only from drinking contaminated water, but also from inhaling VOCs that escape from the water during showers or other home uses. VOCs also may be absorbed directly through the skin during bathing and showering. They are commonly used as solvents, fuels, paints or degreasers. Virtually all VOCs produce an odor in water, although it may not be obvious before the drinking water standard is exceeded. Nearly all VOCs have primary drinking water standards (MCLs), because they cause cancer or damage to the liver, kidneys, nerve system or circulatory system. Numerous VOCs are regulated in public water supplies.

- **Synthetic Organic Chemicals (SOCs).** SOCs are manufactured, carbon-based compounds that are typically found in pesticides, herbicides and fungicides. Others are used in the making of plastics. Nearly all SOCs commonly found in water are pesticides, with a few notable exceptions (such as PCBs and dioxin). They differ from VOCs because they do not readily escape into the air from water.

What are the sampling requirements for VOCs and SOCs?

Each test must be performed during each three- year period, unless a waiver has been obtained from the Department. State certified laboratories have the list of chemicals required for these tests.

How is organic chemical sampling conducted?

How an organic sample is taken depends upon whether it's a VOC or an SOC test. Steps and procedures can vary slightly, depending upon the laboratory used and the sample taken.

Generally, laboratories supply test kits that contain a small cooler, freeze packs, sample bottles and instructions. The lab will sometimes provide a "blank" sample with your kit. Do not do anything with this sample. A blank sample simply assures that sample bottles were not exposed to open sources of chemicals that may affect final results.

The following is a general set of instructions, but again, read your lab instructions carefully.

1. ***DO NOT*** take samples near any open sources of chemicals, such as gas cans, pesticides, weed-killers, etc. Taking a VOC sample near a running engine of any kind, such as a vehicle or lawn mower, can easily produce incorrect results.
2. Freeze the cold pack before sampling.
3. **Carefully read the instructions!** Some tests require bottles to be filled completely, and others require it be filled only to the shoulder. Some vials cannot contain air bubbles. Take care to follow safety instructions. Usually, the VOC sampling test requires adding a few drops of acid to stabilize the sample. The acid can cause burns, so beware!
4. Locate a sampling point that is representative of your source-water ***after*** treatment but prior to entry to the distribution system.
5. Remove any attachments from the tap such as hoses, filters, screens or aerators.
6. Flush the water for about 10 minutes or until a constant temperature is reached. Use this waiting time **to fill out the chain of custody.**

7. Reduce the water flow to a small even flow (about the diameter of a pencil) and fill the sample container as instructed. ***Do not*** wash out preservatives or chlorine neutralizing chemicals in the sample container.
8. Pack the samples with the freeze pack and return them to the laboratory as soon as possible.

2.2.5 - Radionuclides

Why test for radioactivity?

Radioactivity usually occurs in water from radium, uranium or radon. These naturally-occurring materials emit radioactivity as alpha, beta or gamma radiation. Each form of radiation affects the human body differently, yet all can lead to cancer. Radioactivity in water is normally measured in picocuries per liter (pCi/L) or in millirem, which is a measurement of the dosage of radiation to the human body. In the small number of drinking water systems with radioactive contaminant levels high enough to be of concern, most of the radioactivity is naturally occurring — although some systems are located in areas where man-made radioactive contamination may occur. Manmade radioactive contamination sources include facilities that use, manufacture or dispose of radioactive substances. Drinking water contamination may occur through accidental releases of radioactivity or through improper disposal practices. Water systems that are vulnerable to this type of contamination are required to perform extensive monitoring for radioactive contamination to ensure that their drinking water is safe.

What is the sampling requirement for radionuclides?

All community water systems must test for radionuclides. **Specific rules are found in OAR 333-61-0036 and the Primary Standards**. Additionally, if DHS determines the water supply is vulnerable to radiation contamination or is actually contaminated, increased monitoring in accordance with OAR 333-61-0036 will be required.

Initial Monitoring

Community Water Systems without acceptable historical data for ***gross alpha particle activity, radium 226, radium 228 and uranium*** must conduct initial monitoring to determine compliance with OAR 333-061-0030(5) by December 31, 2007.

Samples must be collected from each entry point to the distribution system during four consecutive quarters before

December 31, 2007 according to the following schedule:

Population	Begin initial monitoring by	Complete initial monitoring by
300 or more	First quarter 2005	Fourth quarter 2005
100 - 299	First quarter 2006	Fourth quarter 2006
Less than 100	First quarter 2007	Fourth quarter 2007

DHS may waive the final two quarters of the initial monitoring at an entry point if the results of the samples from the first two quarters are below the method detection limit.

Grandparenting of historical data

A drinking water system may use monitoring data from each source or entry point collected between June 2000 and December 8, 2003 to satisfy the initial monitoring requirements.

Reduced Monitoring

Radionuclide monitoring may be reduced to once every three years, once every six years or once every nine years based on initial sampling results. Contact DHS or your local county health department for more information.

How do I sample for radionuclides?

1. Contact a laboratory that conducts Radionuclide (often referred to as “Rad”) testing and notify them of the appropriate test needed.
2. Read the instructions carefully. Fill each sample container as directed. The sample location is at the source after treatment prior to entry to the distribution system.
3. Fill out the sample paperwork and take the sample. Samples do not need to be cooled, but they should be sent to the laboratory as soon as possible.

2.2.6 - Disinfection By-Products (DBPs)

Why sample for Disinfection By-Products (DBPs)?

Many water systems add chlorine or other disinfectants for treatment to destroy or inactivate microbial organisms. However, these disinfectants may form **disinfection by-products (DBPs)** when they react with naturally occurring organic substances in the water.

The most common DBPs formed when chlorine is used are trihalomethanes (THMs) and haloacetic acids (HAAs); testing requirements will refer to TTHMs (total trihalomethanes) and HAA5 (the 5 forms of haloacetic acids).

These DBPs have been shown to cause cancer and reproductive problems in laboratory animals and may also cause bladder cancer and reproductive problems in humans.

What is the DBP sampling requirement?

In 1998, US EPA finalized the "Stage 1 Disinfectants and Disinfection By-Products Rule (DBPR)." These rules replace the original TTHM Rule and became effective January 1, 2004. ***The rule applies whether the chemical is used as a disinfectant or an <u>oxidant.</u>***

The rule is applicable to the following public water systems:

- All community water systems and non-transient, non-community (NTNC) water systems that continuously use chlorine, ozone, chloramines or chlorine dioxide during any part of the treatment process;
- Transient non-community (TNC) water systems that use chlorine dioxide;
- Any system that purchases disinfected water.

*All community and NTNC systems using disinfectants must develop a **DBP Monitoring Plan** and monitor for TTHMs and HAA5.*

Groundwater systems serving populations of less than 10,000 are required to take one (1) sample of TTHM and HAA5 per plant per year.
Based on results, monitoring may be reduced to one sample per plant per three-year period for these systems. The samples must be taken during the warmest time of the year (i.e., July or August).

2.2.7 - Regulatory Changes

At this time, there are currently (3) three new rules being promulgated. These rules are:

- Long Term 2 SWTR
- Stage 2 D/DBP Rule
- Groundwater Rule

However, the "Groundwater Rule" is expected to have the most impact on small groundwater systems. This rule will provide policy on disinfection requirements and other considerations for groundwater sources. US EPA is always conducting research, and new monitoring requirements may be developed.

It's a good idea to periodically review DHS's website (http://oregon.gov/DHS/ph/dwp/rules.shtml), or speak with a DHS or a county representative to ensure you have the most current information.

2.2.8 - Further Information - Using the Department of Human Services Website & Templates

DHS maintains a web site at http://oregon.gov/DHS/ph/dwp/ that contains a wealth of information. Below are some web site highlights to help you with sampling and reporting requirements. You can always contact DHS or your local county health department for information.

Use the DWP Web-site to Determine Sampling Requirements and Past Results

Once on the main website, use Data Online to review chemical testing requirements and results for your system.
(Note: Not all chemical testing requirements, e.g., rads, are not yet on this page but DHS is working to include them soon.)
Follow these procedures:

1. Go to the website, and "click" the "Data Online" icon (to the left).
2. At the top of the next window you will see numerous options for categories. Click on the "WS Name Look Up" which is in blue at the top.
3. Type in the name of your water system.
4. A list of systems with any matching names will come up on the screen. Click on your system ID number.
5. Scroll down to the bottom of the page. Click on the "Sampling-Schedules – Chemicals" also in blue. (At the bottom you also can see information on latest chemical results, coliform sampling schedule, coliform results and more)

Get important DHS Monitoring Forms & Fact Sheets

From the main website, click on the "Forms/Tools/Fact Sheets" icon (to the left).
Information on the following is available:

- Monitoring and Report Formats;
- Coliform;
- Turbidity and Surface Water Treatment;
- Chemical Monitoring;
- Lead and Copper Corrosion Control;
- Public Notices;
- Order Forms;
- Fact Sheets, Interpretations and Techniques;
- Health Effects.

To obtain a summary of the chemical sampling requirements, click on "Chemical Monitoring" at the top of the page. Then click on "Community and Non-Transient

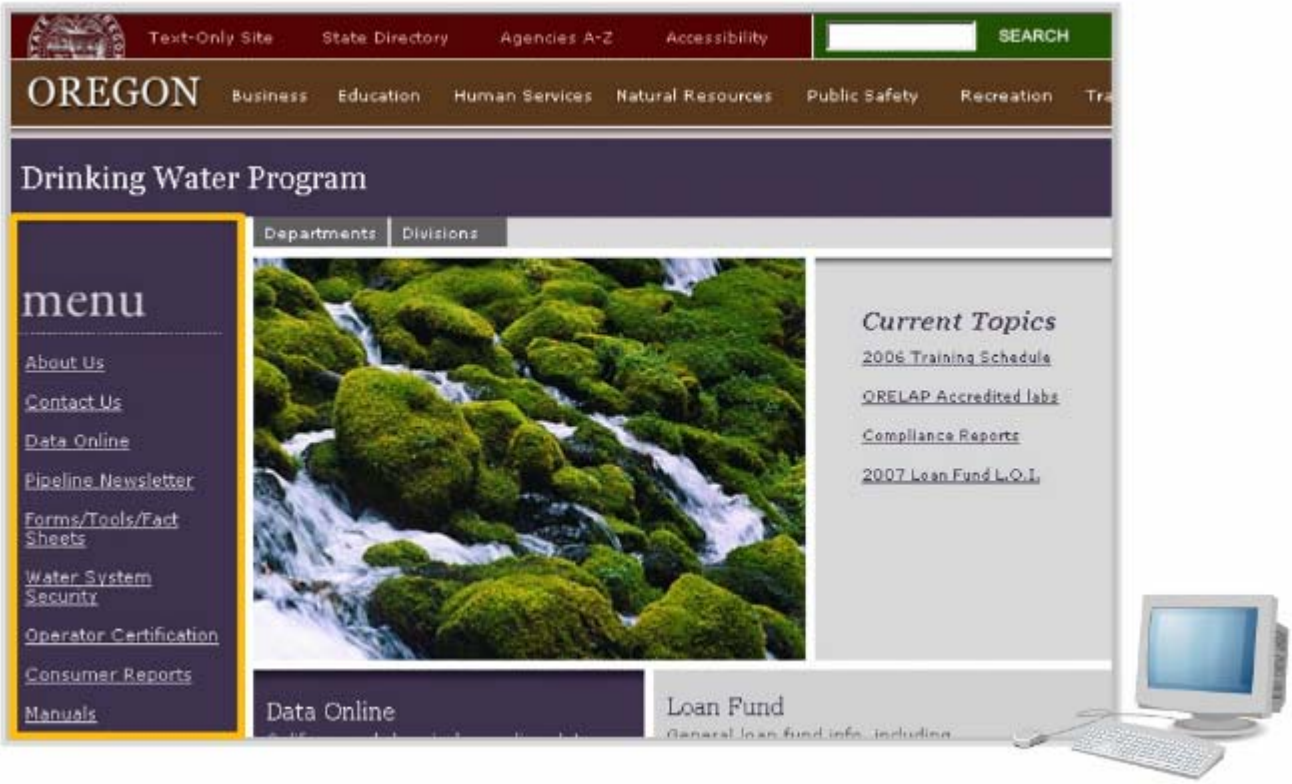
Water Systems" or

"Transient/Non-Community and State Regulated Water Systems." These summaries are also included in the reference section of this Need-to-Know Fact Sheet Library.

To review the regulations go to:

http://oregon.gov/DHS/ph/dwp/rules.shtml

DHS homepage.



UNIT 2: Sampling and Reporting

FACT SHEET 2.3 - Public Notice Requirements

2.3.1 - Public Notice FAQs

2.3.2 - Available Templates

FACT SHEET 2.3 - Public Notice Requirements

2.3.1 – Public Notice FAQs

What is public notice?

Federal and state regulations require all public water systems to provide notice to their consumers any time there is a violation of drinking water standards. Public notice of drinking water violations provides consumers with a means whereby they will always know if there is a problem with their drinking water and, when appropriate, with the information needed to avoid or minimize any associated risk.

Public notification regulations were established under the 1974 Safe Drinking Water Act (SDWA). The SDWA has been amended twice since 1974, with Congress reaffirming its position that public notice is an important responsibility for public water systems. Rules governing public notification are outlined in the Oregon Administrative Rules (OAR), Chapter 333-061-0042 which defines the form, manner, content and frequency of public notices.

Specific language must be used in public notification. It is important that DHS templates are used. (See Fact Sheet 3.8 for links to templates on the DHS web-site.)

Who must give public notice?

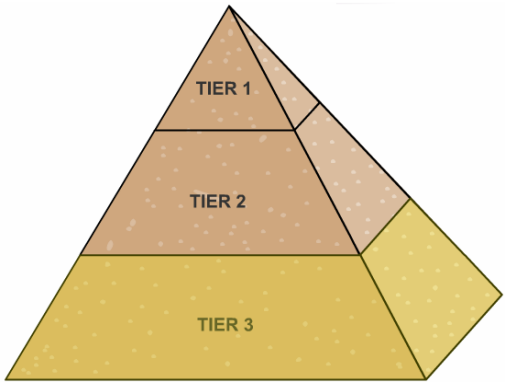
It is the ***responsibility*** of the owner or operator of a public water system to give public notice for all violations of drinking water standards.

Who must be notified?

When required, public notice must be given to ***all persons served by the water system*****.** Public water systems that sell or otherwise provide drinking water to other public water systems (i.e., to consecutive systems) are required to give public notice to the owner or operator of the consecutive system. The consecutive system is responsible for providing public notice to the persons it serves.

If a public water system has a violation in a portion of the distribution system that is physically or hydraulically isolated from other parts of the distribution system, DHS may allow the system to limit distribution of the public notice to only persons served by that portion of the system which is out of compliance. Permission by DHS for limiting distribution of the notice must be granted in writing. A copy of the notice must also be sent to DHS when it is sent to the customers.

What are the three tiers of violations?



Public notice requirements are divided into **three tiers**, designed to take into account the seriousness of the violation or situation and any potential adverse health effects that may be involved. The specific public notice requirements for each violation or situation are determined by the tier to which it is assigned. Tiers are defined as follows:

Tier 1: (Immediate notice required) Public notice is required within 24 hours for violations of the National Primary Drinking Water Regulations (NPDWR) and for situations with significant potential to have serious adverse effects on human health as a result of short-term exposure. (**Table 2.3.1 (a)** lists the violation categories and other situations requiring a Tier 1 public notice.)

Tier 2: (Notice as soon as possible but in less than 30 days) Public notice required for all other NPDWR violations and situations with potential to have serious adverse effects on human health. (**Table 2.3.1 (b)** lists the violations and situations requiring a Tier 2 notice).

Tier 3: (All other violations) Public notice required for all other NPDWR violations and situations not included in Tier 1 and Tier 2.

Public notice must:

- Include appropriate mandatory language,
- Adhere to deadlines and delivery method for distribution (based on the type and tier of violation), and
- Include a description of the violation and any potential health hazard.

More specifically, public notice must address these elements:

- Description of the violation or situation
- When the violation or situation occurred
- Potential health effects
- The population at risk
- Whether alternate water supplies should be used
- Actions consumers should take
- What is being done to correct the violation/situation
- When the system expects to return to compliance
- Name, number and business address for more information
- Standard distribution language
- Monitoring failure language (if monitoring violation)

What are the requirements by tier of violation? (for timing as well as method of notification)

Requirements on public notice, including timing of notification as well as method of notification vary for each tier of violation.

An overview of key items to consider in order to meet notification requirements for each of the three tiers follows.

Tier 1 Violation

When is a Tier 1 public notice required? What additional steps are required?

Table 2.3.1 (a) lists the violation categories and other situations requiring a Tier 1 public notice.

Table 2.3.1 (a): Violation Categories and Other Situations Requiring a Tier 1 Public Notice

- Violation of the MCL for total coliform when fecal coliform or *E. coli* are present in the water distribution system, or when the water system fails to test for fecal coliform or *E. coli* when any repeat sample tests positive for coliform.
- Violation of the MCL for nitrate, nitrite, or total nitrate and nitrite, or when the water system fails to take a confirmation sample within 24 hours of the system's receipt of the first sample showing an exceedance of the nitrate or nitrite MCL.
- Violation of an interim operating plan for turbidity for systems with unfiltered surface water or violation of any of the Surface Water Treatment rules after consultation with the department.
- Violation of the MRDL for chlorine dioxide, when one or more samples taken in the distribution system the day following an exceedance of the MRDL at the entrance of the distribution system exceed the MRDL, or when the water system does not take the required samples in the distribution system.
- Occurrence of a waterborne disease outbreak, or other waterborne emergency (such as a failure or significant interruption in key water treatment processes, a natural disaster that disrupts the water supply or distribution system, or a chemical spill or unexpected loading of possible pathogens into the source water) which significantly increases the potential for drinking water contamination.
- Other violations or situations with significant potential to have serious adverse effects on human health as a result of short-term exposure, as determined by the Department in its regulations or on a case-by-case basis.

Public water systems must

- Provide a public notice as soon as practical, but no later than 24 hours after the system learns of the violation;
- Initiate consultation with DHS as soon as practical, but no later than 24 hours after the public water system learns of the violation or situation, to determine

additional public notice requirements; and
- Comply with any additional public notification requirements (including any repeat notices or direction on the duration of the posted notices) that are established as a result of the consultation with DHS. Such requirements may include the timing, form, manner, frequency and content of repeat notices (if any) and other actions designed to reach all persons served.

What does a Tier 1 public notice look like?

Public water systems must provide the notice within 24 hours in a form and manner reasonably calculated to reach all persons served. This includes residential, transient and non-transient users of the water system.

The notice must include mandatory language describing the health hazard. In order to reach all persons served, water systems are to use, at a minimum, one or more of the following forms of delivery:

- Appropriate broadcast media (such as radio and television);
- Posting of the notice in conspicuous locations throughout the area served by the water system;
- Hand delivery of the notice to persons served by the water system; or
- Another delivery method approved in writing by DHS.

Tier 2 Violation

When is a Tier 2 public notice to be provided?

Tier 2 violations are outlined in **OAR 333-061-0042** and summarized in **Table 2.3.1 (b)**. Public water systems must provide the public notice as soon as practical, but no later than 30 days after the system learns of the violation.

If the public notice is posted, the notice must remain in place for as long as the violation or situation persists, but in no case for less than seven days, even if the violation or situation is resolved.

Table 2.3.1 (b): Violations and Situations Requiring a Tier 2 Public Notice

- All violations of the MCL, MRDL, and treatment technique requirements, except where a Tier 1 notice is required or where DHS determines that a Tier 1 notice is required;
- Violations of the monitoring and testing procedure requirements where the Department determines that a Tier 2 rather than a Tier 3 public notice is required, taking into account potential health impacts and persistence of the violation; and
- Failure to respond to sanitary survey reports or comprehensive performance evaluation reports prepared by the Department as required in OAR 333-061-0076 and 222-061-0077.
- When an emergency groundwater source is used and is potentially under surface water influence but has not been fully evaluated.

DHS may, in appropriate circumstances, allow additional time for the initial notice of up to three months from the date the system learns of the violation. DHS cannot grant an extension to the 30-day deadline for any unresolved violation or to allow across-the-board extensions by rule or policy for other violations or situations requiring a Tier 2 public notice. DHS must grant the extensions in writing.

The public water system must repeat the notice every three months as long as the violation or situation persists, unless DHS determines that appropriate circumstances warrant a different repeat notice frequency. In no circumstance may the repeat notice be given less frequently than once per year. DHS determinations allowing repeat notices to be given less frequently than once every three months must be in writing.

What does a Tier 2 public notice look like?

Public water systems must provide the initial public notice and any repeat notices in a form and manner reasonably calculated to reach persons served in the required time period. There is mandatory language describing the health hazard that must be included. The form and manner of the public notice may vary based on the specific situation and type of water system, but it must at a minimum meet the following requirements:

Unless directed otherwise by DHS in writing, **community water systems** must provide notice by:

- Mail or other direct delivery to each customer receiving a bill and to other service connections to which water is delivered by the public water system; and
- Any other method reasonably calculated to reach other persons regularly served by the system, if they would not normally be reached by the notice in the paragraph above. Such persons may include those who do not pay water bills or do not have service connection addresses (e.g., house renters, apartment dwellers, university students, nursing home patients, prison inmates, etc.). Other methods may include:
    - Publication in a local newspaper;
    - Delivery of multiple copies for distribution by customers that provide their drinking water to others (e.g., apartment building owners or large private employers);
    - Posting in public places served by the system or on the Internet; or
    - Delivery to community organizations.

Unless directed otherwise by DHS in writing, **non-community water systems** must provide notice by:

- Posting the notice in conspicuous locations throughout the distribution system frequented by persons served by the system, or by mail or direct delivery to each customer and service connection (where known); and
- Any other method reasonably calculated to reach other persons served by the system if they would

not normally be reached by the notice in the paragraph above.

- Such persons may include those served who may not see a posted notice because the posted notice is not in a location they routinely pass by.
- Other methods may include: Publication in a local newspaper or newsletter distributed to customers; use of e-mail to notify employees or students; or delivery of multiple copies in central locations (e.g., community centers).

Tier 3 Violation

What does a Tier 3 public notice look like?

Tier 3 violations are defined as violations other than Tier 1 or 2. Specifics are outlined in OAR 333-061-0042. Public notice must be issued within one year of the violation or situation. Following the initial notice, the system must repeat the notice annually for as long as the violation or other situation persists. If the public notice is posted, the notice must remain in place for at least 7 days even if the violation or situation is resolved.

The method of delivery for community and non-community systems is the same as outlined for Tier 2 violations. Instead of individual Tier 3 public notices, a community public water system may use its annual Consumer Confidence Report (CCR) for the initial and all repeat notices detailing all violations and situations that occurred during the previous twelve months.

2.3.2 - Available Templates

The DHS website includes links to models and templates for public notification for specific types of violations. You may also contact DHS or your local health department for templates. The templates include information on required method of delivery, common corrective actions, and sample notice: http://oregon.gov/DHS/ph/dwp/tools.shtml.

Specific language must be used in public notification. It is important that these templates are used.

UNIT 2: Sampling and Reporting

FACT SHEET 2.4 - Consumer Confidence Report

2.4.1 - Consumer Confidence Report FAQs

2.4.2 - Available Templates

FACT SHEET 2.4 - Consumer Confidence Report

2.4.1 - Consumer Confidence Report FAQs

What is a Consumer Confidence Report (CCR)?

Every year, all community water systems must provide their customers with a CCR. The CCR summarizes basic information about the source, operation and water quality of the system using information that your water system already collects to comply with regulations along with some educational information that may be important to consumers. The intent of the report is to inform the consumer about their drinking water so that they can make informed health decisions for their families and themselves. It also provides an opportunity for operators to educate their users on what it takes to keep a system operating.

The reports are due to customers (with a copy to Department) by July 1st following the year covered in the report (e.g., the 2004 CCR is due to consumers by July 1, 2005). A Certificate that specifies when and how the CCR was distributed is due to the Department no later than October 1.

Who gets the CCR?

The water supplier must make a "good faith" effort to send the report to all consumers who use water (both paying and non-paying, such as apartment dwellers). Reports may be included with water bills; sent as separate mailers; or they can be directly delivered to each customer.

What is included in the report?

While there is a lot of flexibility in how the report is constructed, there are some specific language and content requirements for the general report, as well as specific language for contaminants detected in your drinking water.

CCR required content includes:

- General information on the administration of your water system including opportunities for public involvement and water system contact information must be included;

- The source of the water served (such as groundwater, surface water, water from another system), and the name and location of its source;
- If a source water assessment has been completed, the customers must be notified of availability of information and provided with a summary of the report;
- A table showing any regulated or unregulated contaminant or disinfection by-product that has been detected;
- Specific definitions must be given [e.g., Maximum Contaminant Level (MCL), Maximum Contaminant Level Goal (MCLG), etc.] to provide consumers with a means of interpreting the table of detections. (See the OAR 333-061-0043);
- If an MCL is violated, specific health effect language must be included. This is available in the templates or the OAR 333-061-0043;
- If the detection limit is exceeded, possible origins of the contaminant must be noted. This information is available in the templates;
- Any treatment monitoring, reporting or record keeping violations must be noted;
- If the system is operating under any variances or exemptions, they must be acknowledged;
- The report must include specific language addressing vulnerable populations. This language is available in the OAR 333-061-0043 and/or the templates;
- Specific phone numbers for federal and state contacts must be included.

The regulation also requires certain educational language and a specific table format for summarizing detected contaminants. Mandatory language for detected contaminants may also be found in EPA's "Public Notification Handbook" which has a link on the DHS website under the "Publications" section. Utilities may include additional information to better acquaint customers with their particular operations.

When must the plan be distributed and certified?

The CCR must be delivered to all customers of the water system and to the Department by July 1 of each year. DHS must also receive by October 1 of the same year a Certification

as to how and when the CCR was distributed. It is usually easier to submit both the CCR and the certification form to the Department at the same time as it's delivered to the community. A copy of the certification form may be downloaded from the DWP website, http://oregon.gov/DHS/ph/dwp/ccr.shtml

What should the report look like?

A report that contains too much information or is full of technical jargon can discourage consumers from learning about their drinking water. You don't need a fancy computer or a graphic designer to produce a CCR that is easy to read and inviting to your customers.
A few things to consider: Write short sentences. Keep your paragraphs short, too. Don't make your text size too small. You might want to squeeze a few extra sentences into your report, but if you add too much, people might ignore the entire report. Be as simple and straightforward as possible and avoid acronyms, initials and jargon.

As discussed previously, there is specific language and required content for the general report, and specific language for contaminants detected in your drinking water. The DWP website, http://oregon.gov/DHS/ph/dwp/ccr.shtml , has useful templates. Review these templates before you begin preparing your CCR – you'll find they save you a lot of time and effort.

2.4.2 - Available Templates

There are templates available that outline CCR requirements. See the Oregon Department of Human Services Drinking Water Program (DWP) website: http://oregon.gov/DHS/ph/dwp/ for links to several useful templates as well as a checklist of items to include in the CCR.

You can also view examples of CCRs that have been completed in Oregon here: http://oregon.gov/DHS/ph/dwp/ccr.shtml

UNIT 3: Operations

FACT SHEET 3.1 - Overview of Disinfection and Other Water Treatment Methods

3.1.1 - Chlorine

3.1.2 - Ultraviolet Light

3.1.3 - Ozone

3.1.4 - Iron and Manganese Removal

3.1.5 - Corrosion Control

3.1.6 - Nitrate Removal

3.1.7 - Arsenic Removal

3.1.8 - Filtration

FACT SHEET 3.1 - Overview of Disinfection and Other Water Treatment Methods

System treatment needs differ depending on whether the system uses ground water or surface water. When choosing a treatment option, there are several factors to consider including:

- Regulations
- Characteristics of the raw water
- Cost
- Operating requirements
- Configuration of existing system
- Future needs.

Remember, treatment for health protection is the primary consideration, aesthetics are secondary.

A brief overview of disinfection (the process of killing microorganisms in water that might cause disease or pathogens) and other water treatment methods follows.

Chlorine disinfection.

3.1.1 - Chlorine

In the United States, chlorine was first used as a drinking water disinfectant in 1908 in Jersey City, New Jersey. It proved so successful that many other cities followed suit, and cases of typhoid and other waterborne diseases dropped dramatically throughout the country.

Successful prevention of waterborne disease and its relatively low cost have made chlorine one of the most widely used drinking water disinfectants in the world. Chlorine is also used as an oxidizing agent for iron, manganese and hydrogen sulfide and for controlling taste and odor problems.

Its effectiveness as a disinfectant depends on factors such as pH, temperature, free chlorine residual, contact time and the presence of interfering agents.

When combined with some organic matter, chlorine can form disinfection byproducts (DBPs) that can cause cancer in humans. Testing and controlling for DBPs is an important part of running a safe water system.

In all cases, chemicals injected into potable water systems must have an appropriate industry certification for application.

The National Sanitation Foundation (NSF) is one of the larger certification agencies and an “NSF” logo is commonly found on labels of approved products containing chlorine.

How does chlorine work?
Chlorine combines with water to produce the two primary disinfectant forms called hypochlorous acid (HOCl) or the hypochlorite ion OCl^-.

The predominance of either generally depends upon the water’s pH. Hypochlorous acid is more potent and predominates at pH levels below 7.3. The ion form occurs more readily at higher pH levels.

Both HOCL and OCl^- are collectively measured using the “free” chlorine test. Free chlorine has a high affinity for certain chemicals and microorganisms.

The actual reaction these forms of chlorine have with microbial contaminants is still not known. Chlorine appears to breach the cell wall and either kill microorganisms very quickly or destroy the ability of the organism to reproduce, thus killing it.

Chlorine demand and chlorine residual

Upon being added to water, available chlorine combines with organic materials, chemicals or bacteria. As a result the overall available chlorine is reduced.

This immediate reduction in chlorine is called **"demand."** Dosages must be calculated to take into account this phenomenon so that **residuals**, or available/un-used chlorine, are maintained throughout the distribution system.

When testing for chlorine residuals, the "free" test measures chlorine in water that is still available for disinfection. The "total" test measures the sum of both free and combined chlorine.

Simply stated:

Dose = Demand + Residual

Dose is what is applied to the water.

Demand is the amount of chlorine that is absorbed by various chemicals and organic matter in the water.

Residual is what is left over (available) to disinfect water in the distribution system. It is extremely important to have residuals throughout the distribution system.

Forms and Application of Chlorine

Chlorine is a chemical element that has three different forms: solid (powder or tablets), liquid (bleach) and gas. Chlorine can also be combined with ammonia to form chloramine which is also used to disinfect drinking water. Features of chlorine's various forms are described below.

- **Solid or Dry Chlorine**: *Calcium hypochlorite is* the solid form of chlorine. Usually found in tablet or powder form, it generally contains 65% chlorine by weight. It is white or yellowish-white granular material and is fairly soluble in water. It is important to keep calcium hypochlorite safely stored in a dry, cool place. If not stored properly, chlorine's shelf-life can be severely shortened. Dry chlorine can also ignite if mixed with certain organic chemicals, such as gasoline. When mixing, always add calcium hypochlorite to the correct volume of water. There are different types of feeding systems for delivery of calcium hypochlorite, but the most common is dilution in water to create a solution of desired strength based on water demand and needed residual. Once the solution is created, a small chemical feed pump is used to inject it into the water system. The advantages of using dry chlorine are cost and ease of use. The disadvantages are that it produces an inconsistent chlorine residual, and it can react violently with petroleum products and some organic materials.
- **Liquid Chlorine**: Sodium hypochlorite (NaOCl) is the liquid form of chlorine. It is clear with a slight yellow color. Ordinary household bleach is one of the most commonly used forms of sodium hypochlorite. Industrial strength is typically available at 5.25%, 12.5% or 15% by volume. Sodium hypochlorite can lose up to 4% of its available chlorine content per month and therefore should not be stored for more than 60 to 90 days. Caution should be used when using liquid chlorine. It is very corrosive, can cause blistering of the skin and will ruin clothing. It should be mixed and stored away from equipment. Liquid chlorine can be purchased by gallon containers, in 55 gallon drums, in larger plastic totes or it can be delivered by

truck in bulk. Most small systems use gallon containers, because of the decline in chlorine content over time. The gallon containers are mixed into a larger container of water to create a solution of a desired strength. The desired strength will be determined by the water demand and the desired residual. The solution is fed to the water source with a small pump. The advantage of using liquid chlorine is its low cost and ease of use. The disadvantages are loss of potency when not used promptly and some safety issues. However, this is still the most commonly used product for chlorination.

- **Gaseous chlorine** is produced from liquid chlorine placed under pressure in a metal vessel. The vapors rising from the top of the liquid are in gaseous form and are drawn from the vessel to disinfect water. Chlorine gas is very dangerous and may be fatal when directly inhaled. Unless water system personnel are properly trained to work with these containers, chlorine gas should not be used. Smaller systems will likely find the initial cost of installation, the required safety equipment and operator training prohibitive. Small water systems typically use 150 pound cylinders of chlorine gas, which should be secured to prevent them from falling over and causing a leak. In order to draw the chlorine gas from the cylinder, a system comprised of a regulator, rotometer and injector is needed. Typically, the injector has a water supply flowing through an area that is throated, which provides vacuum. The vacuum opens the regulator and allows gas to flow to the injector and into the water being treated. The rotometer allows an operator to control the amount of chlorine gas injected into the drinking water.

Gaseous chlorine cylinders

- **Chloramines** include Monochloramine, Dichloramine, and Tetrachloramine; These are compounds produced by a reaction

between chlorine and ammonia. Chloramination is the process of adding chlorine and ammonia to water for disinfection. Chloramine compounds have far less disinfectant potential than free chlorine, but nonetheless continue to attack microorganisms. Chloramines have two advantages over regular chlorination. They produce chlorine residuals that do not dissipate or “fade away” as quickly and are sometimes used to maintain disinfection residuals in long distribution systems. Depending on the application, chloramination also may produce fewer byproducts.

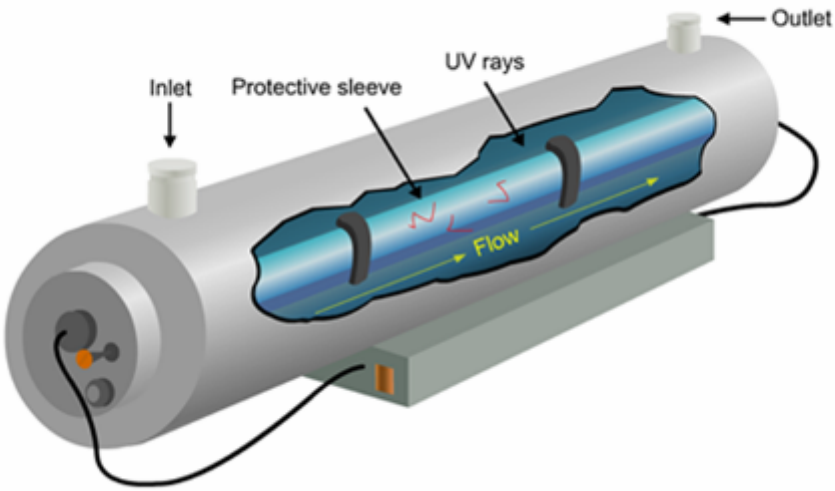
3.1.2 - Ultraviolet Light

Ultraviolet (UV) light produced from UV lamps is an effective bactericide for both air and water. Disinfection occurs through radiation of microorganisms by UV light rays. The rays must come into contact with each microorganism in order to be effective. The quantity of radiation required depends on such factors as turbidity, color and dissolved iron salts, which prevent penetration of ultraviolet energy through water. For this reason, UV light is not satisfactory for disinfecting water with high turbidity.

Cylindrical UV disinfection units with standard plumbing fittings have been designed for in-line installation in water lines. The intensity of the light should be checked frequently and the sleeve around the bulb periodically cleaned. Some units have an externally operated plunger-type apparatus for this purpose.

One disadvantage of UV light is that no residual remains in the water to continue disinfecting throughout the distribution system. Thus, there is no barrier to prevent recontamination. For this reason, when UV light is used, the Department also requires chlorination. Another disadvantage of UV light is that its use requires a continual source of electrical power.

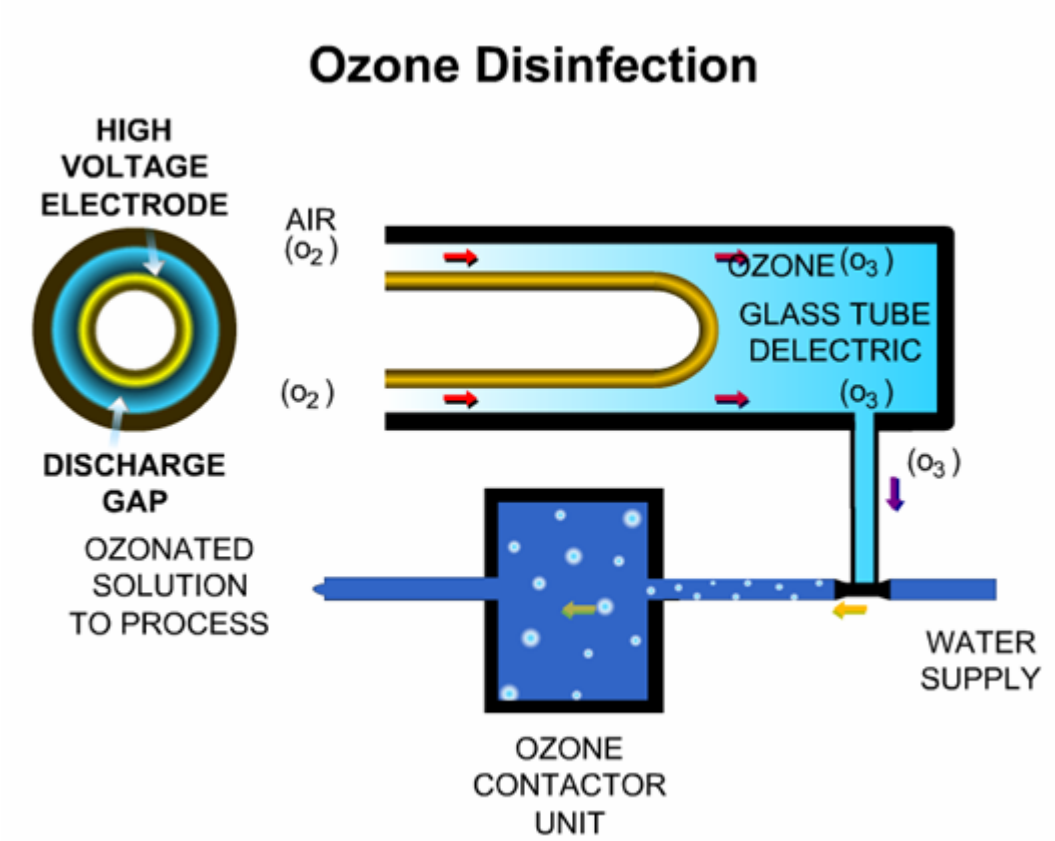
UV Unit



3.1.3 - Ozone

Ozone is a strong disinfecting agent and is also used to control taste and odor. While ozone is widely used for disinfection and oxidation in other parts of the world, its use is relatively new and limited in the United States.

Ozone is unstable at ambient temperatures and pressures and therefore must be generated on site and used quickly. Ozone is generated by applying a high-energy electrical field to either pure oxygen or dried air. Disinfection takes place as ozone gas is added to flowing water. The half-life of ozone in water is fairly short, generally minutes, due to its regression back to oxygen.
For this reason, as with UV light, a secondary disinfectant is required so that a disinfectant residual is maintained and measured throughout the distribution system. Ozone does not form disinfectant byproducts (DBP) such as trihalomethanes (THMs), but, if there is bromide in the water source, it can create the DBP, bromate. Ozone's main disadvantages are its high cost and the complexity inherent in onsite generation.



3.1.4 - Iron and Manganese Removal

Many groundwater systems have iron and manganese problems. Neither iron nor manganese in water presents a health hazard. However, their presence in water may cause problems with taste, coloration and staining of clothes or fixtures. Iron causes reddish-brown staining of laundry, porcelain, dishes, utensils and even glassware.

Manganese acts in a similar way, but causes a brownish-black stain. Soaps and detergents do not remove these stains, and the use of chlorine bleach and alkaline builders (such as sodium carbonate) can actually intensify them. Iron and manganese deposits will also build up in pipelines, pressure tanks, water heaters and water softeners, reducing the available quantity and pressure of the water supply. Iron and manganese accumulations become an economic problem when water supply or softening equipment must be replaced.

Also, pumping water through constricted pipes or heating water with heating rods coated with iron or manganese minerals increase energy costs.

In a water source, these iron and manganese can be independent of each other or exist together.

Iron and manganese are concentrated in water by contact with rocks, minerals, and occasionally, fabricated materials such as iron and steel pipes. Groundwater supplies may require treatment for high levels of iron and manganese. Generally, few surface water supplies have high enough levels of either iron or manganese to cause problems.

How much iron or manganese is needed to cause problems in water?

There is no pat answer to this question, because it varies with each household situation. EPA Secondary Drinking Water Standards set criterion for iron and manganese based on levels that cause taste and staining problems. For most individuals, 0.3 parts per million (ppm) of iron and 0.05 ppm of manganese is objectionable. In natural waters iron and manganese generally do not exceed 10 ppm and 2 ppm, respectively.

The most common processes for removing iron and manganese from water are:

- **Aeration.** Aeration is the physical agitation of water which oxidizes minerals, causing them to precipitate (solidify). The process requires an aeration tank or tower, a source of pressurized air (although sometimes an open media and gravity are used) and a sand filter. Once aerated, filtration is required to remove the precipitate from the water. The filter will require periodic backwashing to remove trapped particulate matter.

- **Polyphosphate treatment.** In their soluble forms, iron and manganese may be stabilized or sequestered by adding polyphosphates or organic sequestering agents. Polyphosphates are also used to inhibit corrosion. Polyphosphates react with dissolved iron and manganese by trapping them in a complex molecule that is water soluble. As a result, iron and manganese are not available to react with oxygen and do not precipitate. Polyphosphates and organic sequestering agents can be fed into the water system with controlled injection equipment. The application must take place before any aeration or chlorination. Treated water should also not be heated as polyphosphates are unstable at high temperatures. Sodium hexametaphosphates may be used at dosages of about 5 mg per mg of iron. In a distribution system, polyphosphate dosages should be limited to less than 10.0 mg/L, because excess phosphorus can stimulate bacterial slime growth. Chlorination following the addition of polyphosphates may help control bacterial slime growth. For low levels of iron and manganese, polyphosphates are a relatively inexpensive water treatment. However, local ordinances may restrict the concentration of phosphates allowed in municipal discharges to receiving waterways.

- **Ion exchange***.* Ion exchange involves removing contaminants by adsorption of contaminant ions onto a resin exchange medium. This technology is also useful for removing minerals that cause hardness, inorganic chemicals or heavy metals. As the name implies, one ion is exchanged for another on the charged surface of the medium, usually a synthetic plastic resin. The resin

surface is designed as either cationic (positively charged) or anionic (negatively charged). The medium is saturated with the exchangeable ion before treatment operations begin. After the medium reaches equilibrium with the contaminant ions, the medium is regenerated with a suitable solution, generally sodium chloride or potassium chloride. Because of required downtime, the shortest economical regeneration cycles are often once per day. Ion exchange waste is highly concentrated and requires careful disposal. Precipitation of iron and manganese by oxygen is one of the disadvantages of ion exchange. Some of the precipitate becomes tightly bound to the exchange resin and over time reduces the exchange capacity by plugging pores and blocking exchange sites. If iron bacteria are present, the problem is worse. Also, if suspended particles of insoluble forms of iron or manganese are present in water prior to softening, they will be filtered out on the resin and cause plugging. Suspended iron and manganese should be filtered out before entering the ion exchange process. Problematic iron bacteria can at times be eliminated by chlorinating and filtering the water at some point before ion exchange. When iron and manganese levels are higher than recommended by the manufacturer, iron and manganese removal will be necessary prior to ion exchange.

- **Greensand (Adsorptive/Oxidative) Filtration**. A “greensand” filter is perhaps the most common process used to treat water for iron and manganese. The active material in greensand is glauconite. Glauconite is a green clay mineral that contains iron and has ion exchange properties. Glauconite is often mixed with other material as small pellets, thus the name "greensand." The glauconite is mined, washed, screened and treated with various chemicals to produce a durable greenish-black product with properties that allow it to adsorb (collect in a condensed form on a surface) soluble iron and manganese. Chlorine is also often injected prior to filtration to oxidize these

contaminants and provide greater precipitation.
As water is passed through the filter, soluble iron and manganese are pulled from solution and later react to form insoluble iron and manganese. Insoluble iron and manganese will build up in the greensand filter and must be removed by backwashing. Regular backwashing is essential for effective filter performance and requires flow rates that are often three to four times the normal usage rate. Backwashing should be done twice a week or as recommended by the manufacturer. Eventually, greensand must also be regenerated by washing with a permanganate solution. Regeneration frequency depends on levels of iron, manganese and oxygen in the water as well as the size of the filter. Manufacturer's recommendations should be followed.

- **Chlorination (Oxidation) Plus Filtration.** Chemical oxidation followed by filtration is the accepted method of iron and manganese removal when concentrations are greater than 10 ppm. Chlorine is generally used for this procedure. In a chlorination plus filtration procedure, a chlorine solution is injected with a chemical feed pump ahead of a sand filter. Soluble iron and manganese begin to precipitate almost immediately after contact with the chlorine solution. However, approximately 20 minutes of contact time is needed for the precipitate to form particles that can be filtered. This type of system will remove both soluble and suspended particles of insoluble iron and manganese from source water. Backwashing the sand filter to remove precipitated iron and manganese is an important part of continued filtration. As with a greensand filter, system flow rate should be checked to ensure it can provide rates needed for backwashing. An additional advantage of the chlorination system is its bactericidal effect.
Iron and manganese bacteria, along with other bacteria, are destroyed and potential clogging problems in the sand filter are eliminated.

3.1.5 - Corrosion Control

Corrosion is the deterioration of a substance by chemical reaction. Lead, cadmium, zinc, copper and iron can be found in water when metals in water distribution systems corrode. Drinking water contaminated with certain metals, such as lead and copper, are health hazards.

Corrosion also reduces the life of water distribution systems and can promote the growth of microorganisms, resulting in disagreeable tastes, odors, slimes and further corrosion. Because it is widespread and highly toxic, lead is the corrosion product of greatest concern. In 1985, Oregon banned the use of lead solders, fluxes and pipes in the installation or repair of any public water system. Using lead-free solders, such as silver-tin and antimony-tin, is a key factor in lead corrosion control.

The highest level of lead in consumers' tap water is found in water that has been standing in pipes after periods of nonuse (overnight or longer). This is because standing water tends to leach more lead or copper out of the metals in the plumbing system than does moving water.

Therefore, the simplest short-term or immediate method of reducing exposure to lead in drinking water is allowing water that has been standing for some time to run for two to three minutes before use. Similarly, drinking water should not be taken from the hot water tap, as hot water tends to leach lead more readily than cold. Long-term measures for addressing lead and other corrosion by-products include:

- ***Alkalinity and pH Adjustment.*** Because it is simple and inexpensive, adjusting pH and alkalinity is the most common corrosion control method. Alkalinity is a measure of water's ability to neutralize acids while pH is a measure of the concentration of hydrogen ions present in water. Generally, water pH less than 6.5 is associated with uniform corrosion, while pHs between 6.5 and 8.0 can be associated with pitting corrosion. However, pH is not the only factor in the corrosion equation; carbonate and alkalinity levels affect corrosion as well. Generally, an increase in pH and alkalinity can

decrease corrosion rates and help form a protective layer of scale on corrodible pipe material. Chemicals commonly used for pH and alkalinity adjustment are hydrated lime (CaOH2 or calcium hydroxide), caustic soda (NaOH or sodium hydroxide), soda ash (Na2CO3 or sodium carbonate) and sodium bicarbonate (NaHCO3, essentially baking soda). Care must be taken to maintain pH at a level that will control corrosion but not conflict with optimum pH levels for disinfection and control of disinfection by-products. Because this is a complex subject, professional help is recommended to find the best course of action for your particular situation.

- ***Corrosion Inhibitors.*** Inhibitors reduce corrosion by forming protective coatings on pipes. The most common corrosion inhibitors are inorganic phosphates, sodium silicates and mixtures of phosphates and silicates. These chemicals have proven successful in reducing corrosion in many water systems. The phosphates used as corrosion inhibitors include polyphosphates, orthophosphates, glassy phosphates and bimetallic phosphates. In some cases, zinc is added in conjunction with orthophosphates or polyphosphates. Glassy phosphates, such as sodium hexametaphosphate, effectively reduce iron corrosion at dosages of 20 to 40 mg/L.

  For over 50 years, sodium silicates have been used to inhibit corrosion. Effectiveness depends on the water pH and carbonate concentration. Sodium silicates are particularly effective for systems with high water velocities, low hardness and alkalinity and a pH of less than 8.4. Typical coating maintenance doses range from 2 to 12 mg/1. They offer advantages in hot water systems because of their chemical stability and consequently are often used in steam heating system boilers.

- ***Coatings and Linings*** Mechanically applied coatings and linings differ for pipes and water

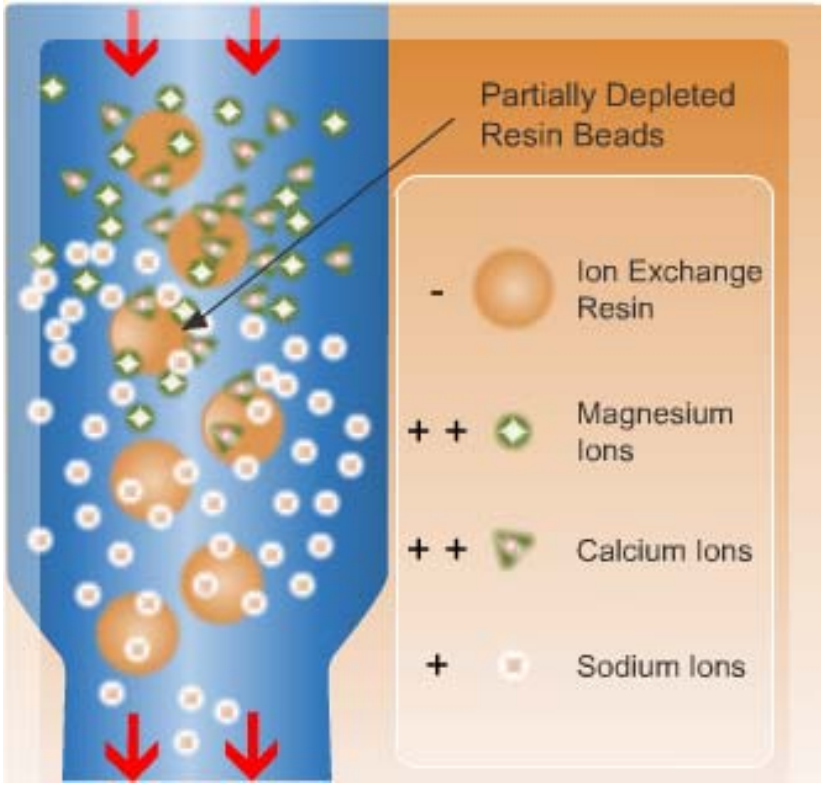
storage tanks. Generally, they are applied prior to installation, though some pipes can be lined after installation. Although coal-tar products have been widely used for coating both tanks and pipes, they are currently under regulatory scrutiny due to the presence of polynuclear aromatic hydrocarbons. The most common pipe linings are epoxy paints; cement mortar, polyethylene and coal tar enamels. The most common types of storage tank linings include vinyls, epoxys and coal tar paints and enamels. The National Sanitation Foundation (NSF), an independent testing lab, maintains lists of paints and coatings that are acceptable for potable water applications.

- ***Cathodic Protection*** Electrolysis can cause steel storage tanks to corrode internally. Electrolysis occurs when metallic ions are released by steel and flow through water, which is electrically conductive. Electrolysis in water can be overcome by installing a “sacrificial anode,” usually composed of magnesium or zinc, and connecting it to the positive side of a DC power source. The wall of the reservoir is connected to the negative side of the power supply. This tends to reverse the flow of electrons from the anode (hence the term sacrificial), through the water and back to the reservoir wall; essentially turning the steel wall of the reservoir into a cathode — or negative terminal. The result is reduced migration of metallic ions from the steel.

3.1.6 - Nitrate Removal

Nitrates in drinking water can come from fertilizers, sewage, and animal waste. It is a concern in areas with intensive agriculture or residential areas with large concentrations of septic systems. Sensitive populations, including infants less than 6 months old, pregnant women and people with certain blood disorders, are prone to methemoglobinemia or "blue-baby syndrome" when consuming water with high levels of nitrates. Excessive levels of nitrate have been known to react with intestinal bacteria in some children, changing nitrate to nitrite that in turn reacts with the hemoglobin in the blood. The reaction reduces the oxygen-carrying ability of blood and creates methomoglobonimia. Common methods of nitrate removal include reverse-osmosis membrane filtration, electro-dialysis reversal, or an ion-exchange process.

Ion-exchange process



3.1.7 - Arsenic Removal

Arsenic is the twentieth most common element in nature and the twelfth most abundant element in the human body. However, too much arsenic is unhealthy. In large enough doses, arsenic can many health problems including:

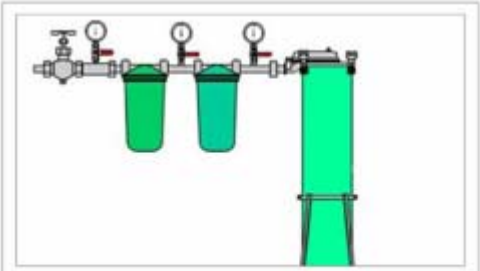
- Cancer of the bladder, lungs, skin, kidneys, nasal passages, liver and prostate
- Cardiovascular disease
- Pulmonary disease
- Immunological deficiencies
- Neurological problems
- Endocrine (diabetes)
- Anemia

Arsenic occurs naturally in soil and rocks, which is why it is often found in groundwater wells. This mineral is especially abundant in the western United States. There are two types of arsenic: arsenite (As3) and arsenate (As5). Arsenite is very difficult to remove from drinking water and needs to be oxidized in order to change it to arsenate. Once it has been changed into arsenate, it can be removed by various methods. The most common methods of removal are conventional filtration and the ion exchange process. Reverse osmosis has been used successfully by small systems to treat arsenic and should be considered as a viable option.

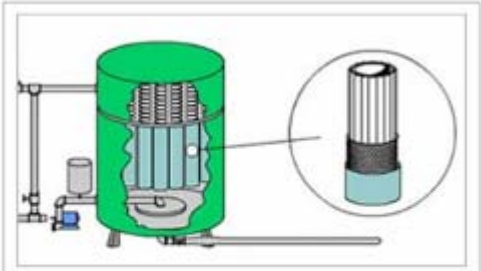
3.1.8 - Filtration

Filtration is the process of removing suspended solids from water as it passes through a porous bed of materials. Natural filtration removes most suspended matter from ground water as it passes through porous layers of soil into aquifers (water-bearing layers under the ground). However, surface waters are subject to runoff and are inherently vulnerable to other sources of contamination such as sewage overflows, industrial discharges and fuel or chemical spills. Surface water systems must be filtered in addition to being disinfected prior to use. Current filtration technologies include cartridge filters, diatomaceous earth, slow sand and conventional rapid sand filtration. Each type has its benefits and tradeoffs depending on the particulars of any application. Contact your local health department of the Drinking Water program for more information.

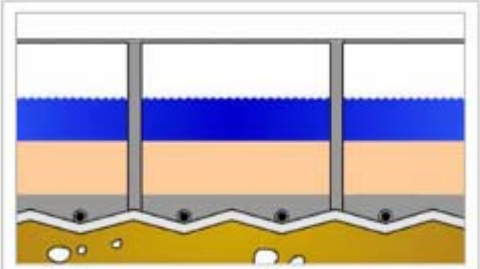
Types of Filtration



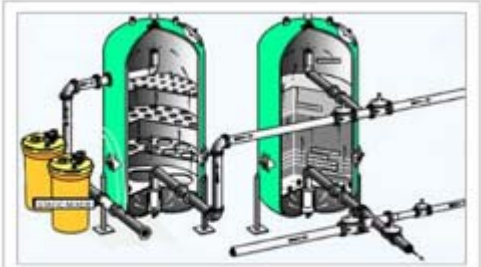
• Cartridge filters



• Diatomaceous earth



• Slow sand



• Rapid sand filtration

UNIT 3: Operations

FACT SHEET 3.2 - Developing and Maintaining an Operations & Maintenance Manual

Sample Form 1: Routine Operational Procedures & Manual

Sample Form 2: Operations Plan for Small Systems with Chlorination

FACT SHEET 3.2 - Developing and Maintaining an Operations & Maintenance Manual

An **Operations and Maintenance (O&M) Manual** is a written document explaining how a public water system is to be operated on a day-to-day basis to ensure public health, safety and compliance with applicable regulations.

The O&M Manual is one of a water purveyor's most crucial documents. In addition to being an important guide for any new staff, the O&M Manual is a critical tool in assuring the public continues to receive safe, adequate drinking water in cases where existing staff is suddenly unable to operate the system.

The O&M Manual should be prepared in such a way that it could explain to another operator how to run the water system and keep it in compliance. The manual should be individually tailored to each water system's size, source water, treatment, water quality, distribution system and available resources. The O&M Manual should provide a complete and accurate view of the water system's operation. The system owner and operator should be involved in creating and maintaining the O&M Manual.

Creating an original O&M Manual will require some work. The following are suggested steps to prepare an O&M Manual. Each step results in the production of a document. Together these documents comprise the full manual. Also, see sample forms included at the end of this document.

1. Prepare a description of all water system facilities. Use an existing description if available.
2. Provide a list of all operational personnel. Include employee name, job title, certification, operator certification number and grade level.
3. Develop a list of routine (daily, weekly, monthly) operational tasks for all operating personnel. For complex tasks, provide a separate detailed description of the steps involved with each task.
4. Review and document procedures that are adequate to meet regulatory requirements.
5. Develop procedures that address operation and maintenance (routine and preventative) of all system components.

6. Describe procedures to comply with all operational requirements that are specified by the regulatory agency or in a water system inspection report.
7. Provide a description of operation, maintenance and record keeping procedures.
8. Prepare a list of past significant operational problems and steps taken to correct them. Establish procedures to respond to these operational problems should they recur.
9. Include a copy of the Coliform Sampling Plan, which is current, accurate and approved by DHS or your county health department.
10. Include a copy of the Emergency Response Plan, which is current, accurate and approved by DHS or your county health department.
11. For any treatment of a surface water source, develop and maintain an accurate and complete Surface Water Treatment Operations Plan.

Information should be categorized in a manner that is practical and easy to find for water system staff. One way to organize the information is shown in an example outline on page 4.

Operations & Maintenance Plan - Example Outline

I. SYSTEM FACILITIES

- *Description of water system facilities*
- *Distribution system map showing location of piping, valves, fire hydrants, blow-off hydrants, system-owned backflow assemblies, etc.*

II. SYSTEM OPERATION & MAINTENANCE

- *Operational and maintenance procedures including:*
    - *Maintaining distribution system pressure*
    - *Responding to loss of pressure*
    - *Main disinfection program*
    - *Flushing water lines, hydrant inspection and testing (how often, etc.);*
    - *Inspection and exercising of water main valves;*
    - *Master flow meter maintenance;*
    - *Storage tank inspection and cleaning;*
    - *Cross connection program (installation, testing, etc.);*
    - *General maintenance plans.*
- *Maintenance Schedule*
- *Record keeping procedures*

III. SAMPLING & REPORTING REQUIREMENTS

- *Overview of sampling requirements*
    - *Sample collection procedures*
        - *Coliform Sampling Plan*
        - *Lead and copper sampling*
        - *Disinfectant By-Products sampling*
    - *Sampling schedule (daily, weekly, monthly, annually, etc.)*
    - *Lab contact information*
- *Overview of reporting requirements*
    - *Public notification and education*
    - *Consumer Confidence Report (CCR) preparation*

IV. EMERGENCY PROCEDURES

- *Emergency operational practices (e.g., interruption of water services, contamination events);*
- *Emergency contact list (e.g., regulatory contacts, lab services, pump repair, leak detection, mutual aid systems)*
- *AND/OR Emergency Response Plan*

V. OWNER / OPERATOR

- *List of operational personnel (Including employee name, job title, certification, operator certification number and grade level)*
- *Responsibilities and routine tasks of operational personnel*
- *Daily operational practices and operational objectives*
- *Consumer complaint response procedures*

Once the O&M Manual is created, it should not be left on a shelf to gather dust. If an O&M Manual is not reviewed regularly, it is not being properly used. The manual should be a regular topic of discussion at staff or board meetings. Once the document is created, it needs to be reviewed and updated at least annually. Remember, there are always changes within a public water system; not only staff changes, but system component and regulation changes as well. Without updates, such factors could make an O&M Manual obsolete and defeat the purpose of creating it.

Sample forms:

- Sample Form 1: Routine Operations Procedure & Schedule.
- Sample Form 2: Operations Plan for Small Systems with Chlorination.

Sample Form 1:
Routine Operational Procedures & Schedule

System Name: _____

List tasks that are performed and the frequency and who is responsible for performing that task. A separate page should be used to describe the procedure in detail for each task, if needed.

	Daily Task	**Performed by**
1.	Inspect well	
2.	Check Storage Tank	
3.	Maintain gauges & valves	
4.	Maintain distribution system	
5.	Respond to consumer complaints	

	Weekly Task	**Performed by**
1.	Inspect valves	

	Monthly by	**Performed by**
1.	Take Bacteriological sample	

	Semi-Annually	**Performed by**
1.	Flush dead end lines	
2.	Flush sediment from storage tank	
3.	Exercise valves	

Sample Form 2:
Operations Plan for Small Systems with Chlorination

RE: For small water systems with a well, storage tank, chlorinator and distribution system, operated by owner or manager.

SYSTEM FACILITIES

- ***System Description:*** Provide a brief description of source, storage, chlorinator unit (treatment) and number of connections. *Example; 200 foot well drilled in 1972, 1500 gallon welded steel storage tank, chlorinator with a diaphragm type pump (manufacturer and model) and 25 gallon disinfectant reservoir, serving 15 connections.*

- ***Map of Distribution System:*** List title of the map, description of information included, and where the document is kept.

SYSTEM OPERATION & MAINTANANCE

- ***Routine Operational Procedures:*** Describe operational procedures for each component of the system. Example information to include is shown below.

  A. *Visual inspection of* ***WELL*** *(daily).*
  1. *Check for the following; leaks, openings, lubricants, electrical hazards, chemical hazards, etc. (record observations and correct problem).*
  2. *Check the pump for proper operation.*

  B. *Visual inspection of the* ***STORAGE TANKS*** *(daily).*
  1. *Inspect for any leaks or damage (record observations and repair as needed).*
  2. *Record system pressure. Record the pressure the pump turns on, the pressure the pump turns off and the duration of the run time.*
  3. *Cleaning of storage tank (quarterly, semi-annually or annually). Record date cleaned and observations.*

C. *Visual inspection of* ***CHLORINATOR PUMP*** *and disinfection reservoir (daily).*

1. *Inspect the pump for proper operation.*
2. *Inspect the disinfectant in the reservoir for concentration and adequate volume for the operational period (record results).*
3. *Determine if there is enough disinfectant on hand for one or more weeks.*

D. *Measure the* ***DISINFECTANT RESIDUAL*** *in the distribution system (free chlorine test kit required).*

1. *Record the results (daily, on attached sheet).*
2. *Determine if an adequate level of disinfectant is maintained.*
   a. *If disinfectant level is low, determine the reason and correct.*
   b. *If no measurable disinfectant, notify owner, determine reason, and remedy. If no disinfectant for 24 hours, notify Department.*

E. *Maintenance of* ***GAUGES and METERS****.*

1. *Inspect all gauges and meters for leaks and proper function daily. Repair or replace as needed (keep record of date).*

F. *Inspection and* ***EXERCISING of the VALVES****.*

1. *Inspect valves for leaks (record observations, repair or replace if leaking).*
2. *Exercise valves on a schedule, as needed (i.e. quarterly, semi-annually, annually, record dates on attached sheet).*

G. *Operation and maintenance of* ***DISTRIBUTION FACILITIES.***

1. *Visually inspect the distribution system for leaks on a regular basis. Record date and observations.*
2. *Flush dead end mains or lines periodically (quarterly, semi-annually, annually as needed. Record date and observations).*

- ***Maintenance Schedule**:* List tasks that are performed and the frequency and who is responsible for performing that task (See provided form).

MONITORING & REPORTING

- ***Sampling Requirements**:* Describe sampling requirements.

  A. ***BACTERIOLOGICAL SAMPLING**; As per approved Sample Siting Plan (attached), required monthly, report to the Department by the 10th of each month, following the sample.*
    1. If sample positive, notify Department and take four repeat samples
    2. Take five routine samples the month following a positive sample.

  B. ***CHEMICAL SAMPLING**; as required by the Department, forward results to the Department.*
    1. Keep chemical results for ten years.
    2. Keep variance and exemptions for five years.

- ***Reporting Requirements**.*

  A. ***PUBLIC NOTIFICTION** of violation required.*
    1. Notification shall be given based on the "tier" of violation, or in a manner directed by the Department.
    2. State problem and what has been done to correct it.
    3. Send a copy of the notification to the Department.

  B. ***CONSUMER CONFIDENCE REPORT** required annually.*
    1. Develop CCR annually.
    2. CCR distributed to customers by July 1st of every year.
    3. Complete certificate that specifies when and how the CCR was distributed. Submit the certificate to the Department no later than October 1st.

EMERGENCY OPERATIONAL PROCEDURES: May refer to the Emergency Response Plan. Also, include the additional information described below.

*A. List of **equipment on hand** for emergency repairs.*
1. Miscellaneous wrenches.
2. Leak clamps.

*B. List of sources of needed **equipment, not on hand**.*
1. Name and address of supplier and type of equipment.
2. If under contract or rental.

Name	***Address***	***Phone #***	***Equipment***	***Rental/ Contract***
			Steel Tank Welder	
			Electrical repair	
			Digging equipment	
			Generator	
			Chemicals	

*C. List of distributors or suppliers of **replacement parts** for the system.*
1. Name and address of supplier and type of equipment.

Name	***Address***	***Phone #***	***Equipment***
			PVC pipe, valves, and fittings
			pumps, pressure tank and gauges
			Chlorinator

*D. List of **emergency contact numbers**:*

	Name	***Phone #***
1.	*Local County Health Department or DHS Contact*	
2.	*Law Enforcement*	
3.	*Electrician*	
4.	*Laboratory*	
5.	*Pump repair service*	
6.	*Chemical disinfectant supplier*	
7.	*Equipment supplier*	
8.	*Owner*	

OWNER/OPERATOR

- ***Operational Personnel List:*** List each person who is involved in the operation of the water system (including treatment and distribution) and their responsibilities:

	Name	***Title***	***Phone #***	**System Responsibilities**
1.		Board Chairman		Pays bills and makes major decisions
2.		Manager		Maintains office and performs related duties, keeps Board informed. Makes routine/normal financial decisions.
3.		Operator		Operate and maintain the water system components.
4.		Laboratory Tech		Take samples as necessary.

- ***Consumer complaint response procedures***. Example procedure is described below.

  A. ***CONSUMER COMPLAINT RESPONSE PROCEDURE***

  1. *Record in complaint log (name, address and nature of the problem).*
  2. *Investigate the complaint.*
  3. *Verify or dismiss the complaint.*
  4. *Record the steps taken to address or correct the problem.*
  5. *Notify complainant of action taken.*

  Keep complaint records with corrective action for five years.

UNIT 3: Operations

FACT SHEET 3.3 – Recordkeeping

FACT SHEET 3.3 – Recordkeeping

Records are very important in supporting the effective operational, administrative and financial aspects of water system management. Too often, when board members or operators move away or are no longer involved with system management, institutional knowledge is lost because of poor recordkeeping.

Good practice deems that records should be kept as long as legally required and/or as long as they are deemed useful. State rules (OAR 333-061-0025) require that monitoring and operating records be made available when the system is inspected. In addition, OAR 333-061-0040(2) sets specific retention requirements. Those requirements are set forth in parentheses in the list below. Good management practice also dictates that a variety of other records be kept as well. Records to keep in a safe but available place include:

Equipment and maintenance records

- Well logs (including name and type of pumps);
- System documents showing layout, “as-built,” maps, etc.;
- List of equipment with make and model numbers and date purchased;
- Equipment manuals;
- Ledger of completed maintenance work;
- Operational logs (run times, meter readings, settings, observations, etc.);
- Schedule of future maintenance needs and general physical condition of equipment;
- Procurement records (ordered parts and supplies to forecast future needs).

Sampling and monitoring compliance records

- Coliform Monitoring Plan;
- Total coliform test results (at least 5 years);
- All other lab analysis results (for at least 10 years);
- Actions taken to correct any non-compliance issues (3 years);
- Issued public notices.

Planning and management documents

- Operation and maintenance manual;
- Consumer Confidence Reports;
- Emergency response plans;
- Sanitary surveys, reports, communications, etc. (10 years);
- Other system-developed programs, such as water conservation and cross-connection control.

Administrative & legal records

- System permits;
- Records of any variances or permits (5 years);
- Water Rights Documents (indefinitely);
- System ordinances, resolutions, by-laws, etc.;
- Financial records (monthly financial reports, annual budgets, etc.);
- Public meeting records;
- Personnel records (kept confidentially).

UNIT 3: Operations

FACT SHEET 3.4 – Shock Chlorination Procedures for Wells

FACT SHEET 3.4 – Shock Chlorination Procedures for Wells

Wells may need to be disinfected to eliminate organisms that may have entered the source during major repairs or other instances. More specifically, chlorination is recommended under the following circumstances:

- After construction of a new well;
- After maintenance of an existing well where the sanitary seal is broken;
- After a positive coliform sample or other contamination event; or
- As a preventative measure to kill biofilms that may have built up in the well casing.

The chlorination procedure involves first determining the volume of standing water in the well, and then calculating the appropriate amount of chlorine solution to add to the well. DHS recommends introducing into the well a solution consisting of 50 ppm chlorine.

The following table can be used to determine the volume of water in the well.

Main diameter, inches	Gallons/foot of length
4	0.65
6	1.5
8	2.6
10	4.1
12	5.9
14	8.0

To calculate the amount of chlorine solution needed, see *UNIT 4 – Specifics for Systems with Treatment*.

Pour the needed amount of chlorine solution into the well, either through the well seal vent port or by carefully removing the well seal.

Recirculate the well water though the hose back into the well (through the vent port or into the open casing) to thoroughly mix the chlorine solution with the well water. Try to wash down the interior walls of the well during the process. Recirculate 1 to 2 hours. Replace the well seal and screened vent.

Open all faucets connected to the system, until a strong odor of chlorine is detected.

The solution should stand for 24 hours, to allow sufficient contact time for disinfection to occur. After 24 hours, run the faucets and let the chlorinated water flush out until the odor of chlorine dissipates. ***Make sure the chlorinated water is disposed of in an environmentally safe manner, away from the vegetation.***

As a final step, bacteriological testing should be conducted after disinfection. Consumers will need to wait until bacteriological testing shows the water is safe before using the water. Always provide affected consumers with advance notice of when the emergency chlorination process will occur and when to expect potable water to be returned to the system.

UNIT 3: Operations

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UNIT 3: Operations

FACT SHEET 3.5 – Leak Prevention & Repair

3.5.1 - Overview of Steps

3.5.2 - Using an Emergency Plan

3.5.3 - Ensuring Staff and Public Safety Before, During and After Pipe Repair

3.5.4 - Notifying Other Utility Companies

3.5.5 - Notifying Customers of Possible Water Outages

3.5.6 - Using Proper Construction Practices and Testing for Leaks

3.5.7 - Disinfecting Repaired or New Lines and Testing for Bacteria

3.5.8 - Keeping Proper Documentation

FACT SHEET 3.5 – Leak Prevention & Repair

3.5.1 – Overview of Steps

All water systems will have leaks in their water pipes. Some leaks are very small and may go undetected for long periods of time.

However, when a leak is discovered it must be repaired to protect public health (backflow possibilities) and reduce costs (wasting water). Operators should have a written Emergency plan and an Operation and Maintenance manual for reference that address the following when dealing with leaks:

- Consider staff and public safety before, during and after the repair;
- Notify other utility companies (i.e., gas, electrical) of repair work;
- Notifying customers of possible water outages;
- Use proper construction practices and tests for leaks;
- Properly disinfect repaired lines and test for coliform bacteria;
- Keep proper documentation.

More information on each of these steps follows.

3.5.2 – Using an Emergency Plan

In addition to an updated Operations and Maintenance Plan, all water systems should have a written emergency plan that addresses a variety of types of emergencies including water pipe leaks and breaks. It is also a good idea to practice the steps in the plan to determine if all issues have been addressed. There are many good templates that can help you create an emergency response plan.

Water systems should have all parts needed to repair a pipe leak or break on the site to prevent workers from having to scramble on a Sunday afternoon to find a repair clamp or other part.

It is also important to have the necessary tools on hand. Small water systems that do not own heavy equipment should have a plan or agreement with a local heavy equipment supplier so severe leaks or breaks can be quickly repaired.

3.5.3 - Ensuring Staff and Public Safety Before, During and After Pipe Repair

When a leak is discovered, water system staff should immediately determine the best and safest method of repair. Staff should have and use safety equipment such as bright clothing, cones, barricades and flashing lights.

It is a good idea to have a plan of action for emergency repairs in the emergency plan. Practicing such a plan can make an emergency seem more like a routine repair. Whether a pipe is dug up by hand or by heavy equipment, safety should always be the primary concern.

Protection of public and private property is also important, as are potential safety issues involving traffic and pedestrians. If a leak is severe and could cause property damage, it must be addressed immediately. Control water loss by a complete or partial line shut down. Only after the following issues have been addressed, will it be time to dig up the pipe and repair the leak.

3.5.4 - Notifying Other Utility Companies

Other utilities place their pipes and wires underground for public convenience. Oregon requires notification of all utility companies when any other utility will be digging more than 12 inches in public rights of way.

Notification must be given two working days prior to any digging. Prior notice prevents damage to other utilities such as phone, cable, electric or sewage lines as well as any other utilities that may be in the area.

Providing no prior notice not only inconveniences the public, but also makes water systems financially liable for any damage done to other utilities' property.

3.5.5 - Notifying Customers of Possible Water Outages

Leaking water pipes need to be partially or completely shut off for repair. However, low pressure or no water can be a hardship — even harmful or life-threatening — to water system customers.

When a drop in water pressure or a water outage is expected, every effort should be made to notify any customers who have sprinkler systems or water cooled refrigeration units as well as industrial, agricultural and medical equipment users (i.e., kidney dialysis machines). Notification is especially important for hospitals, senior citizen complexes, health clinics or any other medical facility. If the leak is at the bottom of a hill, customers at higher elevations should be advised to shut off their inlet valves to prevent draining of hot water heaters or water softening units.

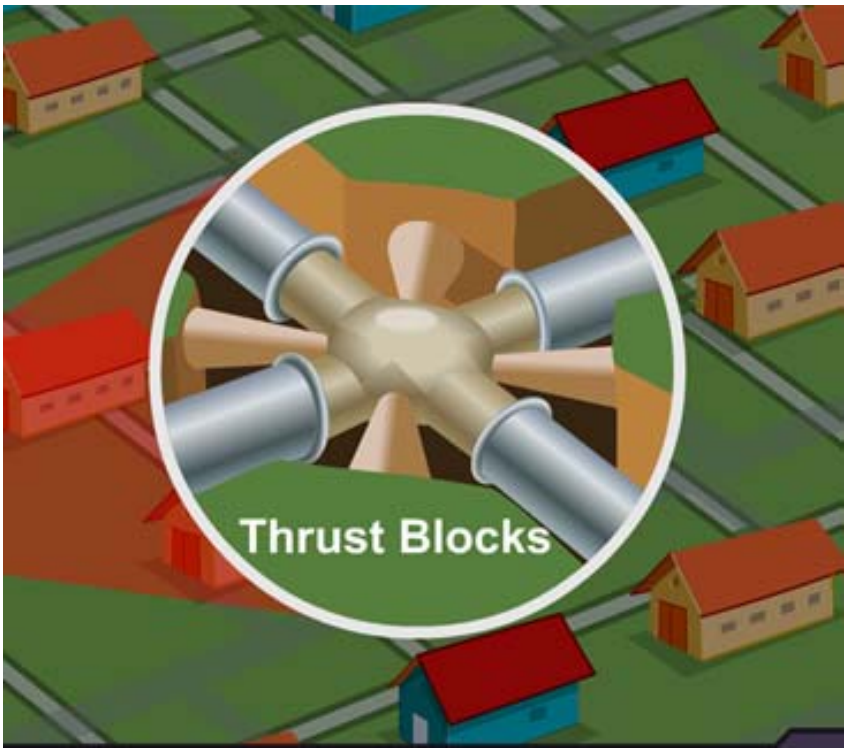
3.5.6 - Using Proper Construction Practices and Testing for Leaks

All pipe installation and repair should be done in accordance with good construction practices. All water mains should be installed under a minimum 30 inches of ground cover to prevent freezing and damage from traffic.

All pipe should be bedded and backfilled properly to allow for surface loadings. Thrust blocks should also be installed on any valves, tees, bends or appurtenances to prevent connections from coming apart when under pressure.

Disinfection of materials used for repair is recommended, and disinfection of pipe is required if pressure was lost and/or new sections of pipe were installed. See the following section for procedures to follow. Once the repair has been made, the line should be tested for leaks by using pumps to put the pipe under higher than normal pressure. If this is not possible, use system pressure as an indicator of any leaks.

Thrust blocks.



3.5.7 - Disinfecting Repaired or New Lines and Testing for Bacteria

DHS rules require disinfection after installation of new lines or repairs to old lines.

Disinfection is the process of killing microorganisms in water that can cause disease (pathogens).

Chlorination is the most widely used form of disinfection. A solution of at least 50 ppm chlorine must be injected into the line with no less than 25 ppm free chlorine residual measured after a minimum of 24 hours.

The first step involves determining the volume of water to be disinfected. To calculate the volume of water in a section of pipe, use the following table.

Main diameter, inches	Gallons/foot of length
2	0.16
4	0.65
6	1.5
8	2.6
10	4.1
12	5.9

Example:

Let's say you just installed 290 feet of 4" main. Before putting it into service, it needs to be disinfected. Calculate the volume of water in gallons using the above table.

One foot of 4" pipe contains 0.65 gallons of water per foot of length. Therefore:

$$0.65 \times 290 = 190 \text{ gallons.}$$

To calculate the amount of chlorine solution needed, *see UNIT 4 - Specifics for Systems with Treatment.*

After disinfection and flushing the highly chlorinated water from the main, a water quality test for coliform bacteria must be performed. If the water main line has lost pressure during the repair, it must again be tested for coliform bacteria before it can be placed back into service. If the sample determines the presence of coliform, re-chlorinate the line following the same procedure, flush and retest. If coliform is absent, place the water line back into service. ***Remember, chlorinated water must be disposed of in an environmentally safe manner***.

3.5.8 - Keeping Proper Documentation

Repairs performed on water systems should be documented. Documentation helps staff complete future repairs and demonstrates the need for system upgrades and improvements. Documentation should include:

- Depth of pipe
- Type of pipe and fittings
- Any unusual conditions
- Any other utilities in the area
- Type of repair
- Date of repair
- Who performed the repair
- Changes (if any) to system maps
- Make any needed changes to the O&M Manual

UNIT 3: Operations

FACT SHEET 3.6 - Facility Operation and Maintenance

3.6.1 - Understanding a Pressurized System

3.6.2 - Understanding and Implementing a Flushing Program

3.6.3 - Understanding and Implementing a Valve Exercising Program

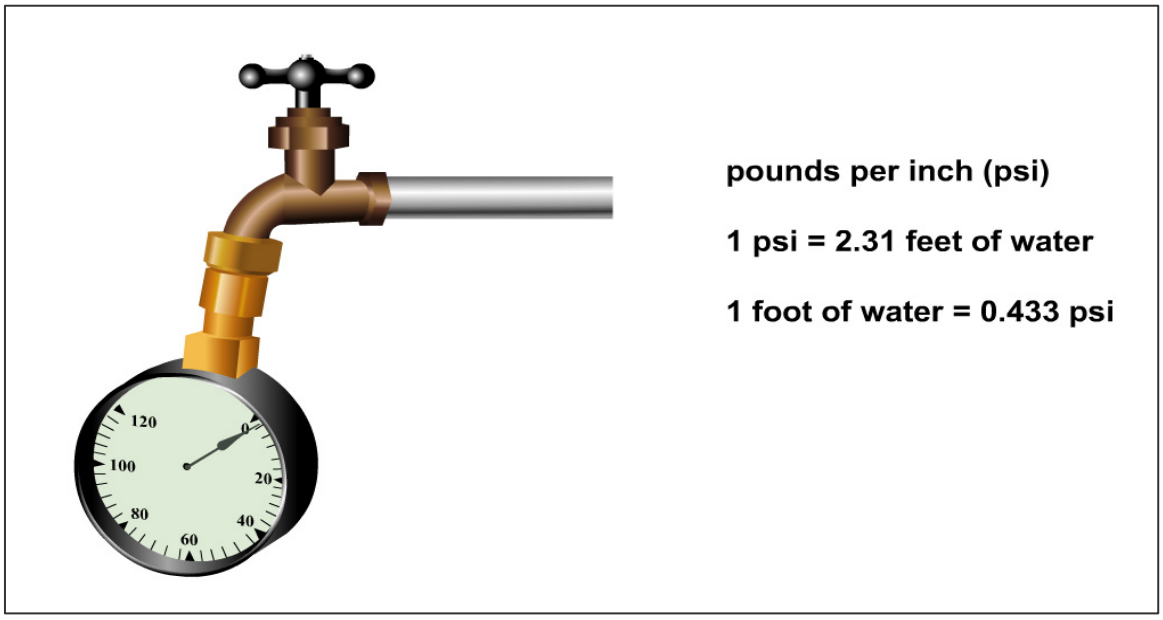
FACT SHEET 3.6 - Facility Operation and Maintenance

3.6.1 – Understanding a Pressurized System

Water in the distribution system must be under pressure at all times. **Pressure** allows water to go where it needs to go and prevents contaminants from entering the distribution system through **backflow**. Backflow is the reversal of the normal direction of water flow in piping and is a source of entry for non-potable water.

For example, positive pressure within a system can be compromised if large quantities of water are pumped out for fire suppression. Distribution systems are designed for certain flows and pressures. If normal flows are exceeded, system pressure can drop. If pressure drops, any **cross connections** without backflow protection devices could result in backsiphoning of non-potable water into the distribution system. The result is contaminated drinking water (See Section I, Part 5 for more information on cross connections).

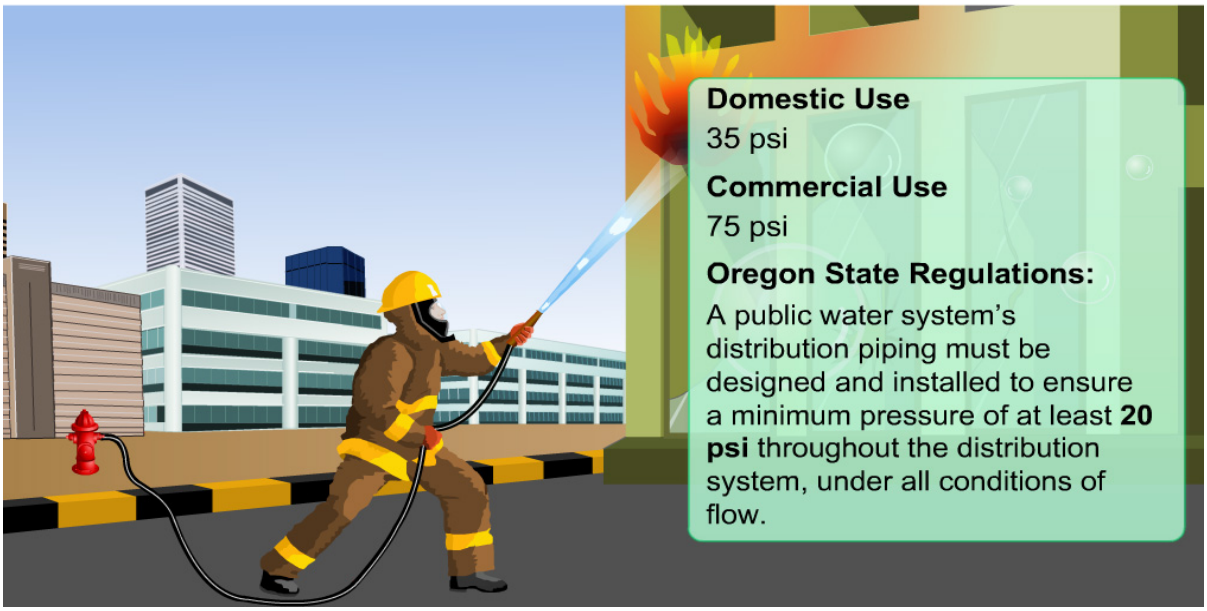
Pressure is provided by the direct force (e.g., from a pump), or by elevation (e.g., storage reservoir). Pressure is measured in **pounds per square inch, or psi.** One psi is equal to 2.31 feet of water or one foot of water is equal to 0.433 psi.



For ordinary domestic use, water pressure should be a minimum of 35 psi. A minimum of 60 psi is usually adequate for a fire hydrant. This amount of pressure allows for a pressure drop of up to 20 psi when fire hoses are used. In commercial and industrial districts, it is common to have 75 psi or higher. According to state regulations, a public water system's distribution piping must be designed and installed to assure a minimum pressure measured of at least 20 psi throughout the distribution system under all conditions of flow.

Pressure tests should be performed several times a year at a number of locations within the distribution system. Ideally, pressure should be measured close to the pumping station, midway in the distribution system and as close to the end of the system as possible.

If positive pressure at the end of a system cannot be maintained during times of high use, booster pumps should be installed. Pressure tests help operators monitor system performance and identify leaks. To provide constant evaluation of system pressure, it is also helpful to have some locations continuously monitored.



3.6.2 – Understanding and Implementing a Flushing Program

A variety of impurities, such as sand, iron and manganese from the well source can build up in the system promote bacterial growth creating cloudy water, or taste and odor problems at the tap resulting in customer complaints. They can also obstruct the proper operation and shorten the life expectancy of meters, valves and other system components.

Iron buildup, manganese and turbidity issues can also be corrected by flushing programs. In addition to shortening the life of a water system, these problems can cause increased water quality complaints from customers.

Most water systems' flushing programs consists of opening fire hydrants (or special flushing hydrants) throughout a water system. If fire hydrants are not available, installation of hydrants or blow-off valves in strategic locations should be considered a priority.

When establishing a flushing program factors such as size of water pipes, locations of flushing outlets, locations of main valves and the ability to dispose of large quantities of water must be considered.

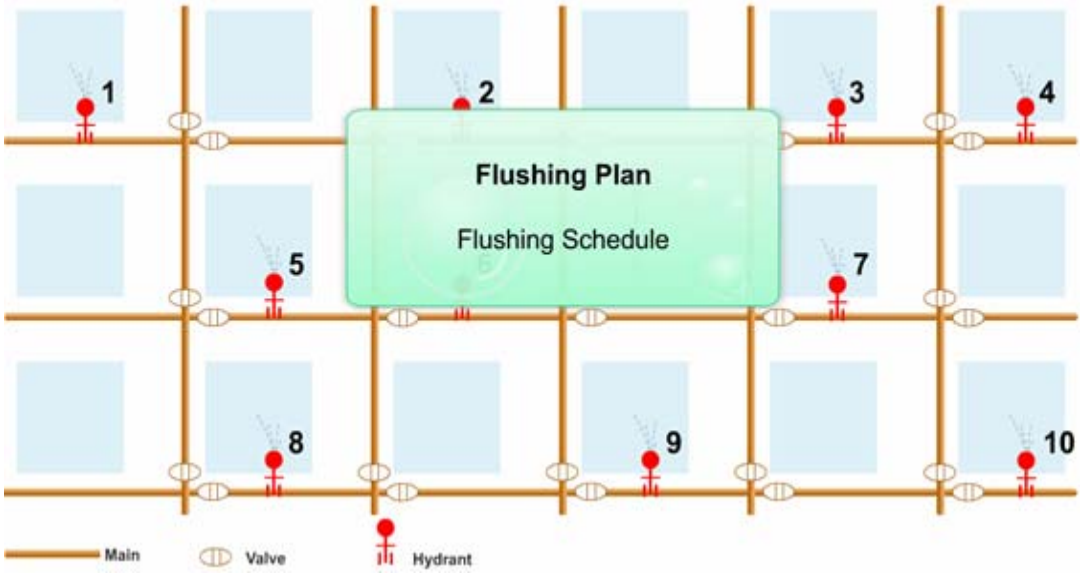
Flushing program procedures should be documented to ensure they are done correctly. Flushing at blow offs on dead end lines and at fire hydrants throughout the system should be done at least once a year, more often if water quality problems exist.

A flushing program should include the following steps and documentation:

- Map of water system with hydrants marked and numbered;
- Attach a sheet with schedule and order in which the hydrants will be flushed;
- Allow only trained staff to flush hydrants (open and close slowly to avoid water hammer or other damage);
- Ensure that detailed procedures are in place to notify customers that some dirty water may be created, and what they should do to flush their lines (run water for a few minutes);
- Begin flushing with the hydrant closest to the pump station or storage tank, then move to the next hydrant (this way, clean water is chasing out dirty water);

- Inspect each hydrant during flushing for leaks, ease of operation, ease of access, painting needs, etc., and document those findings;
- Ensure flow from a hydrant does not cause damage to property or cause a distraction to drivers;
- If water is flowing into a storm drain or water way, make sure to de-chlorinate chlorinated water.
- Document the number of turns needed to open and close hydrants, length of time flushed (at least 2-3 water changes in pipe), findings from inspections, name of operator and so forth.

Sample flushing plan map.



3.6.3 - Understanding and Implementing a Valve Exercising Program

Water main line valves are water system components that often get ignored. **Water main line valves** are usually installed on underground water pipes throughout a water system. Valves isolate sections of water pipes so that installation, repair, replacement or maintenance of the water system can be performed.

In case of an emergency, valves also isolate storage tanks or other parts of the distribution system. Draining a storage tank can cause insufficient pressure for fire protection or adequate water supply.

Debris built up in valves that have not been properly exercised can make it impossible to shut them off completely, or even cause them to fail. Dealing with shut off problems or complete failure is much more time consuming and expensive than simply creating a valve exercising program. Water main valves should be exercised at least annually.

If water quality is poor due to sediment, iron and manganese or other constituents, a more frequent exercise schedule should be considered.

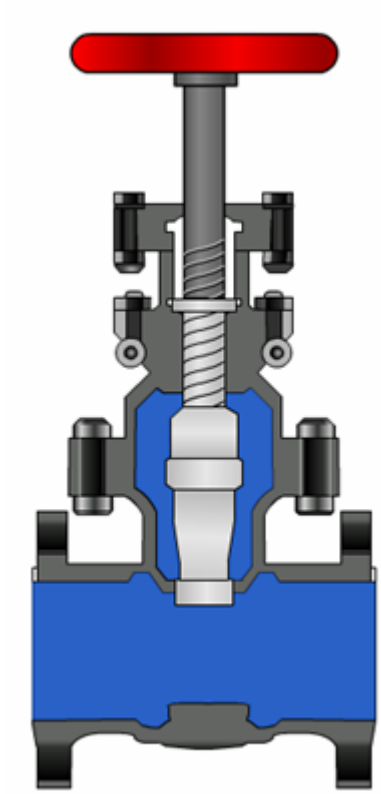
When implementing a valve exercising program:

- Include a map of water system with valves; marked and numbered
- Attach a sheet with a schedule and order in which the valves will be exercised;
- Make sure only trained staff exercise main valves (open and close slowly to avoid water hammer or other damage);
- Notify customers that some dirty water may be created, and what to do to flush lines (run the water for a few minutes);
- Begin exercising valves as described in the documented plan;
- Since most valves are located in street areas, be sure to follow safety requirements and precautions (barricades, cones, safety vests, etc.);
- Inspect and clean valve boxes and document each

valve for leaks, ease of operation and number of turns to open/close (if number changes, consider valve replacement);

- Document inspection findings, name of operator, date, etc.;
- Other tests which should be conducted at a minimum of once a year are: flow test, pressure test, fire hydrant inspection, and others. These tests should be done after the hydrant and flushing exercises to assure accurate and comparable results.

Example valve (gate valve)



UNIT 3: Operations

FACT SHEET 3.7 - Cleaning and Maintaining Storage Tanks

3.7.1 - Overview of Storage Tanks

3.7.2 - Developing a Maintenance Program

3.7.3 - Storage Tank Chlorination

Table - Disinfection of reservoirs to achieve a 25 ppm chlorine dose

FACT SHEET 3.7 - Cleaning and Maintaining Storage Tanks

3.7.1 – Overview of Storage Tanks

Storage facilities allow water systems to meet fluctuating water demands. Their primary purpose is to store water. The storage volume should be equal to between one and three days of the system's average daily use.

Storage tanks should be located at a high enough elevation to allow the water to flow by gravity to the distribution system. This, coupled with consumer use, should provide an uninterrupted water supply in the event of pump failure, loss of power or acute contamination event (sewage bypass, fuel or chemical spill, etc). Also, if feasible, fire protection storage should be provided.

Storage tanks are also used as detention basins to provide required chlorine contact time necessary to ensure adequate disinfection. As such, the contact time in a storage tank is greatly improved when constructed with a separate inlet and outlet pipe, preferably located on opposite sides and at different levels. Also, baffles inside the storage tank (walls, curtains, or spirals) increase contact time by preventing water from leaving the storage tank too quickly (known as "short circuiting").

3.7.2 – Developing a Maintenance Program

The fact that there are no moving parts in a storage tank, leads some water system operators to believe this piece of equipment does not need maintenance. Anyone who has ignored their storage tank only to have it fail knows differently.

A storage tank that is not maintained is capable of failing (water outage) or allowing contaminants to enter the water supply. Correcting these problems can be significantly more expensive than implementing a preventative maintenance plan.

A good operations and maintenance plan for the storage tank will include a list of maintenance tasks, a list of any potential problems associated with the storage tank, viable solutions and whether or not professional help should be sought. Important components of the maintenance plan will be **visual inspections** as well as **cleaning** of the storage tank.

Visual inspections are used to check physical aspects of the tank as well as signal other issues. Both exterior and interior visual inspections should be conducted. Physical aspects to be aware of in any visual inspection include:

- Leaking;
- Rusting;
- Failed vent screens;
- Inspection hatch problems;
- Electrical components (if any);
- Vandalism.

Other issues that could also affect the system's water quality include:

- Mineral buildup;
- Vent screen failure;
- Stale water;
- Vandalism.

How often should exterior and interior visual inspection be performed and what is involved?

A visual exterior inspection is performed annually at a minimum. In preparation for the exterior inspection, a review of original plans or "as-builts" for the storage tank (dimensions, water levels, controls, etc.) is helpful. As part of the visual exterior inspection, be sure to inspect and document exterior paint, ladders, foundations, bolts, valves, hatches, vents, cathodic protection or any other system components.

Interior inspections should also be done at least annually. A visual interior inspection involves opening the hatch and looking inside, checking the vent screening and ladder inspection. All findings should be documented.

More frequent inspections for both the interior and exterior of the tank may be needed depending on the type of tank, age, location, as well as weather conditions and water quality. For example, a newer system with a fenced tank, an alarm system and located near the operator's home, would not need to be inspected as often as an older system that has no security measures and is secluded.

Detected problems should be corrected immediately. Proper coatings should be applied and maintained (touched up) as needed to prolong the life of the tank. Because most tanks are located in isolated places, it is also important to check for potential security problems as part of routine inspections. Examine fencing, locks, lights or any other items used to secure the tank site.

Cleaning of the storage tank should be conducted as needed. Tanks can be drained and then cleaned, or alternatively cleaning can be done by divers and/or mechanical vacuums. Criteria used to determine needed frequency of tank cleaning include:

- Water quality (e.g., mineral content, use of treatment chemicals);
- Local climate and temperature (e.g., algae build up in warm conditions);
- Tank material and condition (e.g., indications of rust);
- Tank age.

If a system's tank has never been cleaned, it may be a good idea to hire a company specializing in tank cleaning that has video equipment. A camera can be lowered into the tank to inspect for tank flaws and/or sediment/mineral buildup. Based on this information, combined with the tank's age, water system owners can determine how often the tank should be inspected and serviced and plan accordingly.

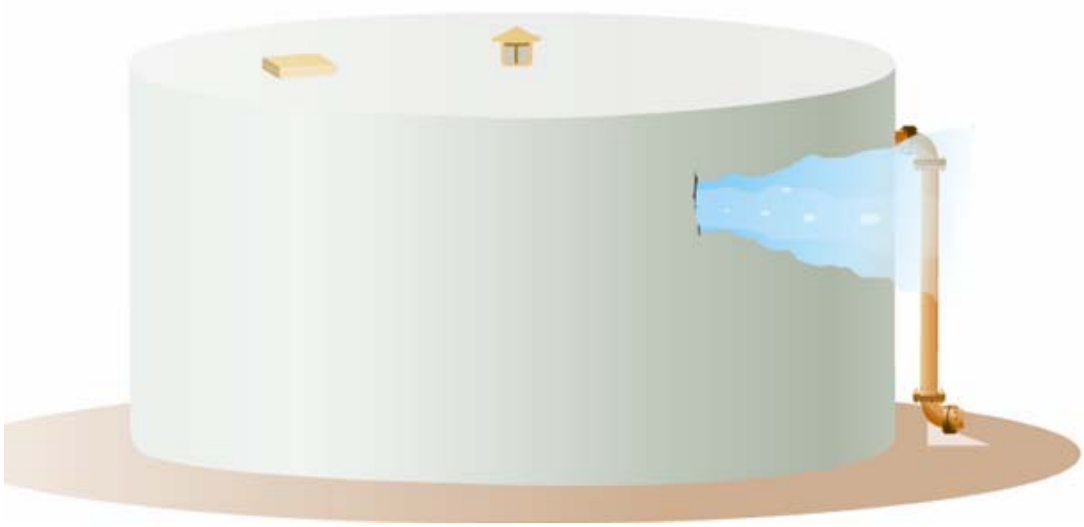
When draining and cleaning a storage tank:

- Make sure customers still have water while the tank is out of service;
- Make sure water being drained does not cause damage or erosion problems;

- Open and close all appropriate valves and drain;
- Treat the tank as a confined space. Have safety harnesses attached to anyone in the tank and a rescue plan in place;
- Clean the tank as needed. This can usually be accomplished with high pressure water hoses;
- Inspect and document the tank interior as recommended by the manufacturer;
- Develop a resolution plan for any issues discovered during the inspection;
- Perform a thorough cleaning, disinfection and bacteriological sampling prior to placing the reservoir back in service;
- Keep records of all maintenance activities.

After draining and cleaning, the tank must be chlorinated as described in the following section.

Leaking Storage Tank.



3.7.3 - Storage Tank Chlorination

After draining and cleaning, it is necessary to clean and disinfect the storage tank before placing it back into service. There are three methods of chlorine disinfection:

Method A. Filling the tank or reservoir with a 10 mg/L chlorine solution and allowing it to remain for 24 hours.
Method B. Filling the reservoir with a 50 mg/L chlorine solution and allowing it to stand for 6 hours.
Method C. Spraying or brushing on a 200 mg/L chlorine solution and allowing it to remain for 30 min. prior to filling the tank.

Table - Disinfection of reservoirs to achieve a 50 mg/L chlorine dose

Reservoir size (gals.)	Gallons of 5% bleach to add to achieve a 50mg/L chlorine dose
1,000	1
2,000	2
3,000	3
4,000	4
5,000	5
10,000	10
20,000	20
30,000	30
40,000	40
50,000	50

Reservoir size (gals.)	Amount (in pounds of dry weight) of 65% strength dry chlorine powder to add to achieve a 25 mg/L dose.
10,000	3.5
20,000	6.5
30,000	10
40,000	13
50,000	16
100,000	32
200,000	64
300,000	100
400,000	130
500,000	160

Regardless of the method used*, chlorinated water must be disposed of in an environmentally safe manner.* Also, after disinfection and flushing a total coliform sample should be taken and tested prior to re-use of the reservoir. Records should be kept of all activities of this type. Such records are useful when scheduling future maintenance.

UNIT 3: Operations

FACT SHEET 3.8 - Accessing the Drinking Water Program Web Site

FACT SHEET 3.8 - Accessing the Drinking Water Program Web Site

The Drinking Water Program's web site provides a variety of information to support public water systems in meeting regulatory requirements and providing safe drinking water to customers. The web site is accessible at: http://oregon.gov/DHS/ph/dwp/

The site provides access to current information on rules, upcoming program changes, contacts for free technical assistance available to small systems, templates and historical data and links to the following:

- **Data Online.** A database with information on each public water system in Oregon. This is where the Department stores all the about your water system including the primary contact information, sampling schedules, latest sampling results, record of violations and much more. Operators should monitor their system to be sure the information is current and accurate.

- **Pipeline Newsletter**. Copies of current and past Pipeline, the quarterly newsletter published by the Department for public water systems in Oregon.

- **Monitoring Information Forms and Fact Sheets.** Tools and information for monitoring and reporting sampling results (e.g., coliform sampling plan template, summary of chemical sampling requirements, proper sampling techniques, waiver forms and guidance, health effects information). Also included are public notice requirements and downloadable templates.

- **Water System Security** Find information on water system security requirements, including links to other resources.

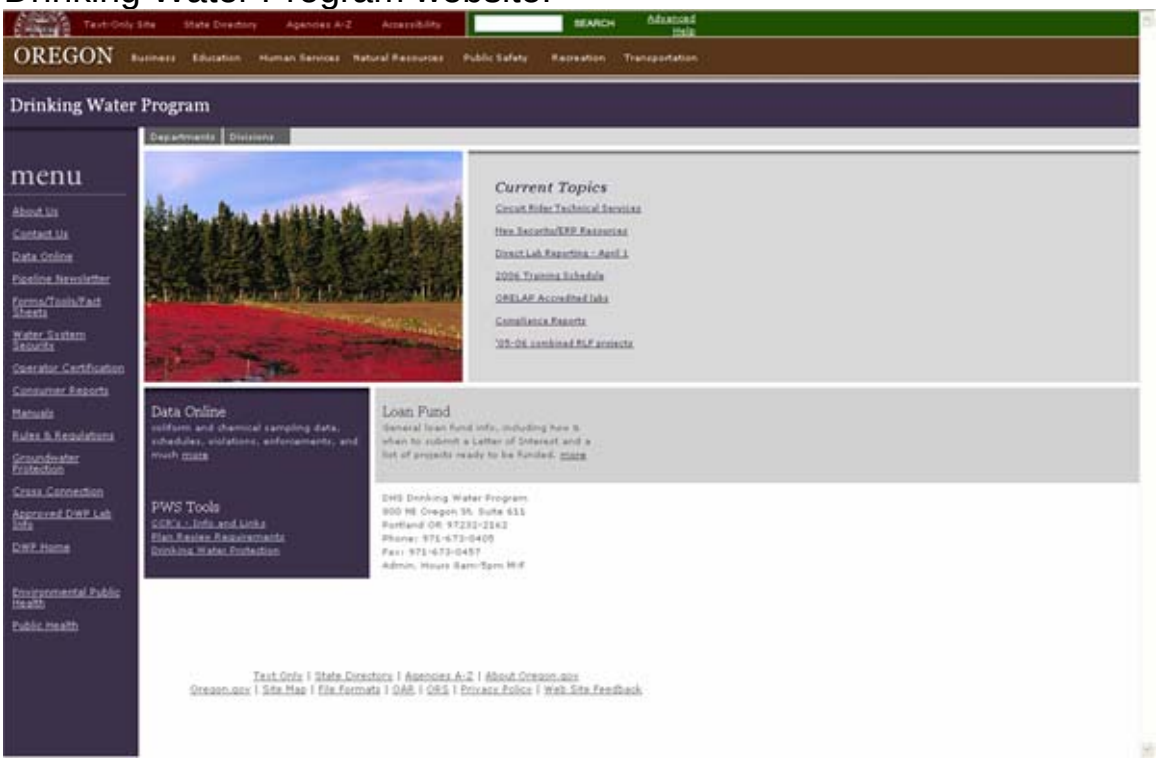
- **Operator Certification** Outlines operator certification requirements. Includes application materials and info on training courses and schedules.
- **Consumer Confidence Reports** Gives requirements, templates, a sample CCR and resources to aid in writing a CCRt.

- **Manuals**
  Offers a general Water System Training Manual and a Groundwater Manual.

- **Rules and Regulations.**
  Copies of current regulations are available here.

- **DWP Staff**
  Contact information for DWP and county health department staff is provided.

Drinking Water Program website.



UNIT 3: Operations

FACT SHEET 3.9 - Who to Call for Help

3.9.1 - DHS Drinking Water Program

3.9.2 - County Health Department Contacts

3.9.3 - DHS Cross-Connection / Backflow Prevention Program

3.9.4 - Drinking Water Protection Program

3.9.5 - Technical Assistance Circuit Riders

3.9.6 – Safe Drinking Water Revolving Loan Fund

3.9.7 - Industry Organizations & Resources

3.9.8 - State Certified Laboratories

FACT SHEET 3.9 - Who to Call for Help

3.9.1 – DHS Drinking Water Program

Use the **DWP technical assistance phone line** to get answers to your questions. DWP staff is available Monday through Friday from 8:00 AM to 5:00 PM to respond to inquiries. **Call 971-673-0405.**

Please make use of this technical assistance phone line unless you feel you must speak with a specific staff member. Staff contacts are listed below.

(Note: Staff are located in Portland unless otherwise listed.)

General Inquiries Drinking Water Program ***Technical Assistance Phone Line, Portland*** ***8:00 AM – 5:00 PM*** **971-673-0405** **971-673-0457 Fax** **After Hours Emergencies: 1-800-452-0311** ***Oregon Emergency Response System***	
Drinking Water Administration	
Program Manager Dave Leland **Adiministrative Specalist** Diane Weis Office Specialist Carol Malka	**971-673-0415** **971-673-0427** **971-673-0469**
Portland Street Address: DHS-Drinking Water Program 800 NE Oregon Street, Ste 640 Portland, OR 97232-2162 **Mailing Address:** *General Correspondence:* PO Box 14450 Portland, OR 97293-0450 *Water Quality Reports & Domestic Well Testing:* PO Box 14350 Portland, OR 97293-0350	

Technical Services-Region 1	
Manager, Chris Hughes	971-673-0411
Plan Review, Tom Charbonneau	971 673-0406
<u>Region 1 – Portland</u> **Lead,** Kari Salis-Portland Gregg Baird-Portland Pete Farrelly-Portland Marsha Fox-Portland Carrie Gentry-Portland Evan Hofeld-Portland James Nusrala-Portland Kurt Putnam –Portland Michelle Bryd **Region 1 – Pendleton** **Lead,** Bill Goss-Pendleton Amy Baker-Pendleton Gary Burnett-Pendleton Carolyn Clemons	 971-673-0423 971-673-0410 971-673-0462 971-673-0408 971-673-0191 971-673-0419 971-673-0459 971-673-0421 971-673-0425 541-966-0900 541-966-0901 541-966-0899 541-966-0902

Technical Services-Region 2	
Interim Manager, Karen Kelley	541-726-2587 x22
Region 2 – Springfield **Lead,** Tom Pattee **Lead,** Amy Parmenter Fred Kalish Russ Kazmierczak Casey Lyon Betsy Parry Nancy Vierra **Region 2 – Medford** Scott Curry Daniel Hough	541-726-2587 X24 X23 X27 X26 X31 X30 X25 541-776-6229 x284 541-776-6229 x407

Data Management & Compliance Enforcement	
Interim Manager, Joe Carlson	971-673-0470
Lead, Chuck Michael Paul Cymbala Brad Daniels David Lew Roberta Lindgren Sharon Ross Michelle Van Kleeck Angela Wahlquist	971-673-0420 971-673-0461 971-673-0407 971-673-0418 971-673-0416 971-673-0412 971-673-0471 971-673-0424

Planning, Protection and Certification	
Manager, Ron Hall	971-673-0409
SRF Loan Fund Coordinator: Roberto Reyes-Colon *Cross Connection Coordinator:* Michael Perry *Operator Certification*: Dottie Reynolds Lee Keyes	 971-673-0422 971-673-1220 971-673-0426 971-673-0413
Debra Lambeth Anthony Fields Marsha Fox Tom Mitchell	971-673-0414 971-673-2269 971-673-0408 971-673-0417

Lab Certification, Public Health Laboratory – Portland	
Coordinator Dr Irene Ronning	503-693-4122 Fax 503-693-5602

3.9.2 – County Health Department Contacts

The Drinking Water Program contracts with the following county health departments to perform much of the program work at the local level. In addition to contacting the DWP, you may also contact your local health department to get answers to your questions. If your county is not listed, your water system is directly overseen by the DHS Drinking Water Program.

COUNTY	CONTACT	PHONE
Benton	Scott Kruger	541-766-6650
Clackamas	Joel Ferguson/Steve Dahl	503-742-5367
Clatsop	Maureen Taylor	503-325-8500x1927
Columbia	Mark Edington	503-366-3828
Coos	Rick Hallmark/Ian Stromquist	541-756-2020x513
Crook	Russ Hanson	541-447-8155
Curry	Mike Meszaros	541-247-3254
Deschutes	Jeff Freund	541-388-6563
Douglas	Gerry Meye/Caroline Gross Regan	541-440-3005
Grant	Ray Huff/John Combs	541-823-2320
Harney	Ray Huff/John Combs	541-823-2320
Hood River	Jeff Fetkenhour/Mike Matthews	541-387-7130
Jackson	Mike Obereigner/Gary Stevens	541-774-7843
Jefferson	Bob Wilson	541-475-4456
Josephine	Alex Giel/Justin Fimbres	541-474-5338
Klamath	Delbert Bell/Dan Osborn	541-883-1122
Lincoln	Amy Chapman/Max Hamblin	541-265-6611x2442
Linn	Deborah Hoy/Rick Partipilo	541-967-3821x2028
Malheur/Baker	Eric Evans/ Susan Fuller	541-473-5186
Marion	Greg DeBlase/Carolyn Stegall	503-588-5407
Multnomah	Gerald Barns/Robert Reardon	503-988-3400
Polk	Jim Solvedt/Jason Borzy	503-623-9237
Tillamook	Annette Pampush/Morgan Poloni	503-842-3902
Union	Ryan Zastrow	541-962-8818
Wasco/Sherman	John Zalaznik/Glenn Pierce	541-506-2622
Washington	Joseph Federico/Abraham Shadbeh	503-846-4935
Yamhill	Gary VanDerVeen/Jenifer George	503-434-7439

3.9.3 – DHS Cross Connection/Backflow Prevention Program

By state law, public water system operators are required to prevent cross connections from existing within their systems. If an actual or potential cross connection exists, installation of an approved backflow prevention assembly is required. The DHS Cross Connection Program Coordinator is available to answer your questions regarding cross connection control and backflow prevention requirements and to assist you in implementing a successful program. Contact the coordinator for answers to your questions.

Michael Perry
Cross Connection Program Coordinator
Ph. 971-673-1220
Fax 971-673-0457
michael.perry@state.or.us
DHS-CC/BPP
PO BOX 14450
Portland, OR 97293-0450

3.9.4 – Drinking Water Protection Program

The Oregon Drinking Water Protection Program is jointly administered by the DWP and the Oregon Department of Environmental Quality (DEQ). The DWP concentrates on assisting communities implement groundwater protection activities, while the DEQ is focused on supporting surface water protection activities. DWP and DEQ staff can help you get started on developing and implementing a drinking water protection plan. Contact the relevant department for more information on drinking water protection.

Oregon DHS Drinking Water Program– Groundwater Protection Coordinators

- Tom Pattee, at 541-726-2587, Ext. 24 tom.pattee@state.or.us

Oregon Department of Environmental Quality (DEQ)– Surface Water Protection Coordinators

- Sheree Stewart, at 503-229-5413 *stewart.sheree@deq.state.or.us*
- Sue Gries, at 503-229-6210 *gries.sue@deq.state.or.us*

3.9.5 – Technical Assistance Circuit Riders

Through the Safe Drinking Water Revolving Loan Fund, contracts have been established with drinking water circuit riders to provide on-site technical services to community water systems with populations under 10,000. This technical assistance service is **offered at no cost to water systems**.

Circuit riders can assist small water systems with a wide variety of issues, including:

- Operational troubleshooting,
- Emergency operations assistance,
- Equipment recommendations,
- Guidance on water system planning,
- Submitting applications for project funding.

Contact the state circuit rider for more information and assistance.

***Oregon Small Water System Circuit Rider*:**
HBH Consulting Engineers, Inc.
Robert Henry, *Sherwood Office*
E-mail: rhenry@hbh-consulting.com
Phone: 503-625-8065
1-866-669-6603

3.9.6 – Safe Drinking Water Revolving Loan Fund

Each year the Safe Drinking Water Revolving Loan Fund (SDWRLF) offers low interest, long-term financing for drinking water infrastructure improvement projects. Projects may be to plan, design, or construct drinking water facilities needed to increase public health protection and maintain compliance with drinking water quality standards. Your project can also include the cost to add or improve security measures to protect drinking water facilities. Public and privately owned Community and nonprofit Non-Community water systems are eligible to receive funding.

Community water systems are also eligible for loans up to $100,000 and for grants up to $20,000 for source water protection efforts to help carry out elements of a Drinking Water Protection Plan.

To apply, drinking water systems should prepare and submit information about their drinking water projects on a *Letter of Interest*. *Letters of interest* are collected annually, usually in early spring.

This program is jointly administered by the DWP and the Oregon Economic and Community Development Department (OECDD). Contact the SDWRLF Coordinator for more information.

Oregon DHS Drinking Water Program,
SDWRLF Coordinator
Roberto Reyes-Colon
971-673-0422
roberto.reyes-colon@state.or.us

3.9.7 – Industry Organizations & Resources

American Water Works Association (AWWA) Pacific Northwest Section
Northwest section of AWWA covering Oregon, Washington and Idaho. Offers trainings and networking opportunities for operators and utility managers.
http://www.pnws-awwa.org/

National Environmental Services Center (NESC)
Service center based in West Virginia that produce materials through the Drinking Water Clearinghouse and offer assistance for small communities in the areas of drinking water and wastewater. Many free resources available including "On Tap" magazine and others.
http://www.nesc.wvu.edu/

Oregon Association of Water Utilities (OAWU)
OAWU offers on-site assistance in many areas, including Safe Drinking Water Act and Clean Water Act regulations, water treatment technology, distribution system operation and maintenance, wastewater treatment and collections, and management issues such as rate structures and reviews, funding programs, budgeting and public relations. In addition, members receive the quarterly magazine, H2Oregon, legislative updates, and discounts on training seminars and annual meeting registration.
http://www.oawu.net/

Oregon Environmental Services Advisory Council (OESAC)
OESAC evaluates non-credit educational programs for continuing education and assigns continuing education units (CEUs) for water and wastewater operators. The web-site includes a list of approved courses.
http://www.oesac.com/

Rural Community Assistance Corporation (RCAC)
Offers assistance to small, rural communities on housing and environmental issues. RCAC also manages a loan fund to support infrastructure and community facility projects in rural areas. Within their environmental program, staff is available to work with communities on finance and budgeting, public outreach and education, project planning and development. Staff can also provide grant writing and other support services.
http://www.rcac.org/

3.9.8 – State Certified Laboratories

All public water systems are required to get samples analyzed at a state certified laboratory. Below is a list of current state certified labs throughout Oregon as of August 29, 2008. This list is continually updated. See the DWP web site for the most updated list.

LAB	CITY	ST	PHONE	COLIF	IOC	SOC	VOC	DIOX	RAD	ASB
Aerotech Environmental Laboratories	Phoenix	AZ	602-437-3340		P					
Alexin Analytical Laboratories, Inc	Portland	OR	503-639-9311	Y	Y		Y			
Alpha Analytical, Inc.	Sparks	NV	775-355-1044		P	P	Y			
Analytical Laboratory & Consultants Inc.	Eugene	OR	541-485-8404	Y	Y		Y			
Anatek Labs, Inc.	Moscow	ID	208-883-2839	Y	Y	Y	Y			
CH2M Hill Labs	Corvallis	OR	541-758-0235		Y		Y			
Pyxis	Portland	OR	503-254-1794	Y	Y	Y	Y			
Columbia Analytical Services - Kelso	Kelso	WA	360-577-7222	Y	Y	Y	Y			
Columbia Analytical Svs-Houston, TX	Houston	TX	503-229-5505					Y		
Delta Environmental Services, Inc.	Eugene	OR	541-689-3177	Y	P					
Energy Laboratories, Inc.	Casper	WY	307-235-0515		Y	Y	Y		Y	
Environmental Science Corporation	Mt. Juliet	TN	615-758-5863		Y	Y	Y			

LAB	CITY	ST	PHONE	COLIF	IOC	SOC	VOC	DIOX	RAD	ASB
Food Quality Labs, Inc.	Portland	OR	503-297-3636	Y						
Frontier Analytical Laboratory	Eldorado Hills	CA	916-934-0900					Y		
Grants Pass Water Laboratory, Inc.	Grants Pass	OR	541-476-0733	Y	P					
Lab/Cor, Inc.	Seattle	WA	206-781-0155							Y
Magic Valley Labs	Twin Falls	ID	208-733-4250	Y	Y					
McCowan Medical Laboratory	Coos Bay	OR	541-267-7853	Y						
MWH Laboratories	Monrovia	CA	626-386-1170	Y	Y	Y	Y	Y	Y	Y
Neilson Research Corporation	Medford	OR	541-770-5678	Y	Y	Y	Y			
Pace Analytical Services, Inc. - Minneapolis	Min-neapolis	MN	612-607-6391		Y		Y	Y		
Pace Analytical Services, Inc. - Waltz Mill	Madison	PA	724-733-1161						Y	
Pacific Analytical	Corvallis	OR	541-753-4946	Y	Y					
Pendleton Lab	Pendleton	OR	541-396-0385	Y	Y					
Spring Street Analytical	Klamath Falls	OR	541-882-6286		Y					
Test America, Analytical Testing Corp. – Cedar Falls	Cedar Falls	IA	319-227-2401		Y		Y			
Test America, Analytical Testing Corp. - Nashville	Nashville	TN	615-726-0177		Y	Y				
The Dalles Water Quality Lab.	The Dalles	OR	541-298-1242	Y						
Tillamook County Creamery Association	Tillamook	OR	503-815-1302	Y						

LAB	CITY	ST	PHONE	COLIF	IOC	SOC	VOC	DIOX	RAD	ASB
U S Filter, Enviroscan Services	Rothschild	WI	800-338-7226		Y	Y	Y			
Umpqua Research Company	Myrtle Creek	OR	541-863-5201	Y	Y	Y	Y			
Waterlab Corporation	Salem	OR	503-363-0473	Y	Y		Y			
Wilsonville Env. Services WQ Lab	Wilsonville	OR	503-682-1051	Y						
Wy'east Environmental Sciences	Portland	OR	503-231-9320	Y	P		Y			

Abbreviations:
COLIF =Coliform bacteria
IOC = Inorganic Chemicals
SOC = Synthetic Organic Chemicals
VOC = Volatile Organic Chemicals
DIOX = Dioxin
RAD = Radioactive Chemicals
ASB = Asbestos
Y = Can test all items in this group
P = Can test some but not all items in this group

UNIT 4: Specifics for Systems with Treatment

FACT SHEET 4.1 - Chlorine Basics

4.1.1 - How Chlorine "Works"

4.1.2 - Chlorination in Small Water Systems

4.1.3 - Chlorine Residuals and Testing

4.1.4 - Chlorine MRDL

4.1.5 - Chlorine Demand

4.1.6 - Breakpoint Chlorination
Figure - Breakpoint Chlorination

4.1.7 - Storage Limitations and Safety Concerns
Table - Half Life Table for 12.5% Sodium Hypochlorite

4.1.8 - Cleaning and Disposal Issues
Figure - Sample MSDS Sheet

FACT SHEET 4.1 - Chlorine Basics

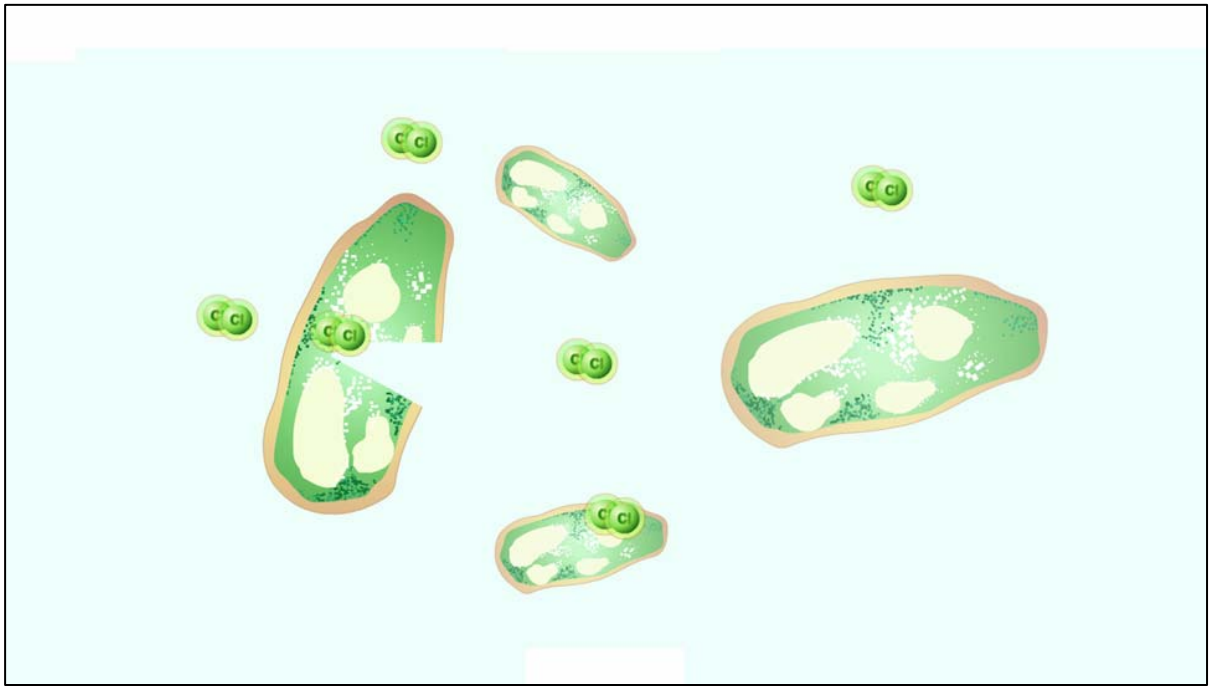
4.1.1 - How Chlorine "Works"

Chlorine is a powerful oxidant, which means that it can combine chemically with various compounds. When encountering microbial contaminants it attacks the microbe's cell wall and either ruptures it or precludes the bacteria from reproducing.

The use of chlorine in water supplies in the United States began in the early 1900's and it quickly proved itself a formidable enemy of diseases such as cholera, dysentery, typhoid, and hepatitis.

An important attribute of chlorine is its ability to persist in water distribution systems, thus providing residual protection against microbial re-growth. It also is used to control taste and odor problems by oxidizing many naturally occurring substances such as hydrogen sulfide and ammonia.

Chlorine attacks microbe's cell wall.



4.1.2 - Chlorination in Small Water Systems

The sources of chlorine most used for disinfection are chlorine gas, sodium hypochlorite and calcium hypochlorite. Chlorine gas is not commonly used by small systems for safety and other reasons.

Gaseous chlorine is injected into the water from cylinders under pressure. There is usually an adjustable device called a rotometer that shows the gas flow and gives a direct reading of pounds per day of chlorine dosage. Chlorine cylinders sit on scales and daily measurements are taken to determine the weight of chlorine used. Since chlorine gas is almost 100% "available," meaning almost 100% of the dosage by weight is chlorine, gaseous chlorination is easy to manage because the chlorine dosage reading is direct and shows usage in pounds per day.

Sodium Hypochlorite (NaOCl) is a liquid also known as "household bleach", and is by far, the most common source of chlorine used. It is a yellow-greenish liquid that is non-flammable by itself. However if it comes into contact with organic materials, it may produce combustible gases. It will generally stain clothing and can cause burns if skin or eyes come in contact. Never store calcium hypochlorite in the same area with sodium hypochlorite because combustible gases will be generated if the two chemicals are mixed.

The percentage of available chlorine is shown on the label. Remember, all chemical injections used in the water system must be certified for use in potable water, typically shown by a "NSF" (National Sanitation Foundation) on the label. Typically either 12.5% or 5-6% NaOCl will be used. The percentage indicates the amount of chlorine in the solution. One percent, by weight, is equal to 10,000 mg/L. Therefore, 6% bleach would contain 60,000 mg/L of available chlorine.

Calcium Hypochlorite, or ($Ca(OCl)_2$) is a very concentrated form of chlorine found in solid or granular form. Safety requirements must be carefully adhered to. Material Safety Data Sheets (MSDS), available from your supplier and often available on-line through supplier websites,

describe safety considerations and hazards. Calcium Hypochlorite is usually mixed into solution in a separate tank, and then injected as a solution into the water supply. There are some small systems that have the water flow over pellets or granules but this method often produces very unpredictable results.

The $Ca(OCl)_2$ label will indicate strength stated as a percentage, often 65%. This indicates the available chlorine by weight, when mixed with water. Weighing any dry chemical, and then multiplying the observed weight by the percentage of available chemical, will give you the weight of that chemical per gallon of solution. For example, weighing out one pound of 65% $Ca(OCl)_2$, and mixing it in a gallon of water, will produced 0.65 pounds of available chlorine.

Calcium hypochlorite tablet

Chlorine gas feed system

Sodium hypochlorite injection

4.1.3 - Chlorine Residuals and Testing

Chlorine residual refers to the amount of chlorine available for disinfection in water. Two types of chlorine residuals may be measured in water- “free” chlorine and “combined” chlorine. **Free chlorine** refers to dissolved chlorine gas, as well as hypochlorous acid (HOCl) or the hypochlorite ion (OCl-) produced from combination of free chlorine with water.

Combined chlorine refers to free chlorine combined with other chemicals to form compounds that retain some disinfection power. Combined chlorine compounds have a far less disinfectant potential than the free chlorine forms, but nonetheless continue to attack micro-organisms. For example, free chlorine reacts readily with ammonia (NH_3) to form one of three compounds called “chloramines”.

One benefit of chloramines is that they do not dissipate, or “fade away” as quickly and are sometimes used to maintain disinfection residuals in long transmission piping.

Small systems that chlorinate will need to measure chlorine residuals in the distribution system to assure that adequate residual levels are maintained.

The Department requires a minimum free chlorine residual of 0.2 mg/l before reaching the first point of use in the water system, and detectable free residual must be maintained in all points of the distribution system.

When testing for chlorine residuals, the “Free” test measures just that, but the “Total” test measures the sum of both the free and combined chlorine.

Chlorine Testing

By far, the most common field test for chlorine residual is the **DPD test**. It uses a chemical called N, N-diethyl-p-phenylene-diamine, (or DPD). DPD usually comes in the form of a white powder that is packaged in a small plastic “pillow” or a foil packet that may be torn open.

The DPD is poured into a test tube and the tube is filled to an inscribed line with sample water. In the presence of free chlorine, or chloramines, the sample will turn a pink color. The color of the sample is then compared to a colored comparator “wheel” until the hues are matched. Once this is accomplished, a direct residual reading from a scale may be obtained.

The DPD packets are labeled “Free” and “Total”. If free available chlorine is all that needs to be measured, that packet is used. Typically the operator mixes the test tube as described above and waits one minute to observe the reading.

The other packet labeled “Total” produces a hue that is developed from both free chlorine and chlorine that has combined with ammonia and formed one of three types of chloramines.

Chloramines have a far less disinfectant potential than free chlorine, but are nevertheless able to kill pathogenic organisms in water. This test is usually timed for three minutes before the reading is taken.

4.1.4 - Chlorine MRDL

Chlorine has a **Maximum Residual Disinfectant Level (MRDL)** of 4 mg/L as measured in any form. Concentrations in excess of this amount must be reported as an MCL (Maximum Contaminant Level) violation for “other chemicals”. It should be noted that “swimming pool water” is typically in the 1-2 mg/L range and that customer complaints would likely increase dramatically before the MRDL is reached. These kinds of high levels are usually a result of equipment malfunction or a major mistake in mixing of the chlorine solution.

Maximum Residual Disinfectant Level (or MRDL) = 4 mg/L

MCL > 4 mg/L

4.1.5 - Chlorine Demand

Chlorine demand, or chlorine uptake, are terms used to describe the reduction of chlorine residual due to chlorine combining with or being "used" by contaminants or chemicals in the water.

When this occurs, the amount of chlorine in the water available to kill pathogenic organisms decreases. Chlorine has a high affinity for combining with commonly found compounds such as Calcium, Sodium, Potassium, Manganese and Iron and Hydrogen Sulfide.

Demand is usually expressed in "milligrams per liter per hour-period". Often, a curve develops and in a high demand condition you might see a reduction of 0.2 for in the first 4 hours, 0.1 in the next 6 hours, and perhaps and additional 0.1 or less per 24 hours after that.

In a small system, assume a pump produces 50 gpm into a storage tank that normally holds water for 12 hours at normal flows. The dose rate of a given strength of chlorine solution may be calculated to achieve a target residual of, say, 0.07 mg/l, which at normal flows maintains a residual everywhere in the system. *See Section 4.4.2: Chlorinator Math for formulas and examples.*

The operator, through investigative testing, may find that during periods of low flow, the residual begins to drop over time and at the farthest end of the water system the residual disappears.

This dissipation of chlorine is due to uptake (demand). To compensate for the uptake, the initial dose rate may need to be increased, or perhaps, artificial movement of the water is needed through flushing.

4.1.6 - Breakpoint Chlorination

In water that has a high chlorine demand it is possible to see residuals decline over time. Increasing the chlorine dose to compensate will produce an occurrence called **"breakpoint chlorination"**. What this means is that once the chlorine demand has been met, any addition of chlorine will be free and available in direct proportion to the amount added. Once the "breakpoint" is reached, the operator will generally see a sudden increase in chlorine measurements as shown in the diagram below.

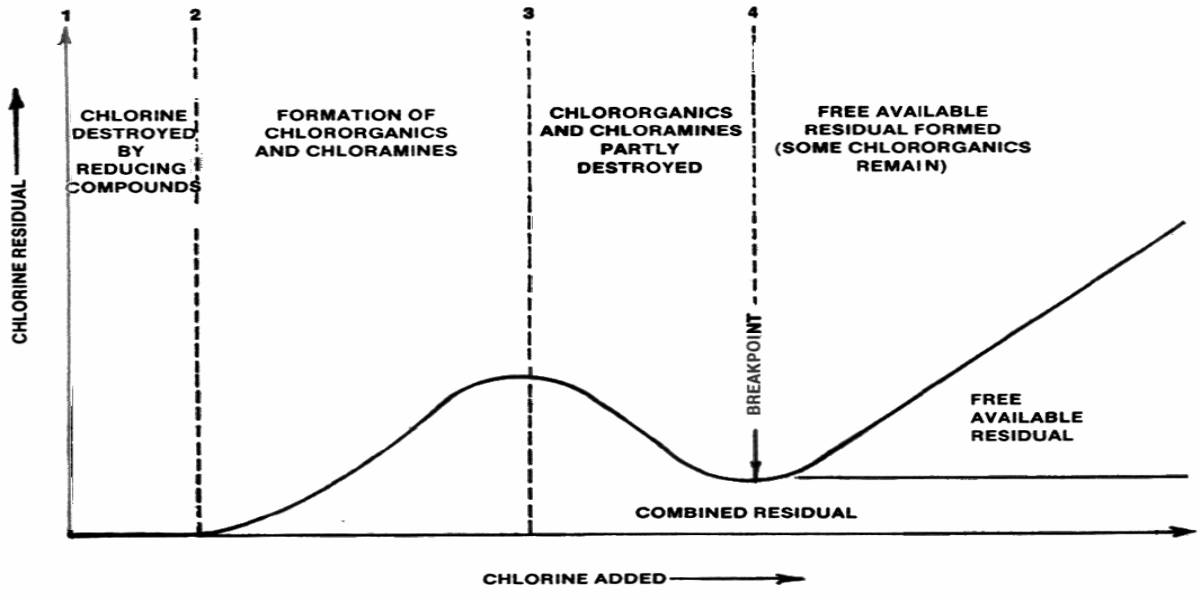


Figure - Breakpoint Chlorination

4.1.7 - Storage Limitations and Safety Concerns

Chemicals should be stored in a secure storage site that doesn't get too hot and is adequately ventilated to prevent concentration of fumes.

You should have a chemical apron, gloves and safety glasses or a face shield when handling chemicals. Also important is to have an eyewash station available. Store only a reasonable amount of chemicals and make sure you have the Material Safety Data Sheets (MSDS) sheets.

BE SAFE! Note the hazards associated with "ordinary" household bleach. (See MSDS excerpt for 5.25% Sodium Hypochlorite at the end of this section).

You can purchase pre-packaged kits that may be hung on a wall, making them easily available in the event of a mishap. Make sure all chemicals are properly labeled and MSDS sheets are close at hand in case of emergency.

Another consideration is to only store a reasonable amount of chemicals. Storing two month's worth of chlorine rather than a year's worth ensures the effectiveness of the chlorine and lessens the overall danger of having excess chemicals in the storage area.

Dilution life is dependent on a number of factors and may vary from manufacturer to manufacturer. Generally speaking, storage times, the temperature in the storage area, impurities in the water and in some cases, exposure to sunlight, are the most common forces that reduce dilution strength. You should ask your chemical supplier for specific information on how to maximize the effectiveness of the chemicals you are using over time.

A common measure of chemical stability is called the "half-life" which is the time it takes to reduce the effective strength of a chemical by one-half.
Material Safety Data Sheets (MSDS) also describe stability. The half-life table shown below was provided by a supplier for 12.5% Bleach.

Table - Half Life Table for 12.5% Sodium Hypochlorite

Degrees F	Number of Days
77°	220
87°	110
97°	55
107°	27

As you can see, the higher the storage temperatures the shorter the time it takes to naturally reduce the strength of chlorine by one-half.

4.1.8 - Cleaning and Disposal Issues

Chemical feed tanks are usually made from a chemically inert substance, commonly polyethylene, and require very little maintenance. However, the chemicals in the solution and the quality of the water may require periodic cleaning of the tank by the operator.

For example, bleach coming into contact with impurities in the water, especially iron or manganese, may produce a precipitate in the tank that must be removed. Other chemicals produce precipitates that must also be removed.

Usually, the tank will be kept in operation and not cleaned until there is a small amount of solution that needs to be discarded.

When it is time to clean the tank, closely follow the directions in the MSDS. The MSDS should have been provided when you purchased the chemical. Often, the solution may be poured back into the original container and returned to the supplier for disposal.

Another option may be to take it to the hazardous waste section of your community landfill. Check with those responsible for landfill operations to determine if your waste can be accepted. In all cases, contact the chemical supplier or read the MSDS sheet before discarding chemicals.

Again, the MSDS sheets will describe the safety considerations needed prior to scrubbing the solution tank. These instructions should be carefully heeded to ensure the safety of you, the operator.

Sample MSDS Sheet

5.25% Sodium Hypochlorite

========== Hazards Identification ==========

Effects of Overexposure: SKIN AND EYE IRRITANT: MAY CAUSE BURNS AND/OR RASH ON SKIN AND MUCOUS MEMBRANES. BLEACHES SKIN AND HAIR.

========== First Aid Measures ==========

First Aid: EYES: FLUSH EYES WITH FLOWING WATER FOR AT LEAT 15 MINUTES. GET PROMPT MEDICAL ATTENTION. SKIN: IMMEDIATELY REMOVE CONTAMINATED CLOTHING AND WASH EXPOSED AREA WITH LARGE AMOUNTS OF WATER. THOROUGHLY WASH CONTAMINATED CLOTHING BEFORE WEARING AGAIN. INGESTION: MAY CAUSE NAUSEA & VOMTIING. GIVE 2-3 GLASSES OF WATER OR MILK ONLY. DO NOT CAUSE VOMITING. SEEK MEDICAL ATTENTION IMMEDIATELY IF EXPOSED. INHALATION OF CONC. VAPORS: REMOVE FROM EXPOSURE. GIVE MOIST OXYGEN. CPR CAN BE GIVEN IF NEEDED OR BREATHING PROBLEMS DEVELOP. TRANSPORT TO A HOSPITAL.

========== Fire Fighting Measures ==========

Extinguishing Media: FLOOD WITH WATER
Fire Fighting Procedures: WHEN FIGHTINF FIRE WEAR APPROVED RESPIRATOR, FLAME RESISTANT CLOTHING AND EYE PROTECTION.
Unusual Fire/Explosion Hazard: COOL CONTAINERS TO PREVENT RUPTURE AND RELEASE OF CHLORINE GAS.

========== Accidental Release Measures ==========

Spill Release Procedures: WASH SPILLS WITH PLENTY OF WATER INTO A HOLDING TANK FOR NEUTRALIZATION AND DISPOSAL. USE LOW PRESSURE WATER SPRAY. OBSERVE

LOCAL, STATE AND FEDERAL REGULATIONS FOR PROPER DISPOSAL PROCEDURES.

===== Exposure Controls/Personal Protection =====

Ventilation: LOCAL VENTILATION NECESSARY
Protective Gloves: RECOMMENDED
Eye Protection: SAFETY GOGLES/GLASSES
Supplemental Safety and Health
VAPOR DENSITY: HEAVIER THAN AIR.WT PER GALLON: 8.04 LBS. THIS PRODUCT IS A COMBUSTIBLE LIQUID CLASS II.

========== Physical/Chemical Properties =========

Boiling Pt: 35.C, 95.F
B.P. Text: 95F
Vapor Pres: LIKE WATER
Spec Gravity: 1.08
pH: 11.5-12.4
Evaporation Rate & Reference: 1
Solubility in Water: COMPLETE
Appearance and Odor: THIN YELLOWISH-GREEN CLEAR LIQUID-MILD CHLORINE OR
Percent Volatiles by Volume: 89

========= Stability and Reactivity Data =========

Stability Indicator/Materials to Avoid: YES
ACID OR AMMONIA CONTAINING PRODUCTS, RUST REMOVERS, TOILET BOWL CLEANERS, FECES. DO NOT USE OR MIX WITH ANY OTHER HOUSEHOLD CHEMICALS.
Stability Condition to Avoid: REACTS VIOLENTLY WITH ORGANIC AND INORGANIC AMINES, ACIDS, AMMONIA BOWL CLEANERS, ETC.
Hazardous Decomposition Products: PRODUCES ENVOLVED CHLORAMINES AND CHLORINE GASES IF MIXED WITH AFORE MENTIONED PRODUCTS.

========== Disposal Considerations ==========

Waste Disposal Methods: DIKE LARGE SPILLS. ABSORB WITH OIL-DRI OR SIMILAR INERT MATERIAL. SWEEP OR SCRAPE UP AND CONTAINERIZE IN INERT (POLYETHYLENE) CONTAINER. RINSE AFFECTED AREA WITH WATER.

========== MSDS Transport Information ==========

Transport Information: DOT SHIPPING NAME: HYPOCHLORITE SOLUTIONS WITH MORE THAN 5 % BUT LESS THAN 16 % AVAILABLE CHLORINE. UN NUMBER: 1791. DOT HAZARD CLASS: 8

UNIT 4: Specifics for Systems with Treatment

FACT SHEET 4.2 - Chlorinator Math for Small Water Systems

4.2.1 - Purpose

4.2.2 - Calculating Pounds of Chlorine to Achieve a Residual

4.2.3 - Calculating Pump / Flow Rates

4.2.4 - Detention Time

FACT SHEET 4.2 - Chlorinator Math for Small Water Systems

4.2.1 - Purpose

If your system chlorinates, the Department requires a minimum free chlorine residual of 0.2 mg/L with a detention time of 30 minutes before reaching the first point of use in your water system.* In other words, a drop of water that has been chlorinated must stay in the reservoir (storage) or piping of the water system for at least thirty minutes before being delivered to the first customer. The higher the maximum water use, in gpm, the larger the need for storage or the combination of storage and piping. Additionally, a detectable free residual must be maintained in all points of the distribution system. A variety of calculations must be made to determine the amount of chlorine to add, and the rate at which it should be added to meet these requirements.

Many operators of small water systems know how much chlorine to add from many years of experience with chlorination at their particular systems, so why try to understand the math? Changes in your system such as system expansion, use of new equipment, changes in regulations and requirements may require revised application of chlorine.

This Fact Sheet provides an overview of common math calculations for small water systems that chlorinate.

Associated calculations are integrated throughout Unit 4 in the following Fact Sheet sections:

4.3 – Preparing Chemical Solutions: Includes calculations related to use of liquid and granular chemicals, calculating proportions for partially filled solution tank.

4.4 – Non-Gaseous Chlorinators: Provides information on calculating chlorinator settings.

4.7 – Typical Math Problems for Small Water Systems: Provides overview of basic math including understanding and converting units, application of common formulas and conversion table.

***An alternative is to calculate the contact time (CT value) to assure a 4-log inactivation of*

viruses. This method requires a Tracer Study for which you'll need professional assistance.

A Tracer Study is the verification of a hydraulic analysis using potable dyes, or in some instances, chemicals such as chlorine. If, for example, detention time in a storage tank was calculated to be 90 minutes at peak withdrawal rates, this could be verified by injecting a potable dye and noting the time of detection at the first point of use in the water system. It is possible for a reservoir to "short circuit" detention time because of the location of the supply pipe, thereby causing shorter detention times than calculated.

4.2.2 - Calculating Pounds of Chlorine to Achieve a Residual

Water systems that chlorinate must calculate the amount of chlorine needed to achieve the desired chlorine residual levels. Too much chlorine will result in taste and odor complaints, too little chlorine will be ineffective in disinfection. The **"Pounds Formula"** shown here is commonly applied to determine the desired chlorine dosage, but is also used for other chemical solutions. The formula uses the volume of water pumped in gallons in one day (the formula assumes the pump is working 24 hours), times the weight of a gallon of water in pounds, times the target residual in mg/L or ppm (remember, mg/L is equal to ppm) to calculate the pounds of available chlorine that must be added. The pounds formula is shown below:

Pounds Formula:

Flow (MG or MGD)	×	8.34 lb/gal	×	Dosage or Residual (mg/L or ppm)	=	Chemical Feed (lbs or lb/day of chlorine)

Where:

MG or MGD = Water pumped in million gallons or million gallons per day (Gallons of water pumped in one day divided by 1 million)

mg/L or ppm = Target residual (ppm = mg/L)

8.34 lbs/gal = Constant, weight of a gallon of water in pounds

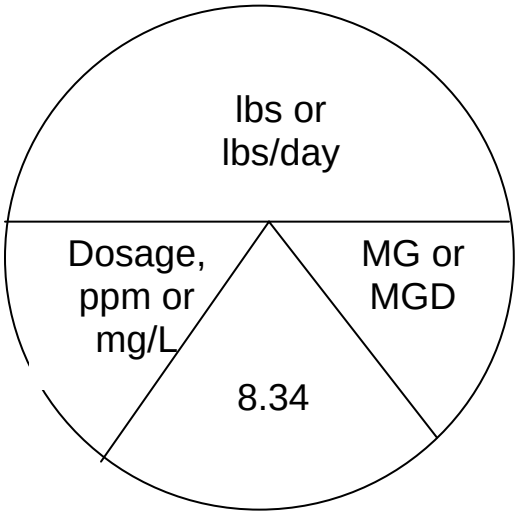
Note: *In order to use the pounds formula, the listed units must be used. Any other units (such as Cubic Feet) will not work.*

The circle diagram below can be helpful in determining the correct formula to use when trying to solve for any of the variables in the "Pounds formula." On the diagram, cover the variable that you are trying to solve for to determine the correct formula. The remaining variables will display the formula to use.

To solve for pounds: multiply (ppm)(8.34)(MG)

To solve for ppm: pounds divided by (8.84 x MG) -**or**-
pounds divided by 8.34 then divided by MG

To solve for MG: pounds divided by (ppm x 8.34) -**or**-
pounds divided by ppm then divided by 8.34



Example: 4.2.2 What is the dose rate, in pounds per day, of chlorine to be injected into water being pumped at a rate of 75 gallons per minute, to achieve a chlorine residual of 1 mg/L?

Step 1 – Convert gallons per day to million gallons per day (MGD)

$$\frac{(75 \text{ gallons/minute})(1440 \text{ minutes/day})}{1{,}000{,}000} = 0.108 \text{ MGD}$$

Step 2 – Apply formula:

(0.108 MGD) (8.34 lbs/gallon) (1 mg/L) = 0.90 lbs/day

4.2.3 - Calculating Pump / Flow Rates

Next, a series of calculations must be completed to set the chlorinator pumping rate so that adequate residual levels are maintained. From the pounds formula, the amount of chlorine in pounds per day has been determined. The next step involves calculating the pumping rate using the following formula.

Pumping Rate Calculation

$$\text{Pumping rate (gal/day)} = \frac{Cl_2\ \text{(lb/day)}}{(\%\ \text{strength}) \times (8.34\ \text{lb/gal})}$$

Where:

Pumping rate = gal/day, chlorinator pumping rate

Cl_2 = lbs/day, Required application of chlorine, given or calculated from the pounds formula

% strength = You must convert % strength to a decimal number. To do this divide the percent given by 100.

$$\textit{Example 65\%} \Rightarrow \frac{65}{100} = 0.65$$

8.34 lbs/gal = Constant, weight of a gallon of water or chlorine solution in pounds

Example 4.2.3: How many gallons per day of 6% NaOCl must be added to achieve application of 0.90 lbs of chlorine/day?

Pumping rate = (0.9) ÷ (0.06 × 8.34) = 1.8 gal/day

Use this calculation to set the chlorinator pumping rate. The chlorinator operates only when the water is flowing. If set correctly, the correct weight of chlorine will be injected to achieve the residual desired.

To meet requirements of minimum free chlorine residual of 0.2 mg/L at first point of usage and minimum detention time of 30 minutes, the volume of water in the distribution system to this first point and chlorine demand are factors to consider. Math calculations, observed results and operator experience are equal factors in arriving at the optimal solution.

In order to maintain residual levels throughout the distribution system as required, chlorine residuals in the distant portions of your water system under *low flow* conditions are essential to know. The natural dissipation of chlorine, as well as any chlorine demand may require the operator to increase chlorine doses. If the dose becomes too large, customer complaints may increase. Reducing dose rates and a flushing program to direct the water to low flow areas may then be necessary.

4.2.4 - Detention Time

As already noted, the Department requires a minimum detention time of 30 minutes before reaching the first point of use in your water system. The detention time calculation is used to determine the theoretical amount of time that a drop of water stays in a storage tank. It can also be used to calculate how long it takes to empty or drain a tank (or basin, etc.). The size of the reservoir in gallons divided by the maximum demand flow determines the minimum detention time the water will remain in the storage tank. The calculation is as follows:

Detention Time Formula

(DT) = volume (V) ÷ Flow (Q)

Where:

DT = Detention time (unit will depend on flow, if using MGD the answer will be in days, if using GPM the answer will be in minutes etc)

V = Volume, typically in gallons or MG in larger systems

Q = Flow, typically in gallons per minute (gpm), or million gallons per day (MGD) in larger systems.

Example 4.2.4: What is the detention time in a basin that has a volume of 10,000 gallons and a flow of 120 gpm?

DT = 10,000 gals ÷ 120 gpm = 83 minutes

Convert to hours: 83 minutes ÷ 60 min/hour =1.4 hours

UNIT 4: Specifics for Systems with Treatment

FACT SHEET 4.3 - Preparing Chemical Solutions

4.3.1 - Using Liquid Chlorine

4.3.2 - Using Granular Chemicals

4.3.3 - Calculating Proportions for a Partially-Filled Solution Tank

4.3.4 - How to Fill and Mix

4.3.5 - Disinfection Tables

FACT SHEET 4.3 - Preparing Chemical Solutions

4.3.1 - Using Liquid Chlorine

For systems that chlorinate, sodium hypochlorite, (NaOCl or "bleach") is most commonly used. The amount needed will depend on the strength of the chlorine solution. Typically, either 5%, 6% or 12.5% NaOCl will be used. Remember, all chemical injections into potable water must be certified for use in potable water, usually shown by a "NSF" (National Sanitation Foundation) symbol.

Using Undiluted Chemical Solutions

In determining the amount of chemical solution to apply, the weight of chlorine per gallon of solution must first be calculated. Even though the weight of NaOCl is a little heavier than water, the pounds of chlorine in a gallon can be determined by multiplying the constant, 8.34 lbs/gallon, times the percent strength of solution, as follows:

8.34 lbs/gal × % strength = lbs chlorine/ gallon

Note: % strength must be converted to a decimal. To do this, divide percentage by 100.
Example 12.5% $\Rightarrow$ *12.5 ÷100 = 0.125*

Subsequent adjustments to "tweak" residuals will almost always be needed, regardless. Determined from the pounds formula (See Fact Sheet 4.2, *Chlorinator Math*) we know how to calculate the pounds of chlorine needed per day to reach target residuals. From this information we can derive the gallons of solution to add per day, as shown in the Example 4.3.1-2, below.

Example: How many gallons per day of 6% NaOCl are needed to treat a flow of 105 gpm with a dosage of 1.2 mg/L?

Step 1 – Convert gpm to GPD.

$$\frac{105 \text{ gpm} \times 1440 \text{ min/day}}{1{,}000{,}000} = 0.15 \text{ MGD}$$

Step 2 - Calculate the chlorinator setting, in pounds per day.

MGD × mg/L × 8.34 lbs/gal = lbs/day
0.15 MGD × 1.2 mg/L × 8.34 = 1.5 lbs chlorine per day

Step 3 - Determine the pounds of chlorine per gallon of 6% NaOCl.

8.34 lbs/gal × % strength = lbs chlorine/gal
8.34 × 0.06 = 0.5 lbs chlorine/gal

Step 4 - Calculate the number of gallons needed per day.

Lbs chlorine/day ÷ lbs chlorine/gal= gal of solution/day
1.5 lbs chlorine/day ÷ 0.5 lbs chlorine/gal = 3 gal/day

Using Diluted or Mixed Chemical Solutions

When mixing any liquid chemical with water, further calculations must be applied. Solutions are composed of a solute and a solvent (SOLUTION = SOLUTE + SOLVENT).

The **solute** part of the solution is dissolved in the **solvent**. The solute in chlorination problems is the hypochlorite and the solvent is water. In water treatment, the most common solvent is water.

Mixed solutions may also be expressed as a ratio where two volumes ingredients are compared to one another.

Adding the two numbers in the ratio together gives the total volume of the solution. For example, one gallon of bleach added to two gallons of water would be a 1:2 ratio and a total solution volume of three gallons.

When working with diluted chlorine solution the following formula may be used to determine the pounds of chlorine per gallon of solution.

$$8.34 \text{ 1b/gal} \times \% \text{ strength} \times \frac{\text{Weight of Solute}}{\text{Weight of Solution}} = \text{lbs chlorine/gal solution}$$

Where:

% strength = % strength must be converted to a decimal.
To do this, divide percentage by 100.
Weight of Solute = Proportion or weight of hypochlorite solution
Weight of Solution = Proportion or weight of solute (e.g. hypochlorite solution) plus solvent (e.g. water)

Example: How many gallons per day of 1:2 diluted mix of 6% NaOCl and water are needed for a chlorine application of 3 lbs/day?

Calculate pounds of chlorine in 1 gallon of 1:2 solution of 6% NaOCl and water.

$$8.34 \text{ 1b/gal} \times \% \text{ strength} \times \frac{\text{Weight of Solute}}{\text{Weight of Solution}} = \text{lbs chlorine/gal}$$

$$8.34 \times 0.06 \times \frac{1}{(1+2)} = 0.17 \text{ pounds/gal}$$

Step 2 - Calculate the number of gallons needed per day.

3 lbs chlorine/day ÷ 0.17 lbs chlorine/gal = 17.7 gal/day

For more on working with proportions see *Fact Sheet 4.3.3 - Calculating Proportions for a Partially Filled Solution Tank*.

4.3.2 - Using Granular Chemicals

Some systems use granular chemicals, such as Calcium Hypochlorite ($Ca(OCl)_2$). This is a very concentrated form of chlorine compound and safety should be carefully observed. Material Safety Data Sheets (MSDS) are available from your chemical supplier, and are also available online at websites (just enter MSDS). The $Ca(OCl)_2$ label will indicate chlorine strength stated as a percentage, often 65%. This indicates the available chlorine by weight, when mixed with water.

Weighing any dry chemical to be added to a gallon of solvent, and then multiplying the observed weight by the percentage of available chemical, will give you the weight of that chemical per gallon of solution.

lbs dry chemical × % strength = Lbs of Chlorine/gallon

Example: How many pounds of chlorine are available when one pound of 65% $Ca(OCl)_2$ is mixed in 1 gallon of water?

lbs $Ca(OCl)_2$ × % strength = Lbs of Chlorine/gallon

1lb $Ca(OCl)_2$ *× 65% = 0.65 lb of available* Cl_2*/gal*

Once you have determined the weight to be added to each gallon of water to make your solution, you must accurately measure or weigh the chemical to be added. In small systems, the solution tank usually is made of polyethylene and has gallons marked on the side of the tank. This is accurate enough for adding liquids such as bleach, calculated out to ½ gallon of chemical. If you need to add smaller measurements, you should have a graduated cylinder or beaker to first pour the chemical into for measurement.

Dry chemicals should first be weighed on an accurate scale that may be purchased through almost any chemical supplier. The chemicals are poured into a container approved for the task, weighed, and then added to the solution.

4.3.3 - Calculating Proportions for a Partially-Filled Solution Tank

Below is a very common example of how an operator may need to calculate proportions for a partially filled solution tank.

Example: If a 30 gallon solution tank has 8 gallons of a 1:3 mix of 6% bleach and water remaining, what is the amount of bleach and water needed to refill the tank?

Step 1– Calculate the total solution volume in gallons.

1 gal bleach + 3 gal water = 4 gal

Step 2 – Divide the remaining volume to be filled by the total solution volume calculated in step 1.

Remaining volume to be filled: 30 gallons – 8 gallons = 22 gallons

$$\frac{22\ gal}{4\ gal} = 5.5$$

Step 3 – To arrive at the proportional volumes, multiply the proportion used by 5.5, in this case, 1 gallon of bleach to 3 gallons of water.

1 × 5.5 = 5.5 gal bleach
3 × 5.5 = 16.5 gal water

This represents the 1:3 mixture to achieve 22 gallons of solution.

4.3.4 - How to Fill and Mix

As always, contact your supplier for advice and read the MSDS sheets. When mixing chemicals it is suggested you ALWAYS add the water first, and then the chemicals. Generally, you should have an apron, a face shield (at least eye goggles), and appropriate gloves for the type of solution. These may be purchased at any supply house. A short word on safety: It is always a very cheap investment that yields BIG dividends….BE SAFE!!

Mixing is important in most solutions. For many chemicals there is a designated mix time before injection into the water system. Mixing may be accomplished by hand using an inert mixing paddle, or perhaps you have a propeller mixer installed on the solution tank. Some systems have timers on the mixer and others are all done manually. As usual, ask the supplier for advice and read the instructions!

4.3.5 - Disinfection Tables

Occasionally, groundwater systems will need to chlorinate to eliminate organisms which may have entered through the source. The Department recommends that a solution consisting of 50 ppm chlorine be used when disinfecting wells. This solution should stand for 24 hours and then be pumped to waste.

Department rules require disinfection after the installation of new water lines or repairs to old lines. A solution of at least 25 ppm chlorine shall be injected into the line with no less than 10 ppm free chlorine residual measured after a minimum of 24 hours. For each 100 gallons of water in a pipe, add one cup of 5% bleach, or 1/2 ounce of 65% calcium hypochlorite to achieve a disinfection dose of 25 ppm. A 50 ppm residual would be half this dose.

To calculate the volume of water in pipes or wells to be disinfected, use the following table. To compute water volume in wells, the distance from the surface to the water level and the depth of the well must be known.

Main diameter, inches	Gallons/foot of length
2	0.16
4	0.65
6	1.5
8	2.6
10	4.1
12	5.9

Adding extreme amounts of chlorine to wells is ***not*** recommended. Concentrated dosages of chlorine may actually prevent effective disinfection by causing "hardening" of the surface of bacterial colonies which may then prevent the chlorine from penetrating, and damage to equipment might occur.

UNIT 4: Specifics for Systems with Treatment

FACT SHEET 4.4 – Non-Gaseous Chlorinators

4. 4.1 - Diaphragm Pumps

4.4.2 - Peristaltic Chlorinators

4.4.3 - Use of Calibration Cylinders

FACT SHEET 4.4 – Non-Gaseous Chlorinators

Pumps are typically used to inject chlorine into the water. Most small water systems use either a diaphragm pump, or a peristaltic type pump. Both types of pumps are positive displacement and must be sized for both pumping rate and pumping pressure. The mechanics of each type of pump is further explained in this fact sheet.

4.4.1 - Diaphragm Pumps

This design is common and has been used for many years to inject a variety of chemicals. The working part of the pump is an oscillating rod that flexes a diaphragm located in a pumping cavity. The pumping cavity has a check valve on both the supply (intake) side and discharge side. As the diaphragm flexes in one direction, the supply side valve opens and the discharge side valve closes, allowing solution into the chamber. When the rod moves in the return direction, just the opposite occurs and the solution is pumped out of the chamber. Anyone using this style of pump will become accustomed to the “click-click” operating sound when the pump runs.

Calculating Chlorinator Settings

To determine the pumping rate of a chlorinator first calculate how much chlorine, by weight, must be injected into the water flow, and how many gallons of solution must then be injected to attain this dose rate. Using this information apply the following formula to determine the desired pumping rate in gallons per day.

$$\frac{\text{lb Cl/day}}{\text{lb available Cl/gal sol.}} = \text{pumping rate, gal/day}$$

Since the chlorinator should only operate when the water is flowing, calculations are based as if the water flows for 24 hours, or a “per day” basis. If the water flow stops, the chlorinator stops so the dose rate of chlorine is always even.

Since the pumps are adjustable in the length of stroke (distance the oscillating rod moves), and the speed (frequency of the stroke) care is needed in calculating the pumping rate.

There are two dials on the face of diaphragm pumps, each with a reading of 0-100%.

The data plate contains information such as the model and the discharge pressure, which is extremely important. You must have a higher discharge pressure than the maximum static pressure in the system at the point of injection! A good rule of thumb is to have a pump capable of 25% higher pressure than the water system at the point of injection.

Also very important, the data plate will show the liters per day (l/day) or gallons per day (gpd) the unit will pump if it were to run for 24 hours with both length of stroke and speed set at 100%. As shown below, multiplying the percentages of both the stroke and speed times the maximum pump rate per day

% Stroke × % Speed × Maximum pumping rate = Actual Pumping Rate shown on the data plate

indicated on the data plate will result in a flow rate for any given setting.

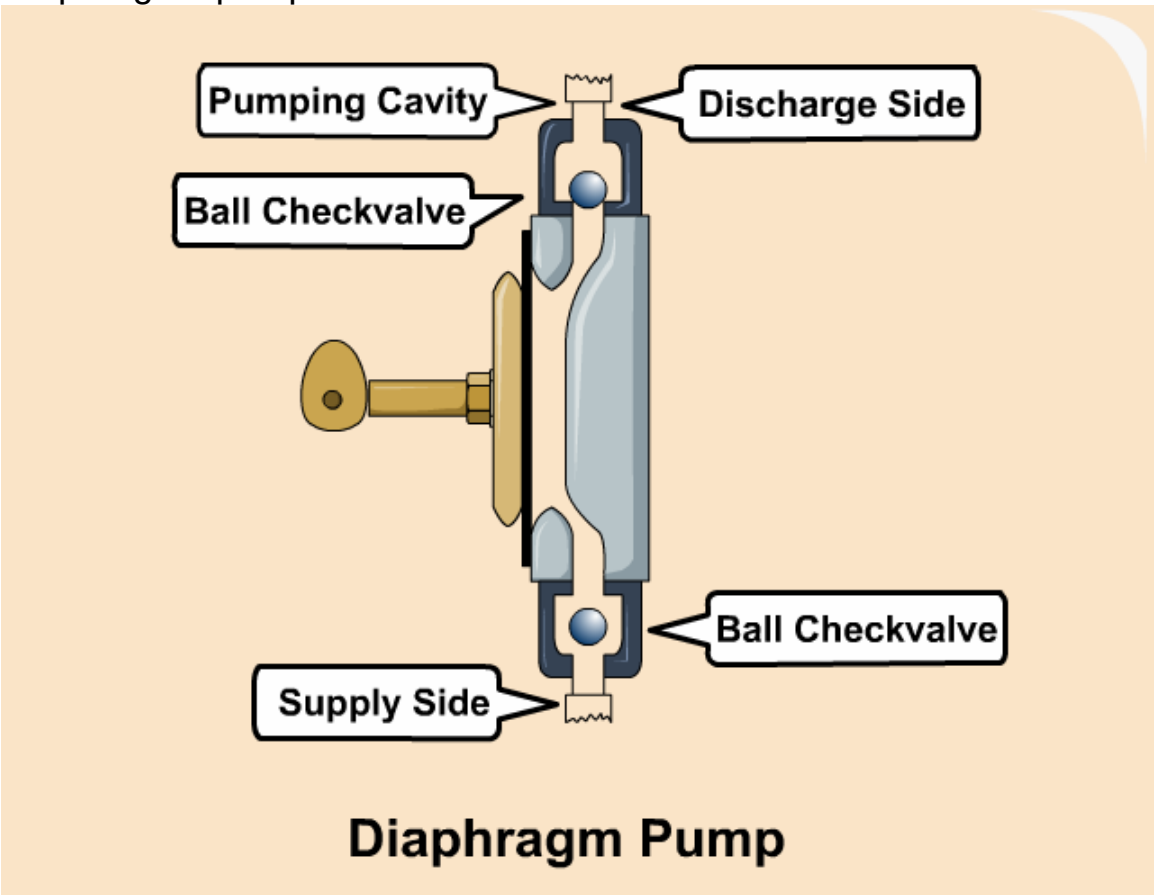
For example, if the data plate indicates the unit can pump 15 gallons per day, and one dial is set at 50%, and the other at 100%, then the total volume that could be pumped will be 50% of the data plate, or 7.5 gallons per day.

If the both dials are set at 50%, the volume pumped would be 25% of the data plate, or 3.75 gallons per day.

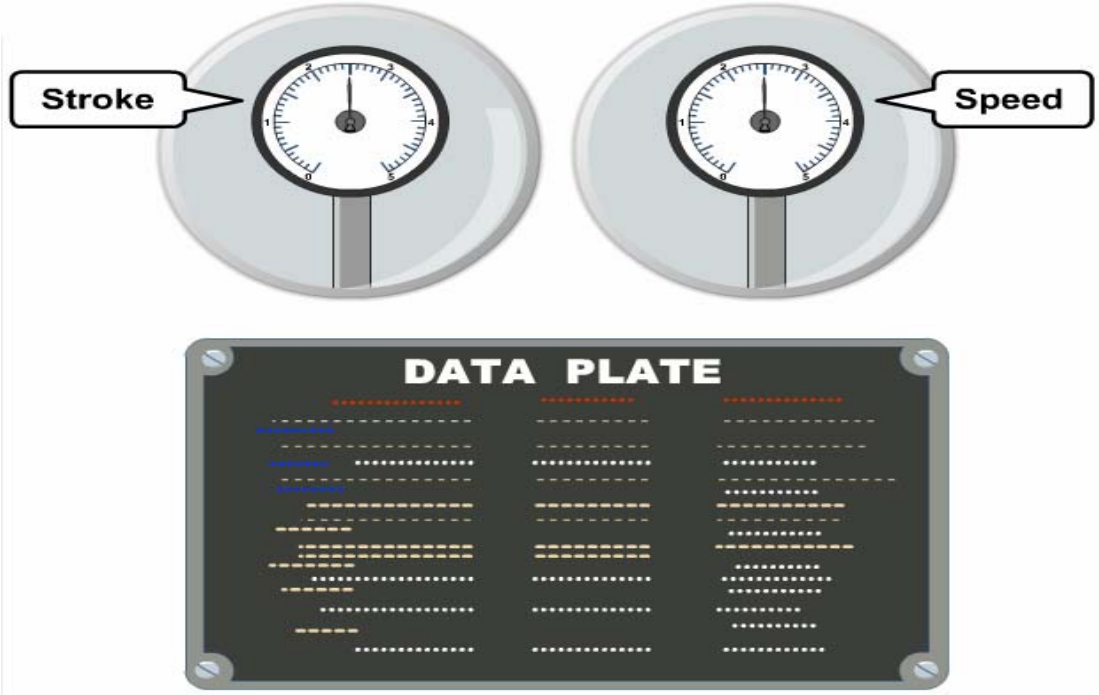
Diaphragm pumps usually have a colored “caution” range indicated on the dial for the lower percentage settings. Because accuracy is less when using the lower ranges, it is desirable to keep the normally used stroke and speed in the middle settings.

This is a consideration when purchasing chlorinators. A typical practice is to keep one of the ranges on the low side, say the stroke, and keep the speed on the higher side for better accuracy.

Diaphraghm pump.



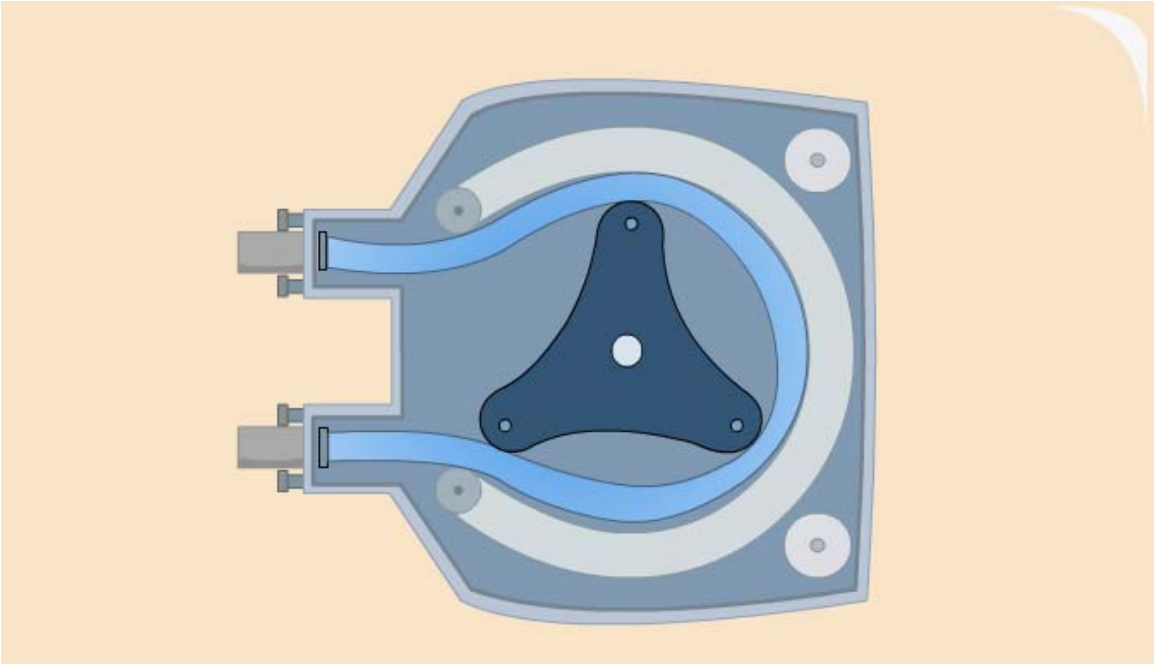
Pump control dials and data plate.



4.4.2 - Peristaltic Chlorinators

Even though they are currently slightly more expensive than the diaphragm types, peristaltic chlorinators are gaining favor due to ease in calculating dosage rates and the fact that they have fewer parts to maintain. These chlorinators have a flexible tube that enters a circular race. There are usually three and sometimes four rollers that compress the tubing and push the solution along into the system. There are no check valves or small components to get fouled by chemical deposits. The face of the pump has a data plate and a speed dial expressed in percent. If the data plate indicates the unit can pump 15 gallons per day, this is the pumping rate when the speed is set at 100%. When the speed is set at 50%, the pumping rate will be 50% of 15 gallons per day equal to 7.5 gallons per day, and so forth.

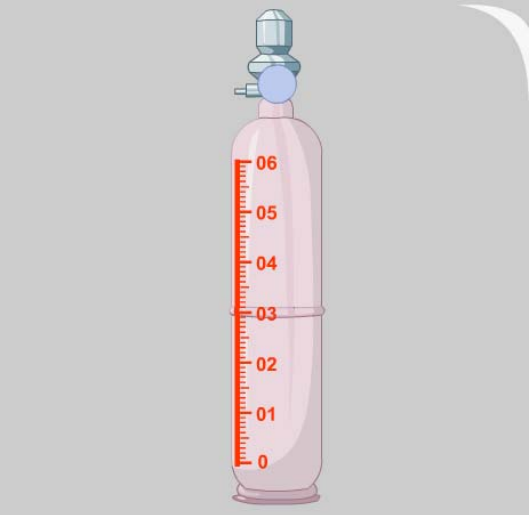
Peristaltic Chlorinator.



4.4.3 - Use of Calibration Cylinders

Graduated calibration cylinders are useful in checking the accuracy of the calculated pumping rate of diaphragm or peristaltic pumps. A calibration cylinder is typically a glass or plastic cylinder with markings denoting mL (milliliters) or ounces. Once the pump settings have been calculated, the pump is turned on and the chemical solution being pumped is directed into a graduated cylinder.

The time it takes to reach a given measurement is noted, and then this may be converted to check the pump rate. For example, if 16 ounces of solution is pumped every 30 minutes, convert this to gallons per day by completing the following steps:



Calibration Cylinder

STEP 1: Calculate the number of possible test periods in one day. Use the conversion factor 1 day = 1440 minutes.

1440 minutes/day ÷ 30 minutes/test period = 48 possible periods

STEP 2: Calculate the gallons of solution pumped per day using the number of possible test periods determined in step 1. Use the conversion factor 1 gallon = 128 ounces.

(48 periods × 16 oz. pumped/period) ÷ 128 oz. /gal = 6 gal of sol./day

This calculated value may then be compared to the data plate pumping prediction.

UNIT 4: Specifics for Systems with Treatment

FACT SHEET 4.5 - Maintenance and Troubleshooting of Chlorinators / Associated Equipment

4.5.1 - Planning for Maintenance and Repair

4.5.2 - Common Chlorinator Problems and Solutions

4.5.3 - Air Relief and Backpressure

4.5.4 - Calibration

FACT SHEET 4.5 - Maintenance and Troubleshooting of Chlorinators / Associated Equipment

An on-going preventative maintenance program is the key to minimizing operational problems and getting the full life out of your equipment. By taking the time to periodically check equipment and make the needed repairs, significant dollars are saved in reduced repair and replacement costs. In addition, equipment failure events are minimized which protects public health. This section provides tips on maintaining chlorinators and associated equipment, and also provides a brief overview of common problems and solutions.

4.5.1. Planning for Maintenance and Repair

Whenever chemicals are injected into a water system, there's going to be ongoing maintenance. Planning for maintenance and repair is critical. Inventory all equipment and keep records located for quick access in the event of an emergency. Keep essential replacement parts on hand, or know where to purchase them on short notice. In the case of chemical pumps, the repair parts are relatively inexpensive and the shelf life is long. Most small groundwater systems use diaphragm or peristaltic pumps, so a standard pump repair kit, which includes the diaphragm, ceramic check balls, spare tubing or rollers etc., should be readily available. Have basic repair instructions for the specific equipment on hand.

4.5.2. Common Chlorinator Problems and Solutions

The fact that the chlorinator pump is making noise is a signal that something is wrong. Chlorinator pumps should be carefully checked daily.

Note any changes in the volume of solution pumped, the sound of the pump and any decline in chlorine residuals in the distribution system. If pumps are checked and residuals measured routinely, the need for maintenance will be apparent almost immediately. If the chemical feed operation is not performing and signs of leakage are obvious, preventative action is required.

In the case of *diaphragm chlorinators,* it is common to see check valves clogged. Naturally occurring metals such as calcium, iron, manganese, or potassium readily combine with chlorine to form salts that can clog and cause equipment to deteriorate and fail prematurely.

Peristaltic pumps do not usually have this problem. Follow the manufacturer's instructions for cleaning. The cleaning itself is generally accomplished with a clean rag or stiff brush, but the pump's electrical circuit should be isolated, appropriate safety gear should be available, and proper procedures followed. Most manufacturers recommend that you NOT to use mechanical tools on the connections and tubing, but rather that you hand-tighten connections instead. Care must be taken to protect the ceramic check-balls located within the check-valves.

If the pump design does not feature a valve to permit the chlorine solution to be returned to the solution tank or to any other receptacle, one should be installed. This feature allows visual observation of the pumping process. Often the valve is located on the discharge side of the pump, or may be installed in the discharge tubing at the solution tank.

Diaphragm pumps usually have a small ceramic ball inside the one-way check valves. These valves may clog from time to time and the pump may be cycling but not actually pumping.

If the pump is not working correctly, and the check-valves do not appear clogged, the diaphragm may have a tear or

small hole. In this case, the pump will sound as if it is operating, but will not be pumping.

Peristaltic pumps have the advantage of less moving parts. Sometimes a check valve may be found on the discharge side of the pump. A frequent problem encountered will be failure of the flexible tubing. Depending on where it occurs, in the tubing, there could be a leak or no pumping at all. The correct diameter and material of the replacement tubing is critical for proper pump function.

If the wall diameter is not correct, the pump may not produce accurate volumes pumped and the improper material may fail early. When investigating pumping operations, check the condition of the rollers to ensure there are no cracks or uneven spots.

4.5.3. Air Relief and Backpressure

From time to time air may enter the chemical feed tubing and cause uneven dose rates, or even air “binding”, in which case there is no movement of solution.

Shutting the pump to the OFF position and opening the discharge valve to the solution tank, may allow system pressure to purge the feed tubing to correct this problem. Pump discharge pressure must be higher than the system pressure at the point of injection. Water pressure approaching the pump’s maximum pressure (e.g., filling a reservoir or pumping into a pressurized tank) could cause uneven chemical dosage.

To avoid this situation, size the pumps with at least a 25% higher discharge pressure than the maximum water head to pump against.

4.5.4. Calibration

Chemical feeders cannot simply be set and then expected to operate accurately without periodic checks. Maintaining a routine calibration schedule ensures that maintenance issues can be addressed (e.g., a pump wearing out) before there is an impact on the chlorine residual. Pump calibration should be checked monthly at a minimum. Some situations require weekly or even daily calibration checks.

UNIT 4: Specifics for Systems with Treatment

FACT SHEET 4.6 - How to Measure pH

4.6.1 - Measuring pH and Typical Test Equipment

4.6.2 - Use of pH Standards to Assure Accuracy

4.6.3 - Calibration with Proper Span

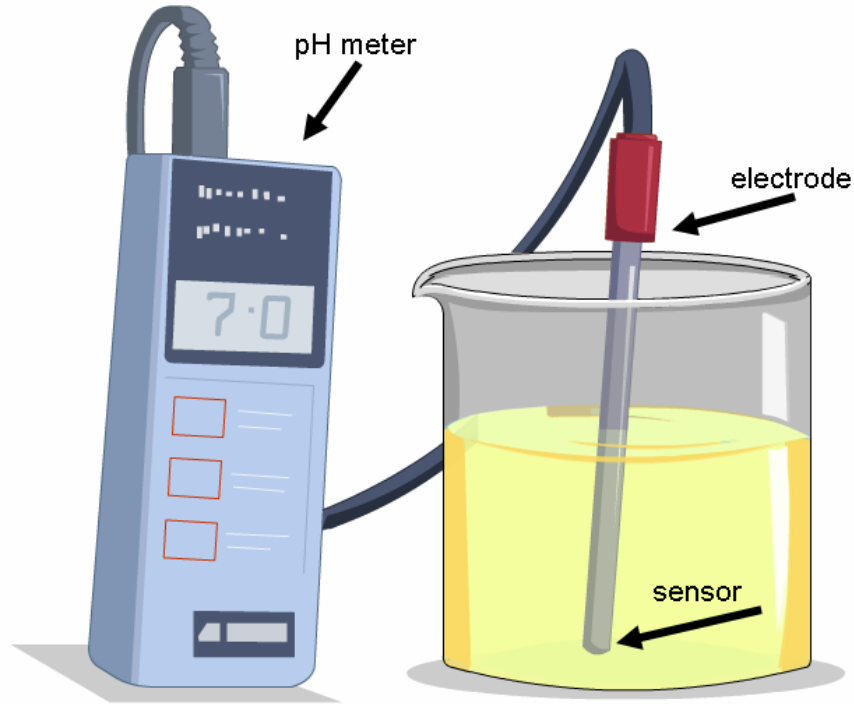
4.6.4 - Lifespan of pH Probes

FACT SHEET 4.6 - How to Measure pH

4.6.1 - Measuring pH and Typical Test Equipment

pH (pronounced as separate letters) is a measure of the acidic or basic condition of a liquid. The pH range is from 0-14, with 0 the most acidic and 14 the most basic. A pH of 7 is considered neutral. pH is an important factor in water treatment and effects coagulation, disinfection and the ability of water to become saturated by certain chemicals such as calcium and magnesium. pH is important in water softening and corrosion control efforts. pH control may even be used as a method of corrosion control. Depending on the type of treatment applied, daily pH measurements may be required.

A variety of makes and models of pH meters are available. pH meters consist of a measurement box which gives a pH reading and contains the calibration controls, and an electrode or probe (a short, narrow tube with a sensor at the tip) that is inserted into the water sample for measurement. The probes are particularly sensitive and require proper calibration, cleaning, and storage are described in the following sections.



4.6.2 - Use of pH Standards to Assure Accuracy

Prior to the testing of water samples, the accuracy of pH meters is determined using "standard" solutions, often called "pH buffers". These buffers are color coded. The following color coding is most commonly used: Red (pH 4.01), Yellow (pH 7.0) and Blue (pH 10.0). To test the probe's accuracy, it will be placed in a standard solution and the read-out adjusted to achieve the appropriate indication on the dial. A typical calibration method using two standard solutions is described next in 4.6.3 - Calibration with Proper Span.

4.6.3 - Calibration with Proper Span

All pH electrodes require calibration prior to use. A two point calibration characterizes an electrode with a specific pH meter. Once an electrode is characterized, the electrode/meter pair can be used to determine the pH of a solution. The buffers should "bracket" the expected sample pH. The step-by-step procedure outlined below is the most common method used to perform a two point calibration. A 7.00 pH buffer solution and a 4.01 pH buffer solution are used in the description below.

1. All equipment, buffers and samples should be as close to the same temperature. Rinse the electrode thoroughly with de-ionized (DI) water to remove all traces of storage solution, process medium or previous test solution. Thoroughly rinse the electrode after each buffer test to prevent carry over contamination of the pH buffer solutions. Gently blot the electrode on a soft tissue to remove the excess rinse water. Do not rub the bulb since it can cause a static charge build-up.
2. Insert the electrode and the automatic temperature compensator (ATC) in 7.00 pH buffer solution. Allow 30 seconds for the electrode/ATC to reach thermal equilibrium with the buffer solution. Adjust the pH meter with the "standardize/zero" control for a pH indication equal to 7.00.

   Note: If the meter does not have an ATC, place a thermometer along with the electrode in the 7.00 pH buffer solution. Allow 30 seconds for the pair to reach thermal equilibrium with the buffer. Adjust the temperature dial on the meter to correspond with the thermometer reading. Then adjust the pH meter with the "standardize/zero" control for a pH indication equal to 7.00.
3. Repeat Step 1, and insert the electrode and the ATC in a 4.01 buffer solution. Allow 30 seconds before adjusting the pH meter with the slope/span control for a pH indication equal to 4.01.

4. Repeat Steps 2 and 3 to maximize the precision of the calibration.

Notes:

a) Always use fresh pH buffer solutions for the most accurate results.

b) A 10.00 pH buffer solution may be substituted for the 4.01 pH buffer solution in Step 3. All pH buffer solutions above 7.0 pH are less stable and have a limited life. These high pH buffers will more readily absorb carbon dioxide from the atmosphere and will typically change to a lower pH value when left open. For this reason, a 4.01 buffer solution is recommended to perform a reliable two point calibration. Also, the buffers should bracket the desired pH range.

c) When a pH electrode is calibrated with an auto-calibration meter, consult the meter's operation manual for the required calibration procedure.

4.6.4 - Lifespan of pH Probes

The lifespan of pH probes or electrodes is directly linked to how well they are maintained. Maintaining the proper electrode solution level inside the probe, rinsing and storing correctly, and preventing hard knocks will achieve optimum life. However, even when well-cared for, the typical life cycle of a probe is in the 2-3 year range. This should be planned for early in the utility's budget process. Some suggestions for care follow.

Storing

The sensor should never be stored dry. Always keep pH electrodes moist. Proper pH electrode storage maximizes electrode performance and extends electrode life. It is best to store electrodes in clean containers filled with pH storage solution or in a pH 4 buffer. Do not store an electrode in distilled or de-ionized (DI) water - this will cause ions to leach out of the glass bulb and render the electrode useless.

Cleaning

The solution used to clean pH electrode depends on the presence of possible contaminants. Mechanically intact electrodes may show slow response due to coating or clogging. Choose the appropriate cleaning solution options:

- For general cleaning: Soak the pH electrode in 0.1 M HCl or 0.1 M HNO_3 for 20 minutes. Rinse well in tap water before use.
- For removing stubborn deposits and bacteria: Soak the pH electrode in a 1:10 dilution of household laundry bleach for 10 minutes. Rinse thoroughly before use.
- For removal of oil and grease: Rinse the pH electrode in mild detergent or methyl alcohol. Wash in water before use.

After any of the cleaning procedures, it is good practice to thoroughly rinse the pH electrode with de-ionized water, drain and refill the reference chamber if necessary before use.

CAUTION: Proper eyewear and hand gloves must be used when handling strong chemicals.

UNIT 4: Specifics for Systems with Treatment

FACT SHEET 4.7 - Basic Math:
(Common Calculations for Small Water Systems)

4.7.1 - Formulas / Conversion Table

4.7.2 - Perimeter Calculations

4.7.3 - Circumference Calculations

4.7.4 - Area Calculations

4.7.5 - Volume Calculations in Cubic Feet & Gallons

4.7.6 - Velocity & Flow Calculations

4.7.7 - Detention Time Calculations

4.7.8 - Pressure Calculations

4.7.9 - Dosage Calculations

FACT SHEET 4.7 - Basic Math:

(Common Calculations for Small Water Systems)

4.7.1 – Formulas / Conversion Table

Mathematics is an essential skill for the small groundwater system operator. Typical tasks involve calculating and converting volumes, areas, flow rates, chemical addition, solution strength, water head and other data into information that is needed to properly operate and maintain the system. Abbreviations, conversion factors and common formulas are attached at the beginning of this section to assist.

Abbreviations, Conversion Factors, and Formulas

Abbreviations:					
ft	=	Feet	**lb**	=	pounds
gpd	=	gallons per day	**mg/L**	=	milligrams per liter
gpm	=	gallons per minute	**mL**	=	milliliter
MGD	=	million gallons per day	**L**	=	liter

Conversion Factors:		
1 acre 1acre foot	**=** **=**	43,560 square feet 43,560 cubic feet
1 cubic foot	**=**	7.48 gallons
1 foot	**=**	0.305 meters
l gallon	**=**	3.79 liters
1 gallon of water	**=**	8.34 pounds
1 horsepower	**=**	0.746 kilowatts
1 million gallons per day	**=**	694 gallons per minute
1 pound	**=**	0.454 kilograms (454 grams)
1 Liter	**=**	1000 mL
1 Liter of water	**=**	1000 grams
1 gram	**=**	1000 kg
1 pound per square inch (psi)	**=**	2.31 feet of water (head)
1%	**=**	10,000 mg/L
Degrees Celsius	**=**	(Degrees Fahrenheit - 32)($^5/_9$)
Degrees Fahrenheit	**=**	(Degrees Celsius)($^9/_5$) + 32
π	**=**	3.14

Common Formulas

Area of a Circle	=	[(0.785)(Diameter^2)] or (3.14)(Radius ^{2}) or $\frac{(3.14)(d^2)}{4}$
Area of Rectangle	=	(Length)(Width)
Area of Triangle	=	$\frac{\text{(Base)(Height)}}{2}$
Chemical Feed Pump Setting, % Stroke	=	$\frac{\text{(Desired Flow)(100\%)}}{\text{Maximum Flow}}$
Circumference of a Circle	=	(3.14)(Diameter)
Perimeter of Square or rectangle	=	Length + Width + Length + Width
Detention Time	=	$\frac{\text{Volume}}{\text{Flow}}$
Discharge	=	$\frac{\text{Volume}}{\text{Time}}$
Dosage, ("Pounds Formula") lbs, or lb/day	=	(mg/L or ppm)(8.34)(MG, or MGD) Note: mg/L = ppm
Efficiency, %	=	$\frac{\text{(In - Out)(100\%)}}{\text{In}}$
Feed rate, lb/day	=	$\frac{\text{(Dosage, mg/L)(Capacity, MGD)(8.34 lbs/gal)}}{\text{(Available fluoride ion)(Purity)}}$
Feed rate, gal/min (Saturator)	=	$\frac{\text{Plant capacity, gal/min)(Dosage, mg/L)}}{\text{(18,000 mg/L)}}$

Gallons/Capita/Day (See Change)	=	$\frac{\text{Gallons/Day}}{\text{Population}}$
Horsepower	=	$\frac{\text{(Flow, gpm)(Head, ft)}}{\text{(3,960)(Efficiency)}}$
Hydraulic Loading Rate	=	$\frac{\text{Flow}}{\text{Area}}$
Reduction in Flow, %	=	$\frac{\text{(Original Flow - Reduced Flow)(100\%)}}{\text{Original Flow}}$
Solids Concentration	=	$\frac{\text{Weight}}{\text{Volume}}$
Surface Loading Rate	=	$\frac{\text{Flow}}{\text{Area}}$
Velocity	=	$\frac{\text{Flow}}{\text{Area}}$ or $\frac{\text{Distance}}{\text{Time}}$
Volume of Rectangle	=	(Length)(Width)(Height)
Volume of Cone	=	$(1/3)(0.785)(\text{Diameter}^2)(\text{Height})$
Volume of Cylinder	=	$(0.785)(\text{Diameter}^2)(\text{Height})$

4.7.2 - Perimeter Calculations

Following, are descriptions and examples of common calculations in part from the "New Mexico Water System Training Manual." Most of the major categories of math calculations that are important to know for both certification and daily operations of water systems are covered in the following order – these topics are in order from basic to more complex calculations.

- Perimeter
- Circumference
- Area
- Volume (cubic feet and gallons)
- Velocity & Flow
- Detention Time
- Pressure
- Dosage

We will begin with perimeter Calculations;
Perimeter is the distance around the outer edge of a shape. In water treatment, most perimeters are rectangular, square, or circular.

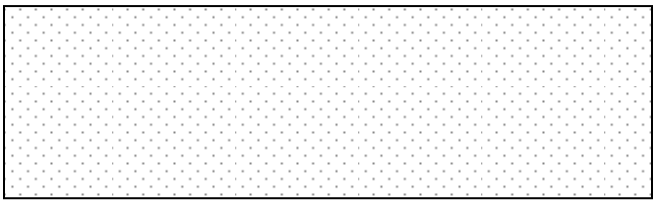
To calculate the **perimeter** of a rectangle or square use this formula where L = length and W = width:

Perimeter = L + W + L + W

Example:

1. What is the perimeter of a rectangular basin, 10 feet by 5 feet?

10 feet



5 feet

L + W + L + W = Perimeter
10 + 5 + 10 + 5 = **30 feet**

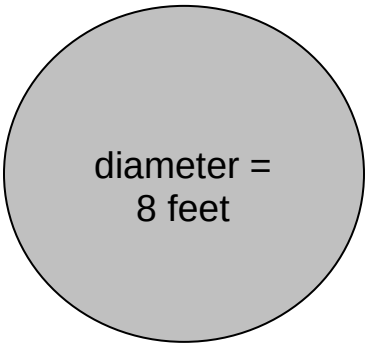
4.7.3 - Circumference Calculations

The perimeter of a circle is referred to as the **circumference**. To calculate the **circumference** of a circle multiply pi (3.14) x diameter.

Circumference = 2 ×3.14 × r, r = radius, or
Circumference = 3.14 × d, d = diameter

Example:

1. What is the circumference of an eight-foot diameter tank?



3.14 × d = Circumference

3.14 × 8 = ***25.1 feet***

<u>Radius and Diameter</u>

Diameter is the length of a straight line measured through the center of a circle from one side to the other. **Radius** is the distance from the **center** of a circle to its edge. Radius equals half the diameter (diameter ÷ 2). In reference to the circle in the example above, the diameter = 8 feet, the radius = 4 feet (8 ÷ 2 = 4).

In water treatment, most calculations are made using the diameter of a circle rather than the radius. This is due to the fact that pipe sizes and basin size are measured according to their diameter. The remainder of the examples will be shown as diameter.

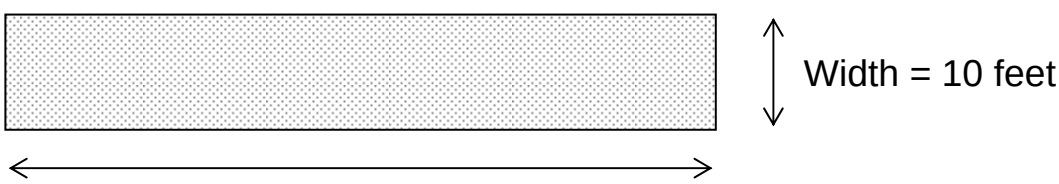
4.7.4 - Area Calculations

Area is a quantity expressing the size of a surface, or surface area of a shape. These measurements are normally referred to in units of square inches, square feet or square yards. Common metric units are square centimeters or square meters. Equations for calculating area of a rectangle or square, and circle follow.

Area (of a Rectangle or Square)

To calculate the area of a rectangle or square multiply length (L) times width (W).

Area = L × W



The area of the above rectangle = 30 ft × 10 ft = ***300 ft²***

Example:

1. Calculate the area, in square ft, of the bottom of a rectangular basin that measures 50 feet long by 25 feet wide.

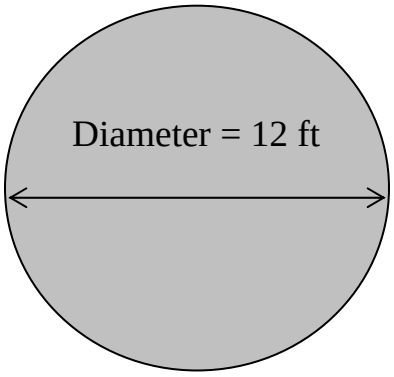
   L × W = Area
   50 ft × 25 ft = ***1,250 ft²***

<u>Area (of a Circle)</u>

In order to calculate volumes of circular tanks and

velocities in pipes, the area of the circle must first be determined. There are two basic formulas used to calculate the area of a circle.

Area = 3.14 × r^2, r= radius OR
Area = d^2 × 0.785, d = diameter



The area of this circle = d × d × 0.785
=12 ft × 12 ft × 0.785 = 113 ft^2

Examples:

1. A sedimentation basin is 60 feet in diameter. What is the area of the tank?

   Area = d^2 × 0.785
   60′ × 60′ × 0.785 = ***2826 ft^2***

2. A pipeline has diameter of 12 inches. What is the area of the pipe?

   Area = d^2 ×0.785
   12″ × 12″ × 0.785 = ***113 square inches***

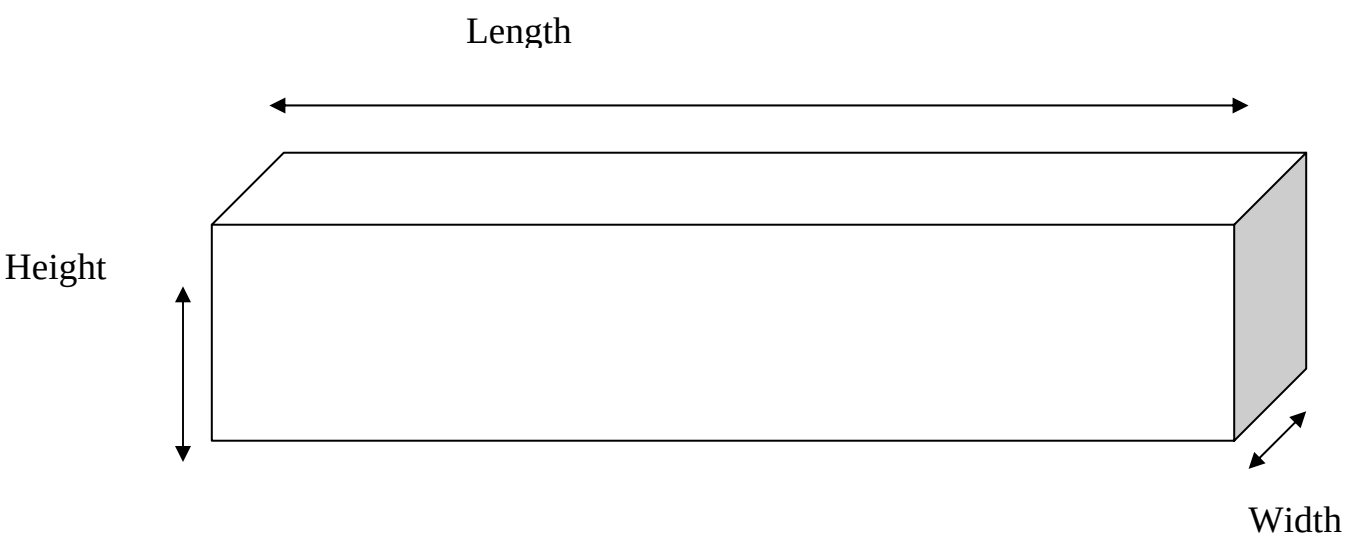
4.7.5 - Volume Calculations in Cubic Feet and Gallons

Volume measurements represent the amount of space an object occupies. Volume is commonly measured in cubic inches, cubic feet, cubic yards and gallons. Common metric units are cubic centimeters, cubic meters, or liters.

Volume - Rectangle

The volume of a rectangular tank can be determined by multiplying the length (L), height (H), and width (W) together.

Volume of rectangular tank (ft^3) = L' x H' x W'



- To calculate cubic feet all measurements must be in feet.
- To convert cubic feet to gallons multiply by 7.48 gal/cubic feet.
- To convert gallons to million gallons divide by 1,000,000.

Example:

1. A sedimentation basin is 60' long by 40' wide and 10' deep. What is the volume of the tank in cubic feet?

L' × H' × W' = Volume

60' × 40' ×10' = ***24,000 cubic feet (ft^3)***

2. A sedimentation basin is 60' long by 40' wide and 10' deep. How many gallons can the tank hold?

Calculate the volume

L' × H' × W' = Volume

60' × 40' × 10' = 24,000 ft^3

Convert cubic feet to gallons

24,000 ft^3 × 7.48 gal/ ft^3= ***179,520 gallons***

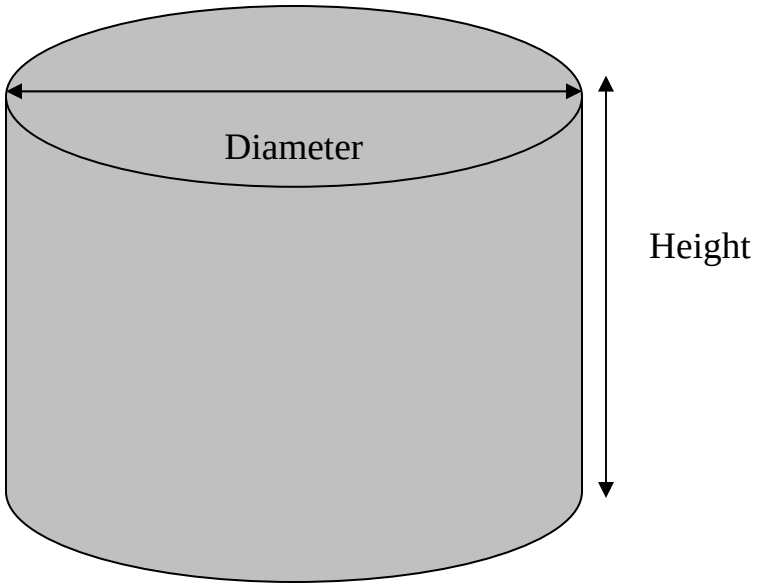
Volume – Circular Tank

The volume of a circular tank can be determined by multiplying the area of the tank by the height (or depth) of the tank.

Volume = Area × Height

Volume of ciruclar tank (ft^3) = 3.14 ×r'^{2} ×H'

Volume of circular tank (ft^3) = d'^{2} × 0.785 × H'



- To calculate cubic feet all measurements must be in feet
- To calculate gallons multiply cubic feet by 7.48 gal/cubic feet
- To calculate million gallons divide gallons by 1,000,000

Examples:

1. A sedimentation basin is 60'in diameter and 12' deep. What is the volume of the tank?

   $d'^2 \times 0.785 \times H' = \text{Volume } (ft^3)$
   60' x 60' x 0.785 x 12' = ***33,912 ft³***

2. A circular tank has a diameter of 40 feet and is 10 feet deep. How many gallons will it hold?

   Calculate the volume:

   $d'^2 \times 0.785 \times H' = \text{Volume } (ft^3)$
   40' × 40' × 0.785 × 10' = 12,600 ft³

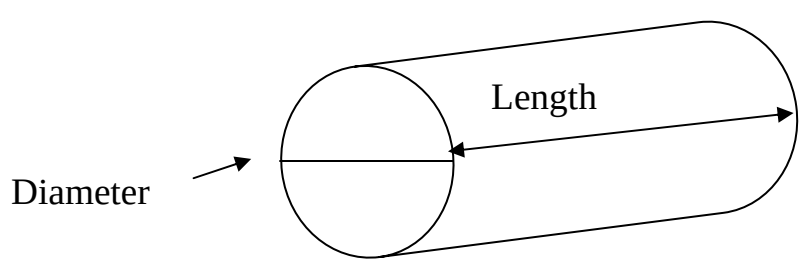
   Convert cubic feet to gallons
   12,600 ft³ × 7.48 gal/ft³ = ***94,200 gallons***

Volume- Pipes

To calculate the volume of a pipe multiply area of the pipe opening times the length (L) of pipe. This calculation is basically the same as the calculation for a circular basin. The difference for students is that pipe diameters are given in inches and must be converted to feet in order to calculate volume in cubic feet. Convert inches of diameter to feet by dividing d"² by 144 as you calculate volume as shown below.

Area (ft²) x Length (ft) = volume in ft³

$$\left(\frac{d'' \times d'' \times 0.785}{144}\right) \times L' = \text{volume in } ft^3$$



- To convert cubic feet to gallons multiply by 7.48 gal/ft^3.
- To convert gallons to million gallons divide by 1,000,000.

Examples:

1. What is the volume of water in gallons in a pipe 6 inches in diameter and 1100 ft in length?

   Calculate volume of water in the pipe.

   $$\frac{d'' \times d'' \times 0.785}{144} \times L' = \text{volume in } ft^3$$

   $$\frac{6'' \times 6'' \times 0.785}{144} \times 1100' = 215.9\ ft^3$$

   Convert cubic feet to gallons.
   215.9 ft^3 x 7.48 gallons/ft^3 ***= 1615 gallons***

2. Calculate the volume, in cubic feet, of a 100 foot section of 24 inch diameter pipe.

   $$\frac{d'' \times d'' \times 0.785}{144} \times L' = \text{volume in } ft^3$$

   $$\frac{24'' \times 24'' \times 0.785}{144} \times 100' = \mathbf{314\ ft^3}$$

4.7.6 - Velocity and Flow Calculations

Velocity

The velocity (in feet per second, or fps) of the water moving through a pipe can be determined if the flow (in cubic feet per second, cfs or ft^3 /sec) and the diameter of the pipe are known. The area of the pipe must be calculated in square feet (ft^2) and the flow is then divided by the area.

$$\textbf{Velocity (V)} = \frac{\textbf{Flow (Q)}}{\textbf{Area (A)}}$$

Example:

1. A 24" pipe carries a flow of 11 cfs. What is the velocity in the pipe?

   Calculate the Area:

   $0.785 \times d^2$
   $0.785 \times 2' \times 2' = 3.14\ ft^2$

   Divide the Flow which is given by the Area:

   $\frac{\text{Flow}}{\text{Area}} = \text{Velocity}$

   $\frac{11\ cfs}{3.14\ ft^2} = \mathbf{3.5\ fps}$

Flow

Using this same formula we can also determine the flow through a pipe (in cubic feet per second, cfs). The area of the pipe must be calculated in square feet and then multiplied by the velocity (in feet per second, fps).

$$\textbf{Flow (cfs)} = \textbf{Area (ft}^2\textbf{)} \times \textbf{Velocity (fps)}$$

Example:

1. A 12''' pipe carries water at a velocity of 5.0 fps. What is the flow in cfs? Find area of the pipe in ft^2.

$$\frac{d'' \times d'' \times 0.785}{144} = \text{Area of pipe in } ft^2$$

$$\frac{12'' \times 12'' \times 0.785}{144} = 0.785\ ft^2$$

Calculate the flow in cfs.

Area (ft^2) × Velocity (fps) = Flow (cfs)
0.785 ft^2 **×** *5.0 fps* = ***3.9 cfs***

Flow Units

The amount of water moving through the system can be measured in one of three different units. They are gpm (gallons per minute), MGD (millions of gallons per day), and cfs (cubic feet per second). The conversion factors and conversions are listed below.

1 gpm = 694 MGD *(Derived from:* $\frac{1\ MG/day \times 1{,}000{,}0000\ gal/MG}{1440\ min/day}$ *=gpm)*

MGD × 694 = gpm

gpm ÷ 694 = MGD

1 gpm = 449 cfs *(Derived from: 1 ft^3/sec ×7.48 gal/ft^3 ×60 sec/min =gpm)*

cfs × 449 = gpm

gpm ÷ 449 = cfs

Examples:

1. A system uses 2 MGD. How many gallons per minute does it use?

MGD × 694 = gpm

2 MGD x 694 = ***1388 gpm***

2. A pipeline has a carrying capacity of 3 cfs. How many gpm can it handle?

cfs × 449 = gpm

3 cfs × 449 = ***1347 gpm***

3. A well pumps 350 gpm. How many MGD will it pump?

gpm ÷ 694 = MGD

350 gpm ÷ 694 = ***0.5 MGD***

4. A 12" pipe carries 1400 gpm at 4.0 fps velocity and reduces to a 6" pipe. What is the velocity in the 6" pipe?

Convert flow to cfs.

gpm ÷ 449 = cfs

1400 gpm ÷ 449= 3.12 cfs

Find area of the pipe in ft^2**.**

$$\frac{d'' \times d'' \times 0.785}{144} = \text{Area of pipe in ft}^2$$

$$\frac{6'' \times 6'' \times 0.785}{144} = 0.196\ ft^2$$

Calculate the velocity in fps.

$$\frac{\text{Flow}}{\text{Area}} = \text{Velocity}$$

$$\frac{3.12\ cfs}{0.196\ ft^2} = \mathbf{16\ fps}$$

4.7.7 - Detention Time Calculations

Detention time is the estimated amount of time it takes to empty or drain a tank (or basin, etc.), in other words, the amount of time a drop of water stays in a tank. To calculate detention time divide the volume of water in the tank by the flow rate through the tank, as shown below.

Detention Time (DT) = volume (V) ÷ Flow (Q)

The answer is expressed in the same time units as the time units in the flow portion of the problem (if using MGD the answer will be in days, if using GPM the answer will be in minutes etc).

It is important to note that the volume units in the flow portion of the problem (Q) be the same units that are used in the volume portion of the problem (V). For instance, if you had a volume in million gallons (MG) and a flow in MGD the problem would work and the answer would be in days. If you had a volume in MG and a flow in CFS the problem would not work unless you converted the CFS to MGD (or convert the MG to cubic feet).

Example:

1. What is the detention time (in hours) in a basin that has a volume of 10,000 gallons and a flow of 120 gpm?

   Calculate detention time.

   Volume (V) ÷ Flow (Q) = DT

   10,000 gals ÷ 120 gpm = 83 minutes

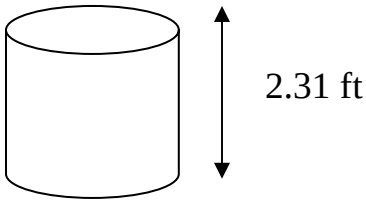
   Convert minutes to hours.

   83 minutes ÷ 60 min/hour = 1.4 hours

4.7.8 - Pressure Calculations

Water pressure is measured in terms of pounds per square inch (psi) and feet (ft) of head (height of a water column in feet). A column of water 2.31 feet high creates a pressure of 1 psi. The water pressure at the bottom of a storage tank can be used to determine the water level in the tank. The pressure on the bottom reflects the height of the column of water not the volume. Centrifugal pumps are rated in feet of Total Dynamic Head (TDH) but system pressures are measured in psi. All water system operators must be able to convert from one pressure unit to the other (e.g., from psi to head and from head to psi.)

1 psi = 2.31 feet of head



A 2.31 foot column of water exerts 1 psi

If the pressure (psi) is known, the height of the water column can be determined by multiplying the psi by 2.31. If the height of a column of water is known, the pressure it exerts can be determined by dividing the feet of head by 2.31.

psi × 2.31 = ft of head

$$\frac{\text{ft of head}}{2.31} = \text{psi}$$

Examples:

1. A pressure gauge at the bottom of a storage tank reads 30 psi. What is the water level in the tank?

   30 psi × 2.31 = ***69.3 ft of water above the gauge***

2. The reservoir level is 115 feet (ft) above the pump discharge. What is the static pressure on the pump?

   $$\frac{115\ ft}{2.31} = \mathbf{49.8\ psi}$$

3. A pump is installed at 5320 feet above sea level. The overflow of the reservoir is at 5460 feet above sea level. What is the static pressure on the pump in psi?

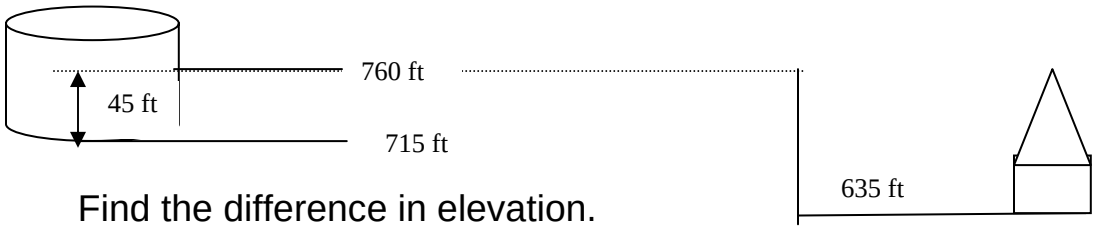
   Find the difference in elevation.

   5460 ft – 5320 ft = 140 ft

   Convert ft of head to psi.

   $$\frac{140\ ft}{2.31} = \mathbf{60.6\ psi}$$

What is the water pressure, in psi, at a house located at an elevation of 635 feet if it receives water from a basin located at an elevation of 715 feet that contains 45 feet of water?



Find the difference in elevation.

760 ft – 635 ft = 125 ft

Convert ft of head to psi.

$$\frac{125\ ft}{2.31} = \mathbf{54\ psi}$$

4.7.9 - Dosage Calculations

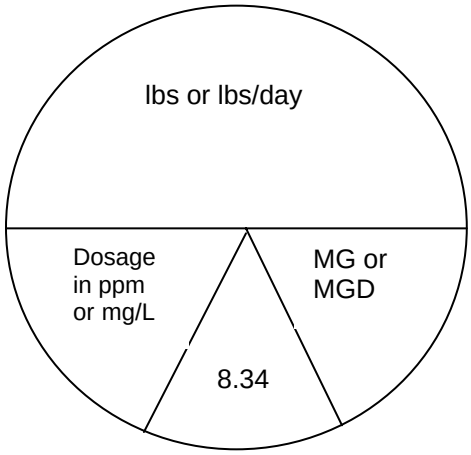
DOSAGE ("Pounds Formula")

Chemical dosages are measured in ppm (parts per million) or mg/L (milligrams per liter.) Parts per million (ppm) is always a comparison of weight (pounds per million pounds). One pound of chemical added to one million pounds of water would be a dosage of 1 ppm. Milligrams per liter (mg/L) is the metric term for a dosage equal to ppm (1 ppm = 1 mg/L)

The number of pounds of chemical needed to achieve a certain dosage can be determined by multiplying the ppm by the number of millions of gallons treated and then by 8.34 lbs/gal. The amount of water to be treated must always be in terms of millions of gallons (MGD). This is the well-known "pounds" formula and is expressed as:

mg/L (or ppm) × MG, or × 8.34 lbs/gal = pounds,
or
MGD pounds per day(lb/day)

Pounds Formula



Pounds (or lbs/day) is the amount of chlorine, in pounds, that will be needed. *PPM* is the dosage that will be used. *MG (or MGD)* is the amount of water, in million gallons, that will be treated. *8.34* is a constant. In order to work a pounds formula you must be in these units. Any other units (such as CFS) will not work. To solve a pounds problem, you will need to find either the pounds, the ppm, or the MG. The rest of the information will be given.
To solve for pounds: multiply (ppm)(8.34)(MG)
To solve for ppm: pounds divided by (8.84 x MG) - **or** - pounds divided by 8.34 then divided by MG
To solve for MG: pounds divided by (ppm x 8.34) - **or** - pounds divided by ppm then divided by 8.34

Note: *If HTH is used, instead of chlorine gas, only 65-70% of each*

pound will be chlorine. Therefore, the amount of HTH must be calculated by dividing the pounds of chlorine needed by 0.65 or 0.70.

Examples:

1. How many lbs/day of chlorine are needed to provide a dosage of 2.2 mg/L in 800,000 gal/day?

   Convert gal/day to mgd by dividing by 1,000,000.
   800,000 gpd ÷ 1,000,000 = 0.8 MGD

   Calculate lbs/day.
   mg/L × MGD × 8.34 = lbs/day
   *2.2 mg/L × 0.8 MGD × 8.34 =**14.7 lbs/day***

2. A tank is 44' in diameter and 22' high and is dosed with 50 ppm of chlorine. How many pound of 70% HTH is needed?

   Find the volume of the tank in cubic feet.

   $d'^2 \times 0.785 \times L' = \text{Volume } (ft^3)$
   $44' \times 44' \times 0.785 \times 22' = 33{,}450\ ft^3$

   Convert ft^3 to gallons.
   $33{,}450\ ft^3 \times 7.48\ gal/ft^3 = 250{,}000\ gal$

   Convert gallons to MG (divide by 1,000,000).
   250,000 gallons ÷ 1,000,000 = 0.250 MG

   Apply "Pounds" formula.
   ppm × MG × 8.34 = lbs
   50 ppm ×0.25 MGD × 8.34 = 104.25 lbs chlorine

   Calculate lbs of 70% HTH.
   $\frac{104.25\ lb\ Cl}{0.70} = \mathbf{149\ lb\ of\ HTH}$

3. A chlorine pump is feeding 10% bleach at a dosage of 5 mg/L. If 2,200,000 gallons are treated in 16 hours, how many gallons per hour is the pump feeding?

   Convert gallons to MG
   2,200,000 gallons ÷ 1,000,000 = 2.2 MG

Find lbs of chlorine

mg/L × MG × 8.34 = lbs of Cl

5 mg/L x 2.2 MG x 8.34 = 91.7 lbs of Cl

Calculate lbs of Bleach. (10% = 0.10)

$$\frac{91.7 \text{ lbs Cl}}{0.10} = 917 \text{ lbs of Bleach}$$

Convert lbs of bleach to gallon

$$\frac{917 \text{ lbs Bleach}}{8.34 \text{ lbs/gal}} = 110 \text{ gal of Bleach}$$

Find gallons per hour

$$\frac{110 \text{ gal.}}{16 \text{ hr}} = \mathbf{6.9\ gal/hr}$$

4. A 12" pipe is 1880' long and must be disinfected with 50 ppm of 65% HTH. How many pounds of HTH are needed?

Calculate the volume of the pipe in gallons.

$$\frac{d''^2}{144} \times 0.785 \times L' \times 7.48 \text{ gal/ ft}^3 = \text{Volume (gal)}$$

$$\frac{12'' \times 12''}{144} \times 0.785 \times 1880' \times 7.48 = 11,045 \text{ gallons}$$

Convert gallons to MG

11,045 ÷ 1,000,000 = 0.011 MG

Find lb of chlorine

ppm × MG × 8.34 = lbs of Cl

50 ppm × 0.011 MG × 8.34 = 4.6 lb of Cl

Find lb of 65% HTH (65% = 0.65)

$$\frac{4.6 \text{ lb Cl}}{0.65} = \mathbf{7.1\ lbs\ of\ HTH}$$

Drinking Water Program

SMALL WATER SYSTEM OPERATOR APPLICATION

PLEASE READ IMPORTANT INFORMATION ON BACK OF FORM!

Section A

Name of system:_____ PWS ID # 41-_____

Mailing address: _____ City: _____State: ___ Zip _____

County:_____ Business Phone: (___)_____X_____

Are you renewing an existing Certification? Yes__ No__ If yes, give expiration date_____

(See # 4 on the back of this form if there are other currently certified operators for this system.)

Section B

Designated Operator in Responsible Charge (DRC)

SSN: _____-____-_____Last_____First_____M.I.___

√ **Certification request is based on : (check one of the following) NEW ❑**

	Operator is Certified in WT or WD	OR Cert#	Level
	Water Operator Training*	Date	Location
	Contract with Certified Operator**	OR Cert#	Level

* Please attach copy of Class Certification ** Please attach copy of Contract

Operator 2

SSN: _____-____-_____Last_____First_____M.I.___

√ **Certification request is based on : (check one of the following)**

	Operator is Certified in WT or WD	OR Cert#	Level
	Water Operator Training*	Date	Location
	Contract with Certified Operator**	OR Cert#	Level

* Please attach copy of Class Certification ** Please attach copy of Contract

If more than 2 are requesting certification, please attach another copy of this form.

Section C

Legal Owner or Authorized Agent (See back for instructions)

Name_____ Title _____ Date:_____

Please Pring

Address:_____ City: _____ State:____ Zip: _____

Signature _____Phone: (____)_____

When completed, mail to: Department of Human Services, Drinking Water Program
PO Box 14450, Portland OR 97293-0450

For further information Go to our website at: www.oregon.gov/DHS/ph/dwp
Or call Drinking Water Operator Certification: (971) 673-0413

PLEASE READ CAREFULLY

Section B DRC-The person in charge of the day to day activities.

1. Currently Certified?

If the applicant is currently certified in Oregon as a Water Distribution (WD) or Water Treatment (WT) operator, please include the Certification # and level of Certification.

2. Certification by Water System Training

Certification via training is good for 3 years expiring July 31 of the 3rd year. The applicant must have completed the Drinking Water Program's Small Water System Training Course within three years prior to the application. See our newsletter The Pipeline or visit our website for upcoming training dates.

3. Contract with Certified Operator

A system can elect to comply with the certification requirements by contracting with an operator with a valid Small Water Certification or Oregon WD or WT Certifications. A copy of the contract must be submitted as proof along with the application.

4. List all Current Operators

If your system has other currently certified operators than those listed on the front of this form, please write their name here. This will ensure our records are updated. _____
_____.

Section C

5. Legal Owner

This portion of the form must be signed by someone with authority to designate the operator on behalf of the system. An operator **cannot designate** themselves as being in Direct Responsible Charge unless they have authority to make the designation on behalf of the system.

Depending on the type of system, that authority could reside with a number of persons. It could be the actual owner or, in the case of a homeowners association, one of the officers of the association. For a school, it could be a District officer or the Principal of the school. For a workplace, it could be the general manager, or an officer of the company.

State law requires you to provide your Social Security Number for any certification, license, or registration issued by the State of Oregon. Failure to provide your Social Security Number will be a basis to refuse to issue or renew the certification you seek. This record of your Social Security Number will be used for child support enforcement purposes and will not be used as a certification number on any certificate.
(Oregon Laws 1997, chapter 746, section 117 (ORS 25.785) and 42 USC § 666(a)(13))