STATE OF ALASKA

DEPARTMENT OF ENVIRONMENTAL CONSERVATION

DRINKING WATER PROGRAM

BEST MANAGEMENT PRACTICES FOR PRIVATE DRINKING WATER SYSTEMS

This document is intended for Private Water Systems which are systems that do not meet the definition of a federally regulated public water system (systems that serve more than 24 people per day for more than 60 days per year). Information and requirements for public water systems is provided in Alaska Drinking Water Regulations, 18 AAC 80.

BEST MANAGEMENT PRACTICES FOR PRIVATE WATER SYSTEMS

Foreword

Dear Private Water System Owner/Operator:

The Department of Environmental Conservation (DEC), Drinking Water Program, began considering revisions to, or repealing completely, the "Class C" (State-regulated) public water system regulations in early 2010. The effective date of the most recent Drinking Water Regulations, 18 AAC 80, revisions package, February 11, 2017, finalized the repeal of the Class C water system classification and associated requirements; and also revised the definition of a private water system.

Private water systems are defined by the Drinking Water Regulations, 18 AAC 80.1990 (a)(108), as "a potable water system that is not a public water system." This includes all those systems formerly classified as Class C systems. Drinking water system classification is determined by the factors in the Drinking Water Regulations, including adopted portions of the CFR (40 CFR 141.2 Definitions, Public Water System, and 141.3 Coverage). A system operating as a public water system that has not yet been classified by the Drinking Water Program should not be considered a private water system. Both groundwater and surface water are utilized by private water systems. Groundwater in Alaska is of varying quality and most private water systems do not treat their drinking water. Surface waters in Alaska vary in quality across the state and typically have a greater seasonal variation in quantity and quality than groundwater. It is recommended that all private water system owners routinely test their drinking water. Those private water systems owners using a surface water source should consult with a professional engineer licensed in Alaska (hereafter referred to as PE) to design their water system to reduce health risks associated with drinking untreated surface water which may contain harmful pathogens, such as bacteria, viruses, and protozoans.

Recognizing the importance of providing guidance to private water system owners and operators, the DEC Drinking Water Program developed this Best Management Practices (BMPs) guidance to assist owners and operators in developing, operating, and maintaining their water system. Application of these BMPs is voluntary; however, the bottom line is that private water systems owners and operators need to provide a dependable supply of safe drinking water of both sufficient quantity and quality.

Although the DEC Drinking Water Program does not regulate private water systems, the owners of such systems should be aware of the other regulatory requirements for private water systems. This BMP guidance is not a substitute for the other regulatory requirements which include, but are not limited to the following: DEC Wastewater Disposal Regulations, 18 AAC 72; DEC Environmental Sanitation Regulations, 18 AAC 31 and DEC Alaska Food Code Regulations, 18 AAC 31; the DEC Solid Waste Regulations, 18 AAC 60; the DEC Underground Storage Tank Regulations, 18 AAC 78; the Department of Natural Resources (DNR) Regulations, 11 AAC 05; the Department of Health and Social Services Regulations, 7 AAC 10, 7 AAC 15, 7 AAC 50, and 7 AAC 57; and the Alaska Water Use Act (AS 46.15) for Water Rights.

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1. PURPOSE

The purpose of this *BMPs for Private Water Systems* is to provide recommended guidance to help private water system owners and operators best develop, operate, and maintain their water systems for the public health protection to the individuals using drinking water from the systems, for source protection of the resource being used and the area surrounding the water system well or surface water intake, and for both sustainability of the system and economic benefit to the water system owner.

2. INTRODUCTION

This *BMPs for Private Water Systems* is not "regulation" but only a guidance document and should not be considered complete, definitive, or a requirement. It is an outline with recommendations focusing on the different elements of private water systems that include, but are limited to, location, design, construction, operation, treatment, storage, distribution, testing, and reference minimum standards and regulatory requirements that are noted in the department or other agency regulations. This document is primarily for private water systems that are plumbed systems (piped distribution systems) that include, but are not limited to: residential (single and multi-family), commercial, and institutional facilities. This *BMP for Private Water System* does not cover water recycling and reuse systems, water haul systems, central watering point systems, or snow/ice melt situations which will require design considerations based on their specific and unique situations. This *BMP for Private Water Systems* does not cover shared water wells or water system agreements or the purchasing of water systems and it is recommended that individuals in these situations seek legal consultation.

The primary criteria of importance for current private water system owners and also for individuals interested in owning, developing, and operating a private water system include, but are not limited to, the following:

- <u>Water source</u>.
  - Do I have the necessary <u>quantity</u> and <u>quality</u> of water to fully meet my needs and any expected growth? This directly correlates to the number of persons being served by the system as well as other anticipated uses from the water well yield for a groundwater or groundwater under the direct influence of surface water source or water intake for a surface water or groundwater under the direct influence of surface water source.
  - Do I have Water Rights? (Note: Water Rights are obtained from the Department of Natural Resources.)
  - Do I have the ability to protect my water source from degradation of water quality and quantity? It is important to understand that surface water, groundwater under the direct influence of surface water, and many groundwater sources may be seasonally affected by spring breakup, flooding, heavy rainfall, earthquakes, and local construction and "land use" activities (logging, mining, etc.) which commonly affects both water quantity and water quality.
- <u>Treatment required</u>. Treatment is dependent on the quality on the source water type (groundwater, groundwater under the direct influence of surface water, or surface water).
  - What is in my drinking water and is it safe to drink?
  - What testing will be necessary to determine the water is safe?
  - Depending on the water source, and the results from water testing, what treatment will be necessary to make it safe?
- <u>Storage required</u>. Storage is dependent on the number of persons being served as well as any other actual or planned water usage activities and the water well yield (ground water or

groundwater under the direct influence of surface water source) or the water intake and treatment system capacity (ground water under the direct influence of surface water or surface water) to consistently meet the total water system usage needs.
    - What storage is necessary, to meet demand (peak water usage and total water usage)?
    - If storage is required, how much is needed to routinely meet demand without running-out of water?
- <u>Costs for the water system.</u>
    - Can I afford to own, operate, and maintain the water system?
    - Do I have the knowledge, skills, and ability to own, operate, and maintain the water system?
    - Do I need to hire an operator for the system which could include a water treatment professional or a PE?

The questions noted above for the primary criteria of importance for a private water system are for serious thought and consideration for both current and prospective owners of a private water system. This BMP provides the basic information private water system owners should know and understand as they consider owning, operating, and maintaining a water system.

3. DESIGN AND CONSTRUCTION

3.A. GROUNDWATER SOURCES – See *Alaska Best Management Practices, Construction of Non-Public Water Wells*, June 6, 2016, guidance document

For information covering Well Location, Well Construction, and Source Protection and Water System Risks see the *Alaska Best Management Practices: Construction of Non-Public Water Wells*, June 6, 2016, guidance document. BMP website link:
http://dec.alaska.gov/eh/docs/dw/DWP/Alaska_BMPs_for_CONSTRUCTION_of_Non-Public_Water_Wells.pdf

Information on well logs and well log requirements can be downloaded from the DEC Drinking Water Program web site at: http://dec.alaska.gov/eh/dw/Engineering/well_logs.html. The *Water Well Log* form is available from the Alaska Department of Natural Resources (DNR) website at: http://dnr.alaska.gov/mlw/forms/water/welllog.pdf

3.B. SURFACE WATER AND GROUNDWATER UNDER THE DIRECT INFLUENCE OF SURFACE WATER SOURCES

Surface water sources used for drinking water include seeps, springs, creeks, streams, rivers, ponds, lakes, and rain catchment. Surface water sources have a greater susceptibility to contamination, primarily microbiological contamination, than groundwater sources. A groundwater source which is under the direct influence of surface water, also referred to as a "GWUDISW", should be treated as a surface water, rather than a ground water unless proven otherwise. These sources require treatment to remove microbial contaminants before using them for drinking water purposes.

3.B.1. Groundwater Under the Direct Influence of Surface Water

A GWUDISW is not exactly ground water or surface water, but is water located under the surface of the ground that is receiving a direct surface water recharge. Groundwater which has significant surface water characteristic, is considered to be GWUDISW. A GWUDISW commonly has some, or all, of the following characteristics:

- static water level in the well which correlates closely to the nearby surface water levels and when levels in the nearby surface water fluctuate due to flooding or drought, the static water level in the well fluctuates accordingly;
- significant and relatively rapid shifts in water quality characteristics, including but not limited to suspended solids (turbidity), temperature, conductivity or pH values that closely correlate to nearby surface waters or climatological (weather) conditions; and
- significant occurrence of aquatic insects or other organisms, algae or large diameter pathogenic protozoa, including *Giardia lamblia* and *Cryptosporidium sp.*

Likely sources of water to be under the direct influence of surface water include:

- shallow wells and Ranney wells (a series of multiple lateral wells from a single well bore) , typically less than 30 feet in depth or drilled close, within 50 feet, to surface water bodies such as springs, creeks, streams, rivers, ponds, and lakes;
- poorly constructed wells which include the lack of adequate and effective grouting and also have ponding around the well head; and
- a well head which does not extend at least one foot above the surface of the ground and is seasonally flooded during high water levels.

3.B.2. Seeps and Springs

Seeps are moist or wet areas on the surface of the ground where water, typically groundwater, percolates out from subsurface aquifers (water-bearing strata or reservoirs). Seeps often form puddles, small ponds, or marshy areas at the base of hills or low lying areas and typically are not a large enough source of surface water for use as a water supply. However, seeps may be excavated (dug out) or dammed to form impoundments or small ponds capable of supplying enough water for a private water system. Springs are naturally occurring situations where water flows from an aquifer (water-bearing strata) to the Earth's surface. Springs can also be artesian (under pressure) or non-artesian. Springs commonly recharge creeks, streams and rivers and because they typically have very stable water quality (low suspended solids and consistent temperature) are used as a source of drinking water for water systems in Alaska. Water from seeps and springs should be adequately disinfected to produce safe drinking water. Because seeps and springs are surface water sources they are impacted by winter freeze-up and spring break-up and water system intake protection from freezing and storage issues are important considerations for water system owners.

3.B.3. Creeks, Streams, and Rivers

Creeks, streams, and rivers in Alaska typically have seasonally variable water quality (suspended solids, temperature, and flow) due to significant rainfall events (floods) and spring break-up as well as availability due to freeze-up; however, they are commonly used as a source of drinking water. The seasonal variability in water quality requires careful consideration when selecting an appropriate water treatment system. The seasonal availability of the water due to winter freeze-up and spring break-up requires water system intake protection from freezing and flooding, and storage issues.

3.B.4. Ponds and Lakes

Ponds and lakes are commonly used water sources for water systems in Alaska. The seasonal variability in water quality (suspended solids, TOC, and variable pH) often requires significant water treatment consisting of filtration and disinfection when compared to a groundwater source to produce safe drinking water. As with creeks, streams, and rivers, the seasonal availability of the water due to winter freeze-up and spring break-up requires water system intake protection from freezing and flooding, and storage issues for water systems.

3.B.5. Rainwater Catchment (Rainwater Collection)

Rainwater catchment water systems are used throughout Alaska and mostly by residential homeowners and small businesses. The largest number of rainwater catchment water systems are located in southeast Alaska. The components of a basic rainwater catchment system include: the roof, sometimes a "roof washer" system, leaf screens (coarse screening) and grit screens (fine screening), gutter and spout system, reservoir for water storage with a tight fitting/secured lid (underground or above ground and made of either concrete, fiberglass, poly-plastic, galvanized steel, or redwood), liners (for the gutters and reservoir), pumps, and filters.

The water collected from rooftops of rainwater catchment systems will typically contain chemical and physical components from the roofing, depending on the type of roofing material, which could be asphalt-based shingles, metal (painted and unpainted aluminum or painted steel), and wood shingles. Additional chemicals commonly found in the water of rainwater catchment systems, but not actually from the rooftop material themselves, include benzene, formaldehyde, and polycyclic aromatic hydrocarbons (PAHs). These chemicals are typically attached to the particles (soot) found in wood smoke primarily from residential wood stoves, heaters, and fireplaces. Additional material collected from rooftops of rainwater catchment systems include, but are not limited to: microorganisms (bacteria and viruses); macro organisms (beetles, spiders, worms, mosquitos and mosquito larvae, etc.); and vegetation (spruce needles, leaves, branches, and moss). A "roof washer" system which is a pre-wash of the roof before rainwater collection begins, is effective in removing some of the chemical and physical contaminants and should be installed and used for a rainwater catchment water system.

All materials used in a Rainwater Catchment System should be approved by NSF/ANSI, or Underwriters Laboratories, Inc., (UL), or Water Quality Association, Inc., or an equivalent standards certification organization. Several important standards to review for Rainwater Catchment Systems information include: NSF/ANSI Standard 53, *Drinking Water Treatment Units-Health Effects* and NSF Protocol P151, *Health Effects from Rainwater Catchment System Components.*

3.B.6. Source Protection and Water System Risks

Source protection is important and water system risks can be significant for surface water used as a source of drinking water. Surface waters are typically much more susceptible to contamination than groundwater due, in part, to the many activities done on, and around, surface waters. One of the most important issues of owning and operating a private water system is to clearly identify the source of the water for your water system. After the source of your water has been identified; whether a seep, spring, creek, stream, river, pond, lake, or rainwater catchment, develop a protection plan to minimize the risk to your water system. The protection strategy should include, but not be limited to, the following:

- Delineate the boundaries of the source of your water and note whether you have control of these boundaries and/or are they protected through easements, adjoining private property, or public lands.
- Within the delineated boundaries of the source of your drinking water, identify and inventory the actual and potential sources of contamination (biological and chemical) and activities which could impact your water source and, ultimately, your water system. Potential sources of contamination or activities could include, your neighbors, animals, construction, roads, boats, airplanes, and a natural disaster, such as flooding, etc.
- Consider the risk of a heavy rainfall event and flooding and could this impact the source of your water (increased suspended solids) and your private water system (intake and treatment), and how often this occurs. Consider the risk to your water system's intake and storage system, or distribution system.

- Develop a management and contingency plan (short term and long term) for your private water system. Keep in mind issues, such as:
  - Who you will contact in an emergency;
  - Illnesses and/or water sample results indicating any form of biological or chemical contamination;
  - Water source disruptions and subsequent water system service disruptions and having an alternate source of water for the water system and prompt notification to users of the system;
  - Running out of filters, media, and/or treatment chemicals; and
  - Losing power, and the importance of having a backup power system to keep the water system functional.

3.C. PLANNING FOR WATER SYSTEM DEMANDS AND NEEDS

Noted in Section "2. INTRODUCTION," two of the most important criteria for a private water system owner are water quantity and water quality. Water quantity is important to routinely and consistently meet system demand, and the bottom line is that "you can't treat and provide to customers what you don't have." Water quality is important for public health protection and should meet the basic drinking water quality standards as noted in item "3.C.8.ii. Initial Water Quality Sampling and Testing." Planning for water system demands requires a basic understanding of the capacity of the source in regards to static water level, drawdown during pumping, well yield, and well casing storage and the expected estimated water usage rates etc. Effective planning provides the water system owner several long term benefits, which include, but are not limited to, the following:

- reduce complaints from customers from running out of water or low pressure events,
- avoid cavitation and excessive pump cycling to reduce "wear and tear" on equipment (pump, pressure tank, storage tank, and distribution system), and
- reduce, or prevent, backflow and backpressure events and possible infiltration into the buried distribution system piping.

Data on estimating water consumption shows wide variability between residential, commercial, and institutional facilities as well as the specific and unique situations of hauled water, central watering point, water reuse and recycling, and ice/snow melt systems. Total and Peak Demand should be based on the representative information for the system. Total Demand is the total estimated daily water consumption expected from the users. For a typical residential water system, Peak Demand is the estimated daily peak consumption expected twice daily (morning/evening) for a 20 minute duration. Consideration must also be given to future anticipated expansion, lawn watering or irrigation, and fire protection where appropriate. For basic sanitation purposes, the minimum recommended potable water for a typical residential water system for drinking, cooking, and handwashing is approximately 26 gallons/day per person. Reuse of handwashing or dishwashing water (greywater) for any potable water purpose would require treatment and is not recommended. [From the *EPA WaterSense 2008* publication: The national typical indoor household (residential) water use is approximately 70 gallons/day per person. This includes approximately 33.5 gallons/day per person for flush toilets and clothes washers, and 9 gallons/day per person associated with leaks.]

3.C.1. Well Yield

A Well Yield Test, commonly referred to as a "pump test" or "production test" provides important well production information such as draw down, aquifer recovery, and a sustainable well production rate which are essential for determining the long-term capacity of the water well's aquifer(s) to support the planned water system. This information is necessary to properly select a pump, or pumps, and potential storage requirements for the water system. A Well Yield Test should be completed by a groundwater professional or a PE who has experience in water well evaluations. Additional information about a Well Yield Test is described in the *Alaska Best Management Practices: Construction of Non-Public Water Wells*, June 6, 2016, guidance document.

3.C.2. Well Casing Storage

This is the amount of water actually in the well, from the static water level to the bottom of the well, and is important information for a private water system owner. Well casing storage varies depending on well casing diameter and the height of the water column in the well and can be calculated using the formula: Well Casing Storage (WCS) = $\pi r^2 h \times 7.48$, where (π is pi) = 3.14159, r^2 = half the diameter of the casing (measured in feet) squared, h = height of water column (measured in feet) in the well, and 7.48 = gallons of water in one cubic foot. WCS is expressed in gallons. As previously noted, commonly used residential well casing diameters range from 2 to 10 inches, with 6 – 8 inches most typical. A 6 inch well casing has 1.46 gallons/ft of water storage and an 8 inch well casing has 2.6 gallons/ft of water storage. The larger the casing diameter the greater the WCS; however, the more costly the water well when compared to being drilled using a smaller diameter casing. Much of the WCS water is typically useable because it is above the well pump intake and could potentially be an alternative for the water system to meet Total Demand and Peak Demand without drilling an additional well or having storage tanks.

3.C.3. Total Demand

There are several methods commonly used to estimate Total Demand. For residential use, 75 gallons per day per person or 150 gallons per day per bedroom is typically used. For commercial, recreational, or institutional use, see Appendix B, Table 1. After all uses have been identified for the system, the total daily flow is the sum of the uses.

3.C.4. Peak Demand

Peak Demand typically governs water system design when compared to Total Demand. There are several methods commonly used to estimate Peak Demand. For a single family home, a Peak Demand of 8 gallons per minute (gpm) is typically used. For multiple homes, a reduction per home is allowed after 5 homes; 6-10 homes use 5 gpm per home; and 11-14 homes use 4.3 gpm per home (see Appendix B, Table 3). Fifteen or more homes, based upon population served (25 or more persons) and 15 service connections, becomes a federally regulated public water system classified as a community water system, and not a private water system, and therefore requires Department approval of engineering plans. For commercial buildings, Appendix B, Table 3 can be used to determine estimated Peak Demand based on type of establishment. If a system is proposed for use outside the scope of these tables, a fixture unit analyses can be done using Appendix B, Tables 2 and 4, respectively. A total list of plumbing fixtures for the water system is needed to use this method. Appendix B, Table 2, is then used to obtain a total fixture unit value for the system. Once the total fixture units are summed, Appendix B, Table 4, is used to determine the estimated Peak Demand.

<u>Example:</u> A small subdivision consisting of five 3-bedroom residential homes. This private water system has five service connections from a well and will serve 14 persons (4 homes with 3 persons and 1 home with 2 persons). The estimated Total Demand for the system ranges from a low of 1050 gallons per day (gpd), using the estimate of 75 gallons per person for 14 persons up to a high of 2250 gpd using the estimate of 150 gpd per bedroom for 15 total bedrooms. Assuming only nine bedrooms are occupied by the 14 persons, then the estimated Total Demand based upon actual bedroom usage would be 1,350 gpd which could be a more realistic Total Demand for this small subdivision at this time; however, to allow for future growth and meet water system needs based upon the total number

of bedrooms (15), the Total Demand of 2,250 gpd would be more appropriate in planning both pump capacity and water system storage needs. Additional considerations for estimated Total Demand needs to take into account a fire suppression system as well as seasonal variations in water usage such as washing motor vehicles and watering lawns and gardens. Using the information from Appendix B, Table 3, the estimated Peak Demand for this small subdivision private water system (residential) would be 8.0 gpm per residence, and for the 5 homes in the subdivision Peak Demand would be 40 gpm.

3.C.5. Determining Appropriate Treatment For Your Water System

After clearly identifying the source of water for your water system, either ground water, GWUDISW, or surface water; determining the water needs for the system (Total Demand and Peak Demand); collecting appropriate raw water samples, and also understanding the actual or potential public health risks with the source of water for your water system, it may be necessary to install treatment. For most water systems, the cost to determine treatment needs, then install, operate, and maintain the treatment system are the greatest costs associated with the water system. Consult with a water treatment professional or PE to determine what is needed for your system. In preparing for a water treatment system, the private water system owner and their consultant should consider the following:

- Review all of the raw water quality data collected from the source of your water to determine what you want, or need, to treat for; such as:
  - Disinfection, if using a surface water source, a GWUDISW, or a groundwater source with total coliform bacteria, or "other bacteria" detections.
  - Turbidity, if using a surface water source with seasonal variations in water quality. Consider a filtration technology and the removal performance and costs of this treatment for your water system.
  - Arsenic or nitrates, and depending on the levels detected, the appropriate treatment.
  - Iron and manganese, both of which discolor the water with precipitates (red/brown for iron and black for manganese), stain sink and toilet fixtures, and can plug or reduce pipe flow with tubercles and encrustation throughout the water system.
  - Taste, odor, and color issues which are aesthetically displeasing. Again, consult with a water treatment professional or PE to identify the source(s) of the taste, odor, and color; and determine an appropriate treatment technology.
- Review the "Basic Water Treatment Technologies for Groundwater, Surface Water, and Groundwater Under the Direct Influence of Surface Water Sources" section and the POU/POE treatment technologies summarized in Figure 1. Additional information on treatment technologies is available in the "References" Section of this BMP guidance.
- After a water system treatment plan has been identified, review the following:
  - The cleaning cycle, backwash frequency, filter replacement, or resin regeneration frequency for the disinfectant unit or filtration system, if needed.
  - The necessary chemicals, chemical dosages, and replacement filters and media.
  - The equipment necessary to measure the effectiveness of treatment, if needed, such as colorimeters for disinfection residual and turbidimeters for turbidity.
  - The waste management issues associated with water treatment and the disposal of sludge, residuals, reject water, or resins.
- Most importantly, decide if you have the knowledge, skills, abilities, and finances to build and operate the treatment technologies for your water system. If not, hire a licensed professional engineer registered in the State of Alaska who has water system design, build, and operation experience. See Section "4.B. PROFESSIONAL ENGINEER'S ASSISTANCE TO PRIVATE WATER SYSTEM OWNERS" for additional information. It is recommended that all private water system owners consult with a PE or water treatment professional before modifying or installing any treatment for their water system.

3.C.6. Sustainability and Budgeting

Knowing the well yield, well capacity, Total Demand, and Peak Demand, the private water system owner can determine the sustainability of his system for long-term production (capacity of the system) and the budget necessary to maintain, or in the future increase, the capacity of the system. Key components for sustainability of the water system is its ability to meet Total Demand of 150 gallons per day per bedroom of the residences connected to the system without water storage and Peak Demand of the water system with storage. The inability to meet Peak Demand indicates the well/water system is inadequate and both public health and safety are compromised. Effective budgeting should provide the private water system owner the necessary finances to meet Total and Peak Demands through deepening the well to increase well casing storage, increase water system storage with above ground water tanks, or drilling additional water production wells.

3.C.7. Pump Selection

Well production (flow) needs to be evaluated to determine if there is sufficient water quantity to meet expected Total and Peak Demands. In order to evaluate well production, well logs and test pumping information is needed. Well yield and drawdown data is obtained from test pumping the well and used to determine adequate production rates when selecting a well pump. If the well is capable of meeting peak demand requirements, then the well pump is sized for Peak Demand. If the well is not capable of meeting Peak Demand, but is capable of meeting total demand, then equalizing water storage is needed to meet peak demand. If the well is not capable of meeting Total Demand, then a supplemental water source may be needed.

3.C.7.i. Well Pump

A pump is used to lift or push water from the well to consumers. There are several different types of pumps: submersible, jet, turbine, and cylinder. Both submersible and jet pumps are most commonly used by private water systems. Submersible pumps are typically used in the deeper drilled wells with casing diameters greater than 4 inches; however, there are some pumps which can be used in casings with a 3 inch diameter. Jet pumps are most often used on wells 3 inches or less in diameter, such as drive point or shallow cable tool or rotary drilled wells. The well pump is sized based on the flow needed and the Total Dynamic Head (TDH). The TDH is the overall head (or pressure) the pump needs to overcome to produce the desired flow rate to the building(s). TDH is based on the difference in elevation between the pump and the highest point in the system, friction through pipe from the well pump to the building, and the minimum working pressure for the system (typically 30 pounds per square inch (psi) measured at the pressure tank). Elevation, friction, and pressure are all converted into equivalent feet of waterhead and summed to obtain TDH.

<u>Example:</u> A building with a 1-bedroom apartment and an office with four employees have a well to provide potable water for the private water system. The Total Demand for the system is 210 gpd and the Peak Demand is 12 gpm. The well pump is located 100 feet (ft.) below the ground surface and the pressure tank is located 4 ft. above the ground surface located in a locked well house. Therefore, the total elevation head is 104 ft. Pipe friction is a function of flow and pipe size (see Appendix B, Table 5). For an estimated Peak Demand of 12 gpm, using 90 ft. of 1-inch steel drop pipe in the well casing and 75 ft. of ¾-inch copper water line from the well to the building, from the friction loss chart at 12 gpm, 16.4 ft. of head loss is obtained for every 100 ft. of steel pipe = 0.9(16.4 ft.) = 14.76 ft. Plus 33.2 ft. of head loss for every 100 feet of copper pipe = 0.75(33.2 ft.) = 24.9 ft. Therefore, 14.8 ft. + 24.9 ft. = 39 ft. The pressure head of 30 psi is converted into feet by: (30 psi) x (2.31 ft./psi) = 70 ft. Therefore, the TDH = elevation (104 ft.) + friction (39 ft.) + pressure (70 ft.) = 213 ft.

The well pump can now be selected from a pump supplier by stating that the pump needs to be capable of producing 12 gpm against 213 ft. of total dynamic head. A pressure tank also needs to be selected to match the well pump. The rule of thumb, is to size the pressure tank equivalent to at least one minute of pump run time, although longer run times may be necessary for pumps with larger motors (>1 HP). In this case, the pump is selected to produce 12 gpm, therefore, 12 gallons of effective storage is needed from the pressure tank. This minimum size ensures the pump will not cycle (turn off and on) excessively. In general, pressure tanks are typically 25 percent effective storage, therefore, a 48 gallon pressure tank would be needed to have 12 gallons of effective storage for the water system. It is best to contact a pressure tank vendor who can recommend a pressure tank suitable for the well pump and system configuration.

3.C.7.ii. Equalizing Storage

If equalizing storage is needed, the well pump is sized for the maximum well flow that can safely be obtained from the well, and this is the importance of a Well Yield Test for determining the long-term capacity of the well to support the water system. Equalizing storage consists of atmospheric storage tank(s) and a booster pump capable of meeting the estimated Peak Demand for 20 minutes. The booster pump supplies water to the water system using the water available from the storage tank. The well pump fills the storage tank as the water level is lowered in the tank. [Note: Hydropneumatic pressure tanks typically provide very limited storage (the amount of storage they provide for equalization is small compared to their total volume) and are not recommended for equalization storage.. This is explained in the "Example" below.]

Example: The private water system for a building with a one bedroom apartment and an office with four employees has an estimated Total Demand of 210 gpd and the estimated Peak Demand is 12 gpm. The well yield for this water system is 6 gpm which is only half of the estimated Peak Demand. If 12 gpm is needed for 20 minutes (240 gallons) and the well can only supply half of this, then the other half (120 gallons) is supplied by storage tanks. Pressure tanks can also be used as equalizing storage; however, it would take 480 gallons of pressure tank storage to produce 120 gallons of effective storage because pressure tanks are typically only 25% effective storage. An atmospheric storage with a booster pump is typically more efficient than pressure storage to create equalizing storage. In this example, a 120-gallon atmospheric storage tank is used in conjunction with a 12-gpm booster pump, and in this example, the booster pump uses a pressure tank for pump protection, and the well pump is controlled by a float or pressure switch located on the atmospheric tank.

3.C.8. Distribution System

If more than one building is to be served by the well, then a distribution system is needed to supply water to each building. There are a variety of piping schemes that can be used to provide adequate distribution of water throughout the system to avoid "dead ends" and potential low pressure zones. However, the hydraulic analysis for a distribution system is beyond the scope of this guidance document. The same pump sizing principles are used as shown above; however, flow and friction for each branch in the distribution system are more complex to analyze. Larger systems use computer models to obtain this information. The Department recommends that the distribution system be designed by a PE with experience in water distribution systems and fluid dynamics, to ensure that all buried water lines will perform as expected.

3.C.8.i. Cross Connections

Before start-up of the water system, the owner needs to verify, by visual inspection, that there are no cross connections, or unprotected cross connections (without appropriate backflow preventers installed) present in the system. A cross connection is any structural arrangement in which a potable water system is connected, directly or indirectly, with "end-use" potential public health hazards. Potential "end-use" public health hazards include, but are not limited to: unapproved water system, sewer, drain, conduit, pool, fire flow/storage reservoir, plumbing fixture, or other devices that contain, or might contain wastewater or other substances of unknown or unsafe quality that might be capable of contaminating the water supply through backflow (reverse pressure gradient) or back-siphonage (often due to a loss of water system pressure).

<u>Example:</u> Boiler-type heating systems are one of the most common potential cross-connection for private water systems in Alaska. The make-up water line needs to be protected using a listed backflow prevention assembly, to prevent the heating fluid (glycol) from entering the water system, in the event there is a loss of pressure within the water system. Boilers may have built in backflow prevention devices that are hard to visually identify without the owners operation and maintenance manual. Before installing any backflow prevention device on a home heating system check the manufacturer's literature to verify accurate placement. A backflow prevention device installed improperly can damage your boiler and invalidate manufacturer warranties.

3.C.8.ii. Backflow Preventers

Specific to water systems, "backflow" means any unwanted flow of used or non-potable water or substances from any domestic, industrial, agricultural, or institutional piping system into the potable water distribution system. Backflow preventers are either a simple physical separation, such as an air gap, or mechanical assemblies. The five distinct (basic) types of backflow preventers include: air gap, Atmospheric (non-pressure) Type Vacuum Breaker, Pressure Vacuum Breaker, Double Check Valve Assembly, Reduced Pressure Principle Assembly, and Double Check Detector Assembly. The selection of the appropriate backflow preventer needs to be based upon the most suitable for the situation and is the responsibility of the water system owner. It is important to note that the air gap, with a physical separation of twice the diameter of the pipe, but not less than an inch, is the only acceptable means of protection against lethal hazards.

3.C.8.iii. Dead Ends

For water systems, dead ends are areas in the distribution system or in buildings (interior plumbing) with uncirculated potable water. The layout (design) of the distribution system or interior plumbing affects the frequency and severity of dead ends. Dead ends often pose a health problem for consumers because as the water ages, it warms and becomes stagnant, the disinfectant residual declines, and both the microbiological (bacteria, viruses, and protozoa) growth activity and disinfection by-products increase. The water in the areas of dead ends often have taste and odor problems and this results in consumer/customer complaints and sometimes outbreaks of illnesses. The potential negative health effects as well as the undesirable aesthetic effects (taste, odor, and color) associated with dead ends can be minimized through routine flushing of the distribution system. [See Section 5.B. FLUSHING for information on water system flushing programs.]

3.C.9. Completion of a Water System

3.C.9.i. Disinfection

The well is drilled, cased, perforated, a pump yield test completed and the well has been disinfected and flushed. The well pump selected and installed, storage needs have been determined, the storage tank purchased and installed, and the distribution system installed and checked for cross connections. The water system installation has been completed, and now the complete water system needs to be disinfected and flushed.

Disinfect the well using a chlorine-containing compound (sodium hypochlorite is an example) that will provide a concentration of at least fifty parts per million (50 ppm) as free chlorine throughout the complete volume of the well. In many cases the most readily available disinfectant is liquid "bleach", typically 4-6% sodium hypochlorite. The many different brands and versions of bleach differ significantly and may have many additives to aid laundry or cleaning processes that would not be appropriate for use in drinking water systems ("lemon scented", "stain remover", "splashless", "gel" etc.). "Clorox Regular" bleach is 5.25% sodium hypochlorite, has no additives and has been approved by NSF as an additive to drinking water. Also, the effectiveness of liquid bleach decays with time. The shelf life of sodium hypochlorite will decrease with warm temperatures, sunlight, and exposure to air (loose fitting caps). "Clorox" states that their bleach should remain "highly effective" for approximately six months. If stored appropriately, bleach used for disinfection should be less than a year old.

Before adding any chemical to any part of a water system, the label should be checked carefully to ensure that it is appropriate and safe. A chlorine solution (1-quart bleach per 10 gallons of water) is introduced into the well casing. This should provide a disinfection concentration of approximately 50 ppm as free chlorine to the entire well, pumps, storage tanks, and throughout the distribution system. <u>NOTE:</u> Higher levels of chlorination can damage parts of your home water system including water softeners and pressure tanks.

The water system is then operated until a chlorine odor can be detected from each plumbing fixture in the building. As the water system is operating, run a hose from the closest hose bib back to the well to circulate the chlorinated water and get some turnover in the well. Additionally, as the water system is operating, fixtures (faucets, taps, etc.) are opened in an organized and systematic manner moving out into the distribution system away from the well or treatment system to best ensure that chlorinated water reaches all branches (segments) of the distribution system. The chlorinated water is allowed to sit in the system a minimum of six hours, preferably overnight. The system is then flushed by operating the system until all the chlorinated water is removed from the system and a chlorine odor is no longer detected. The time needed for flushing the well will vary based upon well volume (depth of well and well bore diameter), size of storage tank(s), length and volume of the distribution system, and pumping rate used for flushing.

3.C.9.ii. Initial Water Quality Sampling and Testing

The water system should be properly sampled and tested for arsenic, bacteria (total coliform and other bacteria), and nitrate contamination after it has been disinfected and thoroughly flushed. This testing should be done to establish a baseline of the water quality of the system and needs to be completed before water is provided to consumers to determine whether a water quality issue exists, and whether treatment of the water is required. Sampling should be completed by a groundwater professional, a PE, a certified laboratory, or the water system owner under the guidance and instructions from a State-certified laboratory.

Water quality analyses of samples collected from a private water system should be completed by a State-certified laboratory (DEC or another state) for drinking water analyses. A listing of DEC-certified labs for drinking water can be found at:
http://dec.alaska.gov/applications/eh/ehllabreports/certmicrolabs.aspx (microbiological contaminants) and
http://dec.alaska.gov/applications/eh/ehllabreports/certchemlabs.aspx (chemical contaminants).

Drinking water quality standards for the basic contaminants of primary concern for private water system owners include:

- Total coliform bacteria – 0 colonies per 100 milliliters (mL),
- nitrate – 10 milligrams per liter (mg/L) (equivalent to 10 parts per million), and
- arsenic – 0.010 mg/L (equivalent to 10 micrograms per liter, μg/L or 10 parts per billion). Arsenic is a naturally occurring substance in Alaska groundwater and surface water, and is tasteless, colorless, and odorless when dissolved in water.

Well water quality parameters that should be tested for under a "general mineral" analysis include; alkalinity, pH, hardness (calcium carbonate), iron, manganese, and total dissolved solids. This information is important as part of the baseline for the water system's water quality and will also be important for determining any future disinfection chlorine demands as well as other water treatment processes, if needed. Additional sampling is recommended when there is a potential of contamination, such as from a contaminated site nearby or naturally occurring contaminants such as fluoride or radionuclides have been detected in nearby drinking water sources.

4. APPLICABLE WATER TREATMENT TECHNOLOGIES AND TESTING

4.A. WATER TREATMENT TECHNOLOGIES FOR GROUND WATER, GROUND WATER UNDER THE DIRECT INFLUENCE OF SURFACE WATER, AND SURFACE WATER SOURCES

The decision to treat any source of drinking water should be based upon public health protection and should also consider both appropriate and applicable treatment technologies necessary for the water system. Appropriate treatment technologies are those that can be sustained by the water system owner and include financial (installation, operation, and maintenance costs of the system), education (knowledge, skills, and ability to effectively operate the system), and technical considerations (complexity of the treatment process). Applicable treatment technologies focus on the technical aspects of the treatment process – basically, "can the treatment do the job."

The water treatment process basically occurs in 4 stages: collection of the water (the well or surface water intake), treatment process using one or several treatment technologies, storage of the treated water, and distribution of the final product - safe drinking water. The choice for an applicable treatment technology may be that it is implemented as "centralized treatment" (one central location with a distribution system or a watering point) or may be Point-of-Entry (POE) treatment or Point-of-Use (POU) treatment. POE water treatment system treats all the water entering a building, business, or residence. A POU water treatment system treats only parts of water in a building, a business, or a home. Typically, a POU water treatment system is installed on one fixture (faucet) in building, business, or home, and this is used for drinking water. The "Water Treatment and Testing" Section of this BMP for Private Water Systems focuses on applicable technologies and it is important to note that the final decision to choose the appropriate technologies is the responsibility of the water system owner in consultation with a water treatment professional or a PE. The overall public health protection goal for the private water system owner should be to treat the water to meet the MCLs for any of the regulated drinking water contaminants. For those private water systems using a surface water or groundwater under the direct influence of surface water source, the water should be treated to meet the MCLs set in 18 AAC 80.300. The treated water turbidity should be less than 1.5 nephelometric turbidity units (NTU) and for public health protection, removal/inactivation of *Giardia lamblia* should be at least 99.9% (3 log) and at least 99% (2 log) for *Cryptosporidium*.

4.A.1. Materials Selected for treatment, Storage, and Distribution System

All materials (chemicals, filters, hoses, liners, pipes, pipe fittings, tubing, storage/reservoirs, and mechanical assemblies such as meters and backflow preventers) that come in contact with potable water should be approved by NSF/ANSI, Underwriter Laboratories, Water Quality Association (WQA) or an equivalent organization that evaluates products using NSF Standards 53, 55, 60, and 61. All treatment technologies selected for a private water system should have the treatment efficacy verified for use by a third party organization such as NSF/ANSI, Underwriter Laboratories, Water Quality Association (WQA) or an equivalent organization.

4.A.2. Disinfection

Disinfection is the chemical or UV radiation treatment of the water to destroy (oxidize) or inactivate micro-organisms (bacteria, viruses, algae, and protozoa) in the water. There are two levels of disinfection; primary disinfection which destroys or inactivates micro-organisms in the water and secondary disinfection which provides a measurable residue in the water throughout the distribution system. The different applicable methods of disinfection for private water systems could include:

3.A.2.i. Chlorination (Chlorine Disinfection)

Chlorination using sodium hypochlorite (chlorine beach) is the most commonly used and least expensive disinfectant for private water systems that disinfect their drinking water. Chlorination is very effective against many types of pathogenic bacteria and viruses and can be used in pretreatment to oxidize iron and manganese, and post treatment to provide both primary and secondary disinfection. Chlorination is not is not an effective disinfectant against the parasitic protozoans *Giardia lamblia* or *Cryptosporidium sp.* Sodium hypochlorite is available as a solution in concentrations of five to 15 percent chlorine. It is more expensive to use than chlorine gas but it is safer and easier to handle than chlorine gas or calcium hypochlorite; however, it is very corrosive and does require special handling, storage, and use procedures.

The overall effectiveness of chlorination is dependent upon several factors, which include: water temperature, water pH, turbidity (cloudiness) of the water, overall general water quality (hardness and organic colloidal material), and the amount of chlorine used (dosage and contact time).

- Water temperature – colder water decreases the effectiveness of chlorination and to achieve the desired/required contact time, an increase in chlorine concentration is required. Chlorination is more effective at higher temperatures.
- Water pH – lower pH (5.5 -7.3) increase the effectiveness of chlorination.
- Turbidity – an increase in suspended solids (measured as "turbidity") decrease the effectiveness of chlorination.

- Overall water quality parameters such as hardness and organic colloidal material reduce the effectiveness of chlorination, especially in cold water.
- Chlorine dosage is the amount of chlorine required to meet the chlorine demand of the water system based upon overall water quality, water temperature, water pH, turbidity, and the necessary contact time to produce a desired residual in the distribution system. Both dose and contact time are extremely important to achieve proper and effective primary and secondary disinfection. Disinfection efficacy is a critical component of the treatment process and the dose, contact time, and baffle factor necessary to achieve effective contact time should be part of the design of the treatment system completed by a PE. This information should be included in the operation and maintenance manual for the water system.

4.A.2.ii. Less Commonly Used Disinfectants

Less commonly used disinfectants include calcium hypochlorite (solid bleach pellets), chlorine gas, chloramines, ozone (ozonation), ultraviolet light (UV radiation), chlorine dioxide, and onsite chlorine and mixed oxidants. From the less commonly used disinfectants, both ozone (ozonation) and ultraviolet light (UV radiation) are effective primary disinfectants for the treatment of bacteria and viruses, parasitic protozoans (ozone) and inorganic contaminants (ozone); however, a secondary disinfectant is required for both UV radiation and ozone to maintain a detectable chlorine residual in the distribution system.

4.A.3. Filtration

Filtration is the process of removing particles of organic material (bacteria, viruses, protozoa, and algae) and inorganic material (suspended solids, minerals, and chemicals) from the water. The filtration of particles from the water includes physical (mechanical), chemical, and biological processes and occurs by several ways: sieving (straining), adhesion (attraction of electrically-charged particles), "in-depth" filter trapping, and microorganism trapping at the surface of the filter. Mechanical filtration systems include cartridge and plate filters (membranes), media and multimedia filters (sand and other porous materials) and precoat filters (such as diatomaceous earth). Media filtration systems which use sand or other fine-grained porous materials have the greatest contaminant removal capacity; however, they typically require more space (larger footprint) than other filtration technologies. Cartridge filters consisting of woven fiber, organic cellulose membranes, or ceramic filter material are made with smaller and more uniform pore sizes and typically are more reliable in removing small particles than media filters, and also require less space (smaller footprint) than media filters.

Which filtration process a private water system owner selects in consultation with a water treatment professional or a PE depends on the concentration and size of suspended solids in the water, the contaminants to treat for, and rate at which the water needs to be treated. Typically, the higher the quality of treatment required, the more time consuming the process and increased costs. The different applicable methods of filtration for private water systems could include:

4.A.3.i. Direct Filtration

Direct Filtration systems use sand-size material, most commonly quartz sand, as the filtration media. The basic difference between Direct Filtration (coagulation, flocculation, and filtration processes) and Conventional Filtration (coagulation, flocculation, sedimentation, and filtration processes) is that Direct Filtration does not have a sedimentation phase. The Direct Filtration treatment process is commonly used in pressure vessels and allows for a "smaller footprint" and compact design for a water treatment system. A Direct Filtration treatment system using the "package plant" concept consisting of skid mounted, compact, fully factory assembled and transported onsite, and ready to go treatment system, could be appropriate for private water systems with high quality source water, such as ground water or ground water under the direct influence of surface water which have low suspended solids (turbidity) and the water also has iron and manganese, or arsenic, or nitrate contaminants to remove. Direct filtration with a pretreatment (oxidation with a disinfectant such as chlorine, potassium permanganate, or ozone) is commonly used in small water systems for removal of iron and manganese as well as arsenic. Package plants using direct filtration offer small water system owners a benefit due to their compact size (small foot print), relative ease of operation using primarily automated operational designs, and cost effectiveness associated with savings in engineering, design and installation. The challenges associated with use of a Direct Filtration System in a package plant design is that the efficiency of the system is directly tied to high quality source water (low suspended solids) and the system has limitations to simultaneously treat for multiple contaminants such as metals, semi volatiles, volatiles, and radionuclides due to its compact design and small footprint.

4.A.3.ii. Membrane Filtration

Membrane Filtration is an advanced filtration process using pressure and a variety a polymers (organic cellulose membranes) or sintered metals or porous alumina (inorganic membranes) to create a semi-permeable material to physically remove material from the water. The higher the level of filtration removal for membranes the greater the energy required for the filtration process and the more reject water produced for each gallon of treated water.

4.A.3.ii.a. Microfiltration/Cartridge Filters

Microfiltration (MF) is a very commonly used membrane treatment technology and a very applicable technology for a private water system. It operates at low pressures and larger filter pore sizes (0.1 – 10 microns) when compared to the other membrane treatment technologies, Ultrafiltration (UF) or Nanofiltration (NF). Spiral-wound and pleated cartridge microfiltration modules, commonly referred to as Cartridge Filters, are placed in a pressure vessel and are routinely used for drinking water treatment. Microfiltration effectively removes sand, silt, and clay-sized materials as well as *Giardia lamblia* and *Cryptosporidium sp.* cysts and most bacteria from the water. Microfiltration membrane filters require low suspended solids influent waters to avoid fouling of the membrane, and the overall microfiltration process typically precedes more advanced membrane treatment processes such as UF, NF, or Reverse Osmosis. MF is not an absolute barrier to viruses and, overall, has limited removal effectiveness for viruses.

4.A.3.ii.b. Ultrafiltration

Ultrafiltration (UF) is a medium pressure membrane system with a small pore size (nominal size range from 0.002 – 0.1 microns) and very effective for removal of some organic material, especially liquid/solid separation. UF is effective in removal of protozoa cysts, most bacteria and viruses; however, UF is not an absolute barrier to viruses.

4.A.3.ii.c. Nanofiltration

Nanofiltration (NF) is a high pressure membrane system with a very small filter pore size (nominal size of 0.001 micron) for removal of ions (charged particles) associated with hardness such as calcium and magnesium, as well as color (tannins) and other humic material commonly associated with the formation of disinfection by-products, and also microbiological contaminants. NF is an effective barrier to viruses.

4.A.3.ii.d. Reverse Osmosis

Reverse Osmosis (RO) is a very high pressure semi-permeable membrane technology with an extremely small nominal filter pore size (< 0.001 microns) for very high removal efficiencies (>70 - 96 percent) of nearly all inorganic contaminants (arsenic (III), arsenic (V), barium, cadmium, chromium (III), chromium (VI), fluoride, lead, mercury, nitrate and nitrite, selenium (IV), selenium (VI), and silver from water. Properly operated RO units, commonly used in series, are very effective in removal of radium, natural organic material (humic colloidal material), pesticides, and microbials (protozoa cysts, bacteria, and viruses). RO is a more expensive technology to install, operate (operator skills), and maintain when compared to other filtration technologies and requires very low suspended solids in the source water to operate most effectively.

4.A.3.iii. Bag Filtration

Bag Filtration is a physical screening process of the water. The effectiveness of the screening process is dependent on the pore size of the bag filter for the sieving and impingement of particles, and the overall quality of the source water. The smaller the pore size the greater the potential for removal efficiencies; however, pretreatment is typically necessary to achieve the greatest filtration efficiencies without clogging the pores of the bag filter when treating water with high values of suspended solids (turbidity) or humic colloidal (organic) material. Bag filtration is becoming less common due to the costs of the materials and also because MF and the use of cartridge filters and the other membrane technologies have become increasing more cost effective.

4.A.4. Ion Exchange

Ion Exchange is used in water treatment to remove ions (charged particles) and dissolved solids (organics and inorganics), and purify water. Ion Exchange (IO) is an ion for ion exchange process typically using a charged synthetic polymer resin (cation exchanger [+], anion exchanger [-], or amphoteric exchanger [+] and [-]) of similar charge where the undesirable contaminants are removed from the water by exchange with another non-objectionable, or less objectionable, substance from the resin medium. "Hard water", which is water with significant amounts of dissolved solids, primarily calcium and magnesium ions, is commonly treated using a water softener, or a cation (+) exchange unit packed with salt. The resin medium is "packed" in a column, commonly referred to as "packed bed", and is usually regenerated using sodium chloride or potassium chloride.

4.A.4.i. Ion Exchange Units

Ion Exchange Units are very effective and commonly used in water systems using groundwater for removal of hardness cations (calcium and magnesium) as well as nitrates, and can effectively remove more than 90 percent of barium, cadmium, chromium (III), silver, radium, nitrites, selenium, arsenic (V), and chromium (VI). Ion Exchange treatment is also typically the best choice for small water systems that need to remove radionuclides and should only be considered for removal of limited (small) quantities of iron and manganese to avoid rapid clogging of the system.

4.A.4.ii. Specialty Adsorption Media

Specialty Adsorption Media for Ion Exchange include ferric (Fe+3) hydroxide, ferric oxide, or iron-enhanced anion (-) exchange resins in a "packed bed" column for specific removal of select contaminants in drinking water, most commonly used for arsenic removal.

Ferric (+3) hydroxide anion exchange resins are also effective in removal of anions of chromate, perchlorate, and phosphate. Specialty Adsorption Media can be used for point-of-entry (POE) and point-of-use (POU) treatment; however, maintenance of the resin cartridges should be sent to water treatment professionals for either regeneration or disposal.

4.A.4.iii. Activated Alumina

Activated Alumina (AA) is a Specialty Adsorption Media used in an Ion Exchange "packed bed" column and is effective treatment method for source water with high total dissolved solids or sulfate levels; and in the removal of arsenic, chromium, fluoride, and selenium. Treatment success for AA is pH dependent and pretreatment is required for source water with high suspended solids. AA can be used as POE and POU treatment; however, maintenance of AA resins/cartridges should be sent to water treatment professionals for regeneration and/or disposal.

4.A.5. Organics Removal

Organics Removal for drinking water includes treatment technologies for volatile organic compounds (VOCs) and synthetic organic compounds (SOCs), and the non-organic compounds, hydrogen sulfide gas, and radon. The most effective treatment technologies for these contaminants is aeration and Granular Activated Carbon (GAC).

4.A.5.i. Aeration

Aeration, also referred to as "Air Stripping", is mixing water with air using various means, such as diffusion (bubbles), mechanical (impellers, paddles, and pumps) spraying (jets and nozzles), and multiple trays/shallow trays (slotted, corrugated, or wired surfaces) to increase the oxygen saturation of the water to volatize (evaporate) the gaseous compounds. The volatized gaseous compounds are collected by passing them through GAC contained in a column (vessel) or if using a POU/POE treatment unit, a cartridge filter. Aeration is typically used as an effective treatment for volatile (gaseous) contaminants and requires the venting of gases, most commonly through a GAC filtration system.

4.A.5.ii. Granular Activated Carbon

Granular Activated Carbon (GAC) is a powdered form of carbon and is used in columns, vessels, and filters to adsorb gaseous contaminants in drinking water. GAC is very effective in removing volatile organic chemicals (paint thinners, solvents, etc.) and synthetic organic chemicals (pesticides) in lieu of air stripping; however, the GAC can only be operated for a specified period of time before the adsorption capacity is depleted (referred to as "spent") and the target contaminant passes through the system unaffected. Activated carbon filters are typically used post treatment and as a polishing filter to remove unwanted taste, odor, chlorine and iodine residuals, detergents, and radon; and for waters without bacteria present because bacteria growth will coat and plug the filter media. GAC is not effective in removing microbiological contaminants, sodium, nitrates, fluoride, and hardness. Spent GAC media and GAC cartridge filters should be sent to water treatment professionals for either regeneration or disposal. Depending on the type and concentration of contaminant being removed, such as radon, may classify spent GAC media and/or filters as hazardous waste and require time consuming and expensive waste handling and management. GAC cartridge filters are commonly used as pour-through POU pitcher units and also POE units; however, POE units should be used for drinking water treatment of volatile organic chemicals, synthetic organic chemicals, and radon before entering the residence or business.

4.A.6. Point-of-Use/Point-of-Entry (POU/POE) Treatment Units

A POE water treatment system treats all the water entering a building, business, or residence. A POU water treatment system treats only parts of a water system in a building, a business, or a home. Typically, a POU water treatment system is installed on one fixture (faucet) in the building, business, or home, and this is used for drinking water. POU/POE treatment units are capable of providing disinfection, filtration, ion exchange, and distillation of water sources for drinking water purposes. When selecting an appropriate POU/POE treatment system for a private water system, the owner, in consultation with a water treatment professional or a PE, needs to consider what contaminant(s) should be removed from the drinking water and which POU/POE treatment unit will most effectively remove the contaminant(s). See Figure 1, (page 37) for a summary of POU/POE Treatment Systems, Costs, and Operation/Maintenance Skills. All POU/POE treatment units and materials should be approved by NSF/ANSI, or Underwriters Laboratories, Inc., (UL), or Water Quality Association, Inc., or an equivalent standards certification organization. Important standards to review for POU/POE treatment units includes: NSF/ANSI Standard 53, *Drinking Water Treatment Units-Health Effects* and NSF/ANSI Standard 58, *Reverse Osmosis Drinking Water Treatment Systems*.

Note: Criteria for selection of an appropriate POU/POE treatment unit should include:

- quality of the source water from recent sampling and analyses;
- type of contaminant(s) and the level (concentration) of contaminants;
- desired level of treatment and an understanding of health effects of the contaminant(s) would be helpful in making this decision; and
- waste disposal issues associated with spent filter cartridges, resins, media, and brines need to be considered.

4.A.6.i. Disinfection

Disinfection is completed with POU/POE treatment devices using either chlorination, ultraviolet light radiation (UV), or ozone. Chlorination and ozonation are reactive and oxidizing disinfectants which destroy most microbial pathogens (bacteria and viruses with chlorination); and bacteria, viruses, and protozoa with ozonation). Ozonation is also effective for controlling hydrogen sulfide (undesirable odor) and dissolved metals (iron and manganese). UV radiation is a passive and primary disinfectant which inactivates rather than kills microbiological organisms. UV leaves no taste, odor, or color in the treated water and therefore provides no disinfectant residual, or secondary disinfection.

4.A.6.ii. Microfiltration

Microfiltration (MF) – see item 3.A.2.ii.a. Microfiltration in the Membrane Filtration section for basic information on MF.

4.A.6.iii. Reverse Osmosis

Reverse Osmosis (RO) – see Item 3.A.2.ii.d. Reverse Osmosis (RO) in the Filtration/Membrane Filtration section for basic information on RO.

4.A.6.iv. Multimedia Filters

Multimedia filters consisting of either Activated Carbon, Solid Block Carbon, or Activated Alumina are very effective for removal of volatile organic chemicals, trihalomethanes (TTHMs), pesticides, radon, lead, mercury, arsenic, cadmium, barium, and fluoride. Multimedia filters are also effective for treating aesthetic issues associated with drinking water which include taste, odor, and color. Disposal or regeneration of filters should be handled by, or sent to, water treatment professionals.

4.A.6.v. Ion Exchange

Ion Exchange - see item 3.A.3.i. Ion Exchange Units in the Ion Exchange section for basic information on the Ion Exchange processes. For POU/POE treatment, Ion Exchange treatment is most typically used for water softening (calcium and magnesium ions removal), dissolved iron and manganese removal, arsenic and nitrates removal, and to a lesser extent; lead, mercury, cadmium, barium, and fluoride removal. As with multimedia filters, the disposal or regeneration of ion exchange cartridges (resins) should be handled by, or sent to, water treatment professionals.

4.A.6.vi. Aeration and Granular Activated Carbon (GAC)

Aeration and Granular Activated Carbon (GAC) filters are POE treatment units used to commonly remove volatile organic compounds (VOCs), hydrogen sulfide (gas), and radon from drinking water. See the "Organics Removal" section for the basic information on aeration and GAC.

4.A.6.vii. Distillation

A POU Distillation device disinfects water by boiling and collecting the resulting steam which cools and condenses in a separate chamber. The treated water is referred to as "distilled" and is relatively free of many contaminants. Distillation commonly removes approximately 99.9% of the dissolved minerals in the water. Distillation is effective treatment for some metals; dissolved solids (iron and manganese); most microbiological contaminants (bacteria, viruses, and protozoa cysts); inorganic materials such as nitrate, sodium, fluoride, and sulfate; some toxic organic chemicals; and hydrogen sulfide (undesirable odor). Distillation is not effective for removal of volatile and semi-volatile organic compounds and some bacteria.

Note: After installation of a POU/POE treatment unit, the operation, maintenance, and monitoring program for the unit should be established in writing by the water system owner, in consultation with a water treatment professional or a PE, and should be site specific for the unit and document contaminants being removed. A POU/POE monitoring program should include:

- raw and treated water sample collection and documentation of sample analyses;
- monitoring equipment meter reading documentation;
- field analyses to include measurement of pH, dissolved oxygen concentrations, and other applicable treatment unit parameters which will influence drinking water quality and performance of the POU/POE unit;
- shipment of samples (if collected for specific treatment units or treatment parameters) to a certified laboratory for analyses; and
- record keeping.

4.A.7. Corrosion and Corrosion Control

Corrosion Control is a system of processes used by water system owners and operators to control corrosion. Corrosion Control treatment technologies are most commonly used by water systems owners for lead and copper leaching issues within the distribution system.

4.A.7.i. Types of Corrosion

Corrosion is a complex oxidation/reduction primarily chemical decomposition process and the resulting dissociation reaction (leaching) of metal ions from pipes, tanks, faucets, and other fixtures which are in contact with water in the distribution system. Corrosion is most often associated with metal pipes (copper, iron, and lead) and solder joining pipes; however, corrosion of plastic PVC plumbing components is also possible and this typically occurs when inferior quality (not NSF/ANSI approved and stamped) PVC pipes and glues are used. Corrosion of PVC pipes could result in unhealthy amounts of vinyl chloride in drinking water. There are four basic types of corrosion associated with water systems, chemical (most common), physical, bio-chemical, and electrochemical (most often found in buildings and residential homes).

4.A.7.ii. Corrosion Control

Commonly used corrosion control techniques include controlling water pH using lime softening, reducing the hot water temperatures (used most often in buildings and residential units), and corrosion inhibitors (inorganic phosphates, silicates, and a mixture of phosphates and silicates).

4.B. PROFESSIONAL ENGINEER'S ASSISTANCE TO PRIVATE WATER SYSTEM OWNERS

For those private water systems using a surface water source, GWUDISW, or a groundwater source which requires treatment, the owner should consult with, or hire, a PE to design, build or contract out the building of the system, and complete initial startup and testing of the water system. The PE should have experience in water system design and operation and should provide, or should be expected to complete, or assist the private water system owner in the completion of the following:

- Prepare water system designs that will function properly and as designed, and operate safely, reliably, efficiently, and cost effectively, as much as practical.
- Prepare complete construction project cost estimates and project schedules and provide to the private water system owner for review and discussion.
- Prepare detailed construction documents for the selected alternative and desired outcome from water treatment.
- Assist the private water system owner in obtaining approvals or permits from any reviewing authority of agency.
- Assist the private water system owner in developing the contract, solicitation of bids, and evaluation of bids from prospective contractors to complete the work.
- Routinely inspect the quality of the selected contractor's work and prepare reports to the private water system owner with recommendations concerning the status of the project and that the system was built to design construction documents.
- Review the start-up of the water system with the contractor and private water system owner.
- Provide training to the owner, or operator, on the operation and maintenance of the water treatment system and sampling procedures for the water system.

4.C. WATER SYSTEM OWNER/OPERATOR TRAINING

All private water systems adding chemicals or using any form of treatment (Disinfection, Filtration, Corrosion Control, Ion Exchange and Demineralization, Organic Removal, and Lime Softening, etc.) should have a properly trained operator with the knowledge, skills, and ability to effectively operate and maintain the treatment for the water system.

4.D. ROUTINE POTABLE WATER TESTING

Private water systems should routinely test the quality of their drinking water regardless of whether the system is connected to a groundwater, GWUDISW, or surface water source, and whether it has treatment or not. Both raw and treated water should be sampled and routinely tested to detect any noticeable changes in source water quality (raw water sampling) and to determine the effectiveness of treatment (treated or "finished" water sampling). The following recommendations should be considered as the minimum routine sampling and testing.

4.D.1. Groundwater Systems

- Private water systems using groundwater without treatment should be sampled and tested semi-annually (twice a year), and at the same time each year. The samples should come from the distribution system. The sampling and testing should include the basic water quality parameters of total coliform bacteria, nitrates. The sampling and testing for arsenic should be done annually if arsenic was detected at elevated levels from the initial well water quality testing or if arsenic has been detected at elevated levels in locally nearby water wells.
- Private water systems using groundwater with treatment should sample the well water before treatment (raw water) annually (once a year) for the basic water quality parameters (total coliform bacteria, nitrates, and also sample the treated water collected from the distribution system (faucet tap) quarterly, or more frequently, depending on what contaminant(s) or treatment process the water system is providing. If disinfection is the treatment, then monthly chlorine disinfection residual levels should be measured using an approved method, and the chlorine residual measurement recorded. Additionally, the free chlorine residual should be greater than 0.2 ppm. If treating for nitrates or arsenic, then the routine sampling should be conducted to make sure the treatment is effective.

4.D.2. Surface Water and GWUDISW Systems

- Private water system using a surface water or GWUDISW source without treatment is not recommended or supported by this BMP.
- Private water systems using a surface water or GWUDISW source with treatment should be sampled and tested at a minimum of monthly, or more frequently, depending on what contaminant(s) or treatment process the water system is providing. The sampling should be for the basic water quality parameters of concern (total coliform bacteria and nitrates), as well as the contaminant for which treatment was installed. Daily chlorine disinfection residual levels should be measured using a colorimeter, and the chlorine residual measurement recorded. Additionally, the free chlorine residual should be greater than 0.2 parts per million (ppm) and sample measurements should be recorded. If treating for turbidity using a filtration technology, then a nephelometric turbidity unit (NTU) from a functional and calibrated turbidimeter should be recorded at least daily to determine if the system is effectively treating the water. It is important to know the amount of turbidity in the water because the higher the turbidity (NTU as measured with a turbidimeter), the less effective disinfection becomes. The disinfection residual and turbidity measurements should be completed at, or nearly at, the same time.

Note: The routine sampling and testing of drinking water quality from a private water system should become more frequent, or investigated, and/or include other contaminants of concern if any of the following events occur:

- There are obvious changes noted in water quality and complaints of water quality issues (taste, odor, color, etc.) from those individuals using the water.
- There are known problems with well water, or surface waters, in the area which include contaminants of concern (volatile organic chemicals, synthetic organic chemicals, or metals).
- There are positive results (positive total coliform and other bacteria, elevated nitrates, elevated total dissolved solids, and significant shifts in pH) for the basic water quality parameters.
- For wells, there is flooding in the area and the wellhead was submerged, and for surface waters there was a flooding event with high turbidity. (These are common problems with water systems during spring break-up and also associated with the heavy rain events in the fall.)
- Water service interruption due to a loss of water pressure, a break in the distribution system, a disturbance in the well, or a treatment system malfunction. These could be the result of natural causes (flooding or an earthquake) or man-made, such as a construction activity.
- A replacement or repair of any part of the water system, to include: the well (deepening or rehabilitating), a water system intake, the treatment process, a pump, a storage tank, or distribution system piping.

5. SELECTIVE OPERATIONAL ISSUES AND ROUTINE PREVENTATIVE MAINTENACE

A private water system, whether using a groundwater or surface water source, is an investment requiring financial resources and time. As with any investment, whether a bank account, a motor vehicle, a home, or a water system, management and routine maintenance are essential to get a "good rate of return" and to enhance the operational life of the investment.

5.A. SEASONAL SYSTEMS (Start-Up and Shut-Down)

Seasonal water systems in Alaska start-up and shut-down each year; typically starting-up in the early spring after "break-up" and shutting-down in the fall before "freeze-up". Seasonal private water system owners should start preparing to "start-up" the water system one month before they provide water to customers. Completing routine tasks at "shut-down" at the end of the operating season helps your water system remain in good functional condition and minimizes repairs when it's time to reopen. The following recommendations should be followed for seasonal private water systems before starting-up and shutting-down.

5.A.1. Start-Up

- Inspect the water system, which includes all components of the water system from the well head, or infiltration gallery, or a surface water intake through the treatment, storage, and distribution system. Document any water system problems, or deficiencies, and complete repairs before serving any water to your customers. Measure the static water level in the well and record this information in your water system log book.
- Activate the source (a well for groundwater or an infiltration gallery or surface water intake for surface water).
    - Turn on the power to your pump and treatment equipment.
    - Read the source meter (master meter), if the system has one, and record the information. This information is important because it lets you know how much water

your system is producing, and if treatment is installed, how much water the system is treating.
    - For systems which provide a chlorine disinfectant, purchase fresh chlorine, mix fresh solution, replace or clean all lines and parts, and verify the necessary dosage and feed rate of the chlorinator.
    - For systems which provide other types of treatment, the owner/operator should refer to the equipment manufacturer's recommendations, or documented operating procedures, or a water treatment specialist/professional, or a PE.
- Operate the water system by running pressurized water through the entire system, open any hydrants, blow-offs, faucets, and check all backflow prevention devices and check valves. Make sure are pressure tanks are functional and can be fully pressurized.
- Disinfect and Flush the system completely. Flush all sources, pressure tanks, storage tanks, treatment works, and distribution lines (piping).
    - Disinfect (chlorinate) the system, leaving the chlorinated water in the distribution lines (piping), storage tank, and pressure tank for at least 24 hours.
        - Note: If there is a chance that anyone could drink water from the system during the start-up disinfection (chlorination) process, use 2 mg/L of unscented household bleach (about ¾ cup [6.6 fluid ounces] of bleach) for every 1,000 gallons of water in the system, which includes: treatment works, if any, pressure tanks, storage tanks, and distribution lines (piping).
        - Note: If no one has access to water from the system during the start-up disinfection (chlorination) process, use 5 mg/L of unscented household bleach (about 1 ½ cups [13.2 fluid ounces] of bleach) for every 1,000 gallons of water in the system, which includes: treatment works, pressure tanks, storage tanks, and distribution lines (piping).
    - Flush the water system starting at the first tap (faucet) closest to the source, and each tap (faucet) and all distribution lines (piping) moving out from the source. While flushing the water system, you should maintain 20 to 30 psi pressure to thoroughly and forcefully clean the distribution system. When flushing the system, every effort should be made to keep the chlorinated flushed water away from draining into nearby surface water(s) and do not dispose of the chlorinated water in a septic system.
- Collect coliform bacteria samples and also samples for any of the basic contaminants of primary concern. Coliform bacteria samples should be collected after checking for, and measuring, the chlorine residual (from disinfecting and flushing the system) from taps throughout the system's distribution lines (piping).
    - For those systems which do not provide any chlorine disinfection treatment, the water system must not have any detectable free chlorine when coliform bacteria samples are collected. If a chlorine residual is detected, re-flush the complete system, recheck again for any chlorine residual, and if no chlorine residual detected, then collect a coliform bacteria sample.
    - For those systems which do provide chlorine disinfection treatment, the water system's free chlorine residual should be measured while the system is operating, and there should be a measurable level (trace) of chlorine at the tap.
    - Collect at least one coliform sample from the system and this should begin at least two weeks prior to opening for the season. Re-evaluate the water system if any coliform samples are unsatisfactory or if there is a change in condition of the water or the water system.
- Provide safe drinking water to your customers after receiving confirmation of satisfactory sample results from the analyses for coliform bacteria samples and/or the basic contaminants of primary concern and the water system is fully operational and functioning as designed.

As previously noted, water quality analyses for samples collected from a private water system should be completed by a State-certified laboratory (DEC or another state) for drinking water analyses. A listing of DEC-certified labs for drinking water can be found at: http://dec.alaska.gov/applications/eh/ehllabreports/certmicrolabs.aspx (microbiological contaminants) and http://dec.alaska.gov/applications/eh/ehllabreports/certchemlabs.aspx (chemical contaminants).

The DEC checklist for *Seasonal Systems Start-up Procedures* can be found at: http://dec.alaska.gov/eh/dw/RTCR.htm or https://dec.alaska.gov/eh/docs/dw/RTCR/RTCR_factsheets_%20Seasonal%20(2-2-16).pdf. Please feel free to utilize the forms as you see fit; however, because this BMP is for private water systems, there is no need to certify the form or to send it to the Department upon completion.

5.A.2. Shut-Down

- Evaluate the water system thoroughly during the shut-down process. Identify and document problems with the system that need repair or replacements during the off-season shut-down. Take a final source meter (master meter) reading and record this information in the water system's log book. This will allow you to determine the total amount of water used by the system during the period of operation for the year.
- Drain all the water out of the tank(s) and inspect and repair, if needed, the storage tank(s). Clean out any sediment or other material in the storage tank.
  - Check the storage tank(s) for any openings that could allow rodents, birds, insects, or other undesirable material(s) to enter, and close the opening as needed. Inspect all vents and overflows and clean and rescreen if necessary.
- Pressure tanks should be check for cracks and rust and cleaned.
  - If there is the potential for the tank to freeze in the off-season, then the tank needs to be drained when not in use. Pressure tank maintenance guides are typically specific and the manufacturer should be contacted for instructions on how to prepare the tank for the off-season shut-down.
  - If there is no potential for the tank to freeze in the off-season, the tank can be either left full, or drained. Overall, it is probably simpler and safer to drain the tank along with the storage tank and distribution lines (piping).
- Shut down the source(s) which could include a well head, infiltration gallery, or surface water intake. Shutting-down the source could include just turning-off the power; however, if the source(s) have the potential to freeze, and be damaged, or might be subject to vandalism, flooding, vermin, then the power supply may need to stay on to protect the source. This could be site specific for your system. The key point is to protect the system from freezing during the winter off-season shut down.
  - To protect the source(s) from freezing, use Styrofoam insulation and make sure to secure or close all openings that could allow vermin, insects, birds, or other potential contaminants to enter.
- Shut down treatment, if treatment is being provided, and also turn off power to all treatment systems. Discard unused chlorine disinfection solutions and stock, it disinfection treatment was provided. Do not dispose of chlorine disinfection solutions or stock in a septic system or in nearby surface waters (springs, marshy areas, creeks, streams, rivers, ponds, or lakes).
- Protect the distribution system during the time the water system is shut-down by completing draining the line and close all taps (faucets) during the off-season shut-down. Exercise all the valves and backflow preventers to ensure they are functional and working. Do not use anti-

freeze in any part (treatment, pressure tank(s), storage tank(s), or distribution piping) of the water system. If anything is nonfunctional, it should be repaired, and document any repairs in the water system's logbook.

The DEC checklist for *Seasonal Systems Shutdown Procedures* can be found at: http://dec.alaska.gov/eh/dw/RTCR.htm or https://dec.alaska.gov/eh/docs/dw/RTCR/RTCR_factsheets_%20Seasonal%20(2-2-16).pdf. Please feel free to utilize the forms as you see fit; however, because this BMP is for private water systems, there is no need to certify the form or to send it to the Department upon completion.

5.B. FLUSHING

Many water systems experience problems with slow moving water or stagnant water (also referred to as "old water") in their distribution system. These problems include, but are not limited to: customer complaints associated with taste and odor, corrosion issues such as "build ups" in the distribution system which restrict flow, loss of disinfection residual for those systems providing a disinfectant treatment, and positive coliform bacteria results or detections of other microbiological contaminants (bacteria or viruses). To avoid, or limit, these problems in the water system's distribution piping, water system owners and operators try to ensure the following: 1.) water is turned over in the water distribution system's pipelines to maintain a disinfection residual, reduce taste and odor issues, and also reduce microbial growth; 2.) sediment in dead-end lines is removed to minimize chlorine demand and buildup of harmful disinfection by-products; and 3.) water detention times in storage tanks is not causing an overall loss in the quality of effective disinfection.

To minimize or eliminate these types of problems, water system owners should complete routine flushing programs. Water system flushing should also be completed after a loss in water system pressure and also following an emergency disinfection (shock treatment) event. There are two basic types of flushing programs commonly, and successfully, used by water system owners and they are targeted (focused) on very specific problems. These flushing programs are conventional (also referred to as "traditional") and unidirectional.

- A conventional flushing program is typically in response to complaints (taste, odor, color, etc.) or a positive coliform sample result and allows the water system to reduce the water's age (time) in the distribution system; raises the disinfectant residual level in the distribution system, if the water system is providing a disinfectant treatment; and removes color associated with high levels of dissolved iron and odor problems. A conventional flushing program is a simplistic approach and is often focused on a limited section (problem areas) of the distribution system. Conventional flushing rate velocities are less than (<) 2.5 feet per second and usually successful when about 3 pipelines of water volume are flushed through the system; however, because of the low flow velocities (< 2.5 feet per second) there is less scouring (cleaning of the pipe) and the flushing direction is less controlled which can result in "dirty water" flushed to clean areas.
- A unidirectional flushing program is focused on removing solid deposits (sedimentation) and biofilm from the entire distribution system and is often associated with a regularly scheduled routine flushing program including fire hydrant testing or valve inspection programs. Unidirectional flushing programs utilize an orderly and controlled directional flushing at rates greater than 2.5 feet per second, use less water (40% or more less water) than a conventional flushing program, and overall are less expensive in the long-term than a conventional flushing program.
- An additional, but much less commonly used, flushing program is the continuous blow-off which focuses on stagnant areas and operates using low flow velocities (< 1 foot per second)

which provides less scouring (poor pipe cleaning), and uses very large quantities of water for minimal results.

The most practical flushing program for private water systems depends on the overall needs of the system taking into account desired outcomes and costs. Conventional flushing or unidirectional flushing could be successfully used to meet the desired outcomes of the flushing program. When developing a flushing program for your water system, it is important to know the volume of water required to flush the system which includes pressure tanks, storage tanks, and the piped distribution system including any fire hydrants, flush valves, and faucets. For pressure tanks and storage tanks, the capacity (volume) for each is typically note on a placard which is attached to the tank. To determine your water system's pipeline volume, you need to know your pipe diameter and the total length of your water system's distribution pipeline. For estimating volume of water in the distribution system, use the following information for the most commonly used pipe sizes:

- 1 inch diameter pipe/4 gallons per 100 feet of pipe,
- 2 inch diameter pipe/16 gallons per 100 feet of pipe,
- 4 inch diameter pipe/65 gallons per 100 feet of pipe, and
- 6 inch diameter pipe/147 gallons per 100 feet of pipe.

A well-designed flushing program should include the following components:

- locate any dead-end mains, low water use areas, and problem areas identified from complaints, from customers, on a water distribution map, if a map of the system is available;
- locate all flush points, such as a fire suppression system (hydrant), flush valves, and faucets nearest the affected area(s) or potential problem;
- schedule the water system flushing during the hours of lowest flow (lowest water usage) and Notify the Customers before the flushing is scheduled to begin; and
- flush the system outward from the source and during the flushing process, check the water storage tank(s) to confirm tank turnover during the flushing**.** Water storage tank turnover is best confirmed using a tank level recorder.

5.C. EMERGENCY DISINFECTION

Sometimes, during the normal course of your water system's daily operation an unusual and unplanned event just happens. Sometimes, the events are minor with minimal disruption in service from the water system, and sometimes the events are catastrophic and shut the water system down for lengthy periods of time. In Alaska, we have the potential for man-made events such as routine construction activities and power outages as well as several types of naturally-occurring catastrophic events, such as widespread flooding, earthquakes, volcanic eruptions, and avalanches. Private water system owners should disinfect their complete water system after experiencing any of the following operational events:

- the water system loses pressure for any reason because the loss of pressure can result in backsiphonage;
- any part of the water system (the source, pressure tank(s), storage tank(s), or distribution system) is "opened up" for maintenance, repair, or replacement;
- an identified backflow or backsiphonage has created a cross connection event; and
- the water system has experienced two or more coliform detections in succession or within a short period of time.

If you suspect contamination of your drinking water from any of the activities noted above, the private water system owner is referred to the following DEC documents for emergency disinfection:

Disinfection Procedures for Surface Water and Well Water Sources which can be found at:
http://dec.alaska.gov/eh/docs/dw/brochures/Pure.pdf and

Water Storage Tank Maintenance which can be found at:
http://dec.alaska.gov/eh/docs/dw/brochures/water%20storage%20tank%20disinfection_Updated%205-20-15.pdf

5.D. ROUTINE PREVENTATIVE MAINTENANCE

Recommended routine preventative maintenance should include some, possibly all, of the following daily, weekly, monthly, annually, and "as needed" activities. All significant maintenance activities should be recorded, in writing, with date completed and the activity. This can be important information when developing a budget for the private water system.

5.D.1. Daily Maintenance

Items to consider should include:

- checking the condition of the well head, or infiltration gallery, or surface water intake;
- checking for leaks around pumps, pipe joints, storage tanks, pressure tanks, and fix them immediately [do not allow the ponding, spraying, or accumulation of water on any electric equipment or control systems to avoid shock, electrocution, or equipment failure];
- checking chemical levels of treatment chemicals if treatment is being used and documenting the usage;
- confirming the functionality of treatment equipment (disinfection, filtration, ion exchange, etc.) to ensure they are working as designed and are maintained following manufacture's recommendations;
- checking and recording well pump run times and pump cycle starts at the same time each day, when possible, to determine if there is a problem with a pressure tank or if the pressure tank is undersized for well pump or well yield; and
- completing security checks on the locks on a well cap, well house, or treatment plant or the fencing around a intake system, well house, water storage tanks, or chemical storage, and ensure that hazardous material or junk are not being discarded near the well head or infiltration gallery or any surface water intake.

5.D.2. Weekly Maintenance

Items to consider should include:

- checking and recording water levels in pressure tanks (provided the tank has a viewing port window);
- checking and recording pumping rates if a flow meter is used within the system;
- inspecting pumps, and documenting any unusual conditions, such as vibrations, unusual heat, leakage from seals and gaskets on the pumps, and loose mounting attachments which need to be tightened; and
- documenting meter readings or water pressure gauge(s) readings from both the suction side and discharge sides of the pump, if meters or water pressure gauges are installed.

5.D.3. Monthly Maintenance

Items to consider should include:

- inspecting well pumps, motors, controls, and other instrumentation and document the status and functionality;

- checking the ventilation system of the well house, pump room, or treatment plant to avoid overheating equipment (summer) or freezing of equipment (intakes, pumps, and pipes (winter);
- checking sump pumps, and well and pump house flood prevention or detection systems, especially important in the spring and fall;
- checking and recording electric meter reading, if one is available at pump house or in the treatment plant, to determine continuity of electric use, i.e., the consistent usage from year to year for the specific season;
- checking and recording the chlorine disinfectant supply which should be between 30 – 60 days; and
- reviewing the monthly expenditures and compare with the overall financial budget planned for the water system to note any significant deviations from planned costs. (Basically, private water system owners should be able to routinely track whether they are operating their system within their planned budget.)

5.D.4. Annual Maintenance

Items to consider should include:

- cleaning the well house/pump house and the treatment system;
- inspecting cleaning, and overhauling the chlorination unit, chlorine disinfectant feedlines and solution tank, and calibrating the chlorinators, if the water system is adding a chlorine-based disinfectant;
- inspecting, cleaning, and flushing the complete distribution system, the storage tank(s), the pressure tank(s) (this activity is very dependent on source water quality); and updating the record keeping log book for the water system;
- completing necessary preventative repairs, upgrades, replacement of materials (pipes, tubing, valves, etc.) to the well house, pump house, or treatment works (filters and filter media, ion exchange resins, etc.);
- inspecting, cleaning, repairing and replacing any control panels in the well house or water treatment system;
- reviewing an emergency response plan if one was developed, and if no emergency response plan was developed for the system it is recommended that one should be developed;
- inspecting and testing the check valves and backflow preventers if any have been installed on the system;
- testing any alarms installed for operation of the water system;
- inspecting and testing the backup power generators; and
- reviewing the monthly expenditures while preparing the annual financial budget for the system which should include any equipment replacement, upgrades, and chemicals if used for treatment.

5.D.5. As-Needed Maintenance

Items to consider should include:

- storage tank(s) and pressure tank(s) inspection, cleaning, repairing, painting, and disinfecting; and replacing, if needed;
- contacting a certified electrician to check the amps on running well pumps, disinfection system pumps, or water treatment plant pumps and mixers;
- reviewing and implementing all reasonable forms of wellhead and water intake protection, to include buffer zones and physical barriers;

- backwashing filter frequency, replacing filter media, and/or regenerating or replacing ion exchange resins due to unexpected/unplanned changes in source water quality or overall water treatment system performance; and
- updating the log books for the water system, to include: wellhead protection, pumps, storage tanks, pressure tanks, treatment system, and distribution system piping.

6. REFERENCES

A Consumer's Guide to Water Wells in Minnesota, Well Management Section, Environmental Health Division, Minnesota Department of Health, 4th Edition, January 2014, *Well Owner's Handbook*,

Agency for Toxic Substances & Disease Registry (ATSDR), September 1996, *Tox FAQs for Polycyclic Aromatic Hydrocarbons (PAHs).*

Alaska Administrative Code 18 AAC 72, *Wastewater Disposal.*

Alaska Administrative Code 18 AAC 80, *Drinking Water.*

Alaska Statute, 46.15, *Water Use Act.*

AWWA Distribution Workshop (Presentation pdf), July 17, 2012, Bob McNutt, PE, Arcadis, *UDF What? Is it for Me & How Does it Really Work?*

Center for Disease Control and Prevention, March 2014, *A Guide to Drinking Water Treatment Technologies for Household Use.*

Clean Water Store, 2016, *How to Use Chlorination Systems for Well & Spring Water – Residential Well Water Treatment.*

Cold Climate Housing Research Center, February 2003, *Best Management Practices for Rainwater Catchment Systems in Alaska.*

EPA, Office of Water, Office of Ground Water and Drinking Water, EPA 816-R-03-002, February 2003, *Cross Connection Control Manual.*

EPA WaterSense, May 14, 2008, *Water-Efficient Single-Family New Home Specification*.

Florida Rural Water Association, Sterling Carroll, P.E., May 30, 2013, *FRWA Whitepaper – Unidirectional Flushing & Superchlorinating.*

Florida Rural Water Association, Robert McVay, P.E., May 16, 2008, *Effective Flushing Techniques for Water Systems*, [http://www.frwa.net]

Groundwater Protection Stakeholder Workgroup: Water Wells, Alaska Best Management Practices, June 6, 2016, *Construction of Non-Public Water Wells.*

Irrigation Training, Foundation for Cross-Connection Control and Hydraulic Research, University of Southern California, 1998, *An Introduction to Cross-Connection Control.*

*National Drinking Water Clearinghouse (NDWC), National Environmental Service Center (NESC), West Virginia University:

Tech Brief: Treatment Technologies for Small Drinking Water Systems Poster; item #DWFSOM37, 2008.
Tech Brief: Filtration, item #DWBLPE50, September 1996;
Tech Brief: Corrosion Control, item #DWBLPE56, February 1997;
Tech Brief: Disinfection, item #DWBLPE47, September 1998;
Tech Brief: Ion Exchange and Demineralization, item #DWBLPE56, May 1997;

Tech Brief: Organics Removal, item #DWBLPE59, August 1997;
Tech Brief: Package Plants, item #DWFSOM48, November 1997;
Tech Brief: Lime Softening, item #DWBLPE67, June 1998;
Tech Brief: Iron and Manganese Removal, item #DWBLPE70, September 1998
Tech Brief: Membrane Filtration, item #DWFSOM43, March 1999;
Tech Brief: Slow Sand Filtration, item #DWFSOM40, June 2000;
Tech Brief: Ultraviolet Disinfection, item #DWFSOM40, September 2000;
Tech Brief: Diatomaceous Earth Filtration for Drinking Water, item #DWFSOM39, Summer 2001;
Tech Brief: Water Quality in Distribution Systems, item #DWFSOM20, Fall 2002;
Tech Brief: Point-of-Use/Point-of-Entry Systems (POU/POE), item #DWFSOM31, Spring 2003;
Tech Brief: Preventing Well Contamination, item #DWFSOM57, Fall 2003;
Tech Brief: Chlorination, item #DWFSOM68, Fall 2004;
Tech Brief: Cross Connection and Backflow Prevention, item #DWFSOM58, Winter 2004;
Tech Brief: Taste and Odor Control, item # DWFSOM 88, Spring 2006;
Tech Brief: Development of Low-Cost Treatment Options for Arsenic Removal in Water Treatment Facilities, item #DWFSOM94, Fall 2006;
Tech Brief: Simultaneous Compliance with Drinking Water Regulations, item #DWFSOM95, Winter 2007;
Tech Brief: Biofilm Control in Distribution Systems, item #DWFSOM124, Summer 2008;
Tech Brief: On-Site Generation of Disinfectants, item #DWFSOM133, Spring 2009; and
Tech Brief: Well Maintenance and Groundwater Protection, item #CWFSOMG226DL, Spring/Summer 2015.
[*Website for NDWC Tech Briefs: http://www.nesc.wvu.edu/techbrief.cfm]

National Ground Water Association (NGWA), May 2014, ANSI/NGWA-01-14, *Water Well Construction Standard.*

NSF/ANSI Standard 53: *Drinking Water Treatment Units - Health Effects.*

NSF/ANSI Standard 55: *Ultraviolet Microbiological Water Treatment Systems.*

NSF/ANSI Standard 58: *Reverse Osmosis Drinking Water Treatment Systems.*

NSF/ANSI Standard 60, *Drinking Water Additives - System Chemicals Health Effects.*

NSF/ANSI Standard 61, *Drinking Water Additives - System Components Health Effects.*

NSF Protocol P151, *Health Effects from Rainwater Catchment System Components.*

State of Alaska, Department of Environmental Conservation, Division of Water, Engineering Support and Plan Review, January 27, 2016, *Onsite Wastewater System Installation Manual.*

The Trust for Public Land and American Water Works Association, 2005, *Source Protection Handbook - Using Land Conservation to Protect Drinking Water Supplies.*

**United States Department of Agriculture (USDA) / National Institute of Food and Agricultural (NIFA), New Technologies for Ag Extension Project, Drinking Water Treatment, eXtension Tagged Fact Sheets, January 4, 2010 – February 11, 2011:
Selecting a Home Water Treatment System, February 11, 2011;
Questions to Ask Before You Buy A Water Treatment System, January 4, 2011;

Drinking Water Treatment – Ultraviolet Radiation, January 4, 2011;
Drinking Water Treatment – Oxidizing Filters, January 4, 2011;
Drinking Water Treatment – pH Adjustment, January 3, 2011;
Drinking Water Treatment – Chlorination, December 17, 2010;
Drinking Water Treatment – Activated Carbon Filter, December 8, 2010;
Home Water Treatment Devices, December 6, 2010;
Drinking Water Treatment – Reverse Osmosis, December 6, 2010;
Drinking Water Treatment – Potassium Permanganate, December 6, 2010;
Drinking Water Treatment – Filtration, December 6, 2010;
Drinking Water Treatment – Distillation, December 6, 2010;
Drinking Water Treatment – Cation Exchange Units, December 6, 2010;
Drinking Water Treatment – Anion Exchange Units, December 6, 2010,
Drinking Water Treatment – Aeration, December 6, 2010; and
Drinking Water Treatment – Activated Alumina, December 6, 2010.
[**Website for USDA/NIFA Drinking Water and Human Health, eXtension Fact Sheets: http://articles.extension.org/category/drinking_water_treatment]

***Washington State Department of Health, Group B Public Water Systems – Hiring an Engineer, 2012, *A Guide for How to Hire an Engineer.*
[***Website: http://www.doh.wa.gov]

Wellcare®, May 2016, *Information for you about Disinfecting Your Well*

West Yost Associates – Consulting Engineers, Charles Duncan, P.E., 2012, (Presentation pdf), *Developing Unidirectional Flushing Programs in a Water Distribution System.*

POU/POE Treatment Units

POU/POE Technology	**Some** Contaminants Removed or Inactivated (UV specific)	Initial Costs	Operating Costs	Operation and Maintenance Skills
Chlorine (Disinfection)	Microbials (Bacteria, Viruses)	Low	Low	Low
UV (Disinfection - Inactivation only)	Microbials (Bacteria, Viruses, and Protozoa)	Moderate	Low	Moderate
Ozone (Disinfection) & (Oxidation w/Filtration)	Microbials (Bacteria, Viruses, and Protozoa); Iron and Arsenic (Oxidation w/ Filtration	Moderate to High	Moderate to High	Moderate to High
Cartridge Filter	Suspended solids, Protozoa, most Bacteria and some Viruses	Low	Low to Moderate	Low
Reverse Osmosis	Microbials (all), Inorganic Chemicals and Metals, some Organic Chemicals, Dissolved Solids, and Radium	Moderate	High	High
Distillation	Protozoa, most Bacteria and Viruses, Inorganic Chemicals, some Metals, Dissolved Solids, some Organic Chemicals, Radium, and Uranium	Moderate	Moderate	Moderate
Activated Carbon	Radon and Volatile Organic Chemicals (POE most effective), Taste, and Odors. Solid Block Carbon can filter Sediment, Lead, Asbestos, some Bacteria, and Protozoa cysts	Moderate	Moderate to High	Low
Aeration (Packed Column/Tower)	Radon and Volatile Organic Chemicals (POE most effective), Tastes, and Odor	Moderate	Low	High
Ion Exchange	Arsenic, Chromium, Selenium, Iron, Manganese, Inorganic chemicals, Dissolved Solids, Nitrate, Radium, and Sulfate	Moderate	Moderate to High	Moderate
Activated Alumina	Arsenic, Selenium, and Fluoride	High	High	High

Figure 1. Summary of POU/POE Treatment Systems and Costs
(NSF, 1999; modified 2016)

8. DEFINITIONS AND TERMINOLOGY

AAC – Alaska Administrative Code.

Aquifer – water bearing material that may be consolidated or unconsolidated beneath the surface of the ground that produces water.

- Consolidated Aquifer ("bedrock") – a type of aquifer that is primarily composed of solidified (cemented) groups of grains of sediment (e.g., siltstone, sandstone, conglomerate, or combinations of any of these materials), or solid crystalline rock with fractures, cracks, subterranean caverns (karst), or voids (e.g., limestone, volcanic rock, and metamorphic rock).

- Unconsolidated ("alluvial aquifer") – a type of aquifer that is primarily composed of loose grains of sediment (e.g., silt, sand, gravel, or combinations of any of these materials).

Arsenic – a metallic element (heavy metal) that even at low levels over a relatively long period of time can have long-term (chronic) health effects. Arsenic occurs naturally in rocks and soils; however, other sources may be from industrial and agricultural uses. Arsenic is tasteless, odorless, and colorless when dissolved in water.

Bacteria (*singular*: bacterium) – a microorganism that comes in a variety of shapes and sizes. Some bacteria in drinking water can cause short-term (acute) health effects.

- Coliform bacteria – a group of bacteria that are found in the digestive systems of warm-blooded animals, in soil, on plants, and in surface water. Some coliform bacteria in drinking water can cause short-term (acute) health effects.

- Fecal coliform – a type of coliform bacteria included in total coliform that originates in feces of warm-blooded animals. Some fecal coliform in drinking water can cause short-term (acute) health effects, such as *Escherichia coli* (*E. coli*), and may also be an indicator of the presence of other pathogens.

- Total coliform – a measure of the presence of coliform bacteria that is used as an indicator of the possible presence of harmful coliform bacteria, such as fecal coliform.

Best Management Practices (BMP) – those practices proven effective through research and field applications.

Chlorination – adding chlorine gas (Cl_2) or as a mixture (liquids), or compounds (solids) containing chlorine, such as sodium hypochlorite ($NaHO_3$) and calcium hypochlorite ($CAHO_3$) respectively, or the electrochemical dissociation of a salt, such as sodium chloride (NaCl), in water to aid in disinfection of the water to kill most microorganisms. Chlorination-related terms in respect to disinfection of drinking water include the following:

- Total Chlorine Demand – is the amount of chlorine needed to react with the contaminants (metals or organic substances) in the water. The more contaminants and the "dirtier" the water, the more chlorine is needed to complete disinfection. Note: In completely clean water, the chlorine demand is, or should be, zero.

- Free Chlorine (FC) – a chlorine atom by itself; as a separate molecule; not bound with other molecules or material in the water and "free" to disinfect when needed. Free chlorine is a component of Total Residual Chlorine.

DEFINITIONS AND TERMINOLOGY (contd.)

- Combined Chlorine (CC) – chlorine atoms that have bonded with chemicals, typically nitrates, and other material, typically organics, in the water. This chlorine is not free to disinfect.

- Free Chlorine Residual – that chlorine remaining after part of the original amount has been removed by the treatment (disinfection) process.

- Total Chlorine Residual – is the sum of the Combined Chlorine + Free Chlorine and this is measured throughout a water system's distribution system.

Contaminant – a physical, chemical, biological, or radiological substance or material in water that, in sufficient quantity, makes water unfit for human consumption.

Contamination – the presence of a contaminant, or group of contaminants.

Department – Alaska Department of Environmental Conservation.

Disinfection – a process that inactivates or kills pathogenic organisms in water by chemical oxidants or equivalent agents.

Engineer ("PE, groundwater professional" and/or "water system professional") – a licensed professional civil, mechanical, or environmental engineer registered in the State of Alaska pursuant to Alaska Statue 8.08. Considered here as a "groundwater professional" when has demonstrated work experience and/or educational background in groundwater technical issues and construction. Considered here as a "water system professional" when has demonstrated work experience and/or educational background in water system design, operation, and maintenance issues as well as water treatment technologies.

Groundwater – any water, except capillary moisture, beneath the land surface or beneath the bed of a stream, lake, reservoir, or other body of surface water regardless of the formation in which the water stands, flows, percolates, or otherwise moves.

Groundwater professional – well drillers, pump installers, hydrogeologists, geologists, and engineers with demonstrated work experience and/or educational training in groundwater technical issues and water well construction.

Microbial – a microbiological organism (microorganism), typically a very small life form (often microscopic), such as bacteria, algae, diatoms, parasites (protozoans), plankton, fungi, and viruses. Some may cause severe disease and death.

Micron (µ) – often referred to as "micrometer" (International Bureau of Weights and Measures) or micrometer (American spelling) is a unit of very small length equaling 1 x 10-6 meters; that is one millionth of a meter (0.000001 meters) or one thousandth of a millimeter (0.001 mm) or approximately 0.000039 inch.

DEFINITIONS AND TERMINOLOGY (contd.)

mg/Liter – Milligrams per liter (equivalent to "parts per million" or "ppm") as a unit of measure in respect to concentrations of materials (chemicals or contaminants) measured when dissolved in water.

Nephelometric turbidity unit (NTU) – the measurement of turbidity, commonly referred to as "cloudiness" of the water due to suspended solids.

Nitrate – a chemical compound that, for very young children, taking in high levels in drinking water over a relatively short period of time can cause serious health effects. Sources of nitrates may be natural, but may also include fertilizers, animal feed lots, manures, sewage, septic systems, industrial wastewater, sanitary landfills, and garbage dumps.

NSF International (NSF) – formerly known as the "National Sanitation Foundation" and the name was changed in 1990 to NSF International. NSF is a product testing, inspection, and accredited third-party certification organization that tests and certifies products to verify they meet public health and safety standards.

Pathogen – an infectious biological agent, such as a virus, bacterium, or protozoan, that causes disease or illness.

Permeable – describes the ability for fluids to pass through an aquifer or soils.

pH – a basic unit of measure of how acidic or basic a solution (water) is. The range in pH measures goes from 0 – 14, with 7 being neutral. A pH less than 7 is acidic and solutions with a pH greater than 7 are basic or alkaline. Technically, pH is a measure of the hydrogen ion concentration in the solution (water).

Pitless adapter – an NSF/ANSI approved devise attached to the well casing, constructed to permit the flow of water from the well casing.

Polycyclic aromatic hydrocarbons (PAHs) – a group of over 100 different chemicals that are formed along with soot during the incomplete burning of coal, oil, gas, garbage, or other organic substances like tobacco, charbroiled meat, and wood. . PAHs are components of wood smoke and commonly are attached to soot and other particles in the air. PAHs naturally enter the air mostly as releases from volcanoes and forest fires; and from human activities such as burning coal, automobile exhaust, cigarette smoke, grilling, and wood stoves. Exposure to PAHs usual occurs by breathing air contaminated by wild fires, coal tar, or wood stoves; or by eating foods that have been grilled, or by drinking water from sources (rain water catchment systems or other industrial sources) contaminated by soot and other particles which contains attached PAHs. Most PAHs do not easily dissolve in water and tend to stick tightly to particles in the water (suspended solids, etc.). PAHs are reasonably expected to be carcinogens and bio-accumlate in animals and people. Some people who have breathed or touched mixtures of PAHs and other chemicals for long periods of time (chronic exposure) have developed cancer. [*Information obtained from the Agency for Toxic Substances & Disease Registry (ATSDR) – ToxFAQs for Polycyclic Aromatic Hydrocarbons.]

Polyvinyl chloride (PVC) – a synthetic plastic polymer that is manufactured in two basic forms: rigid and flexible. The rigid form of PVC is strong and lightweight and used for construction projects as

DEFINITIONS AND TERMINOLOGY (contd.)

primarily pipe material for water and wastewater projects and in profile applications such as doors and windows. Adding plasticizers to rigid PVC makes it softer and more flexible where it is used to make bottles and products for plumbing, electrical cable insulation (coated wire), inflatable products, and as replacement material for rubber.

Potable water – is water suitable for human consumption, also referred to as "drinking water".

Protozoa (*singular*: protozoan) – a diverse group of microscopic unicellular (single-cell) organisms of different shapes and sizes with both motility (motion) and predation behaviors. A number of protozoan pathogens are human parasites and can cause chronic (long-term) diseases such as giardiasis (*Giardia lamblia*) and cryptosporidiosis (*Cryptosporidium parvum*) which result from consuming untreated drinking water.

Public water system (PWS) –

- (A) means a system for the provision to the public of water for human consumption, if the system has at least 15 service connections or regularly serves 25 individuals daily at least 60 days of the year;
- (B) is either a community or non-community water system
- (C) includes
  - a. any collection, treatment, storage, or distribution facilities, including a water haul vehicle, under control of the operator of the system and used primarily in connection with the system; and
  - b. any collection, or pre-treatment storage facilities not under control of the system operator that are used primarily in connection with the system;
- (D) does not include a private water system;

Sanitary well cap ("sanitary seal" or "well seal") – a securely fasted and vented well cap with a gasket, attached to the top of a well casing or pipe sleeve, that prevents insects, dirt, or incidental water or other liquid(s) from entering the well under normal conditions, that also allows air to flow in and out of the well, and that is NSF/ANSI approved.

UL LLC – formerly known for almost 100 years as Underwriters Laboratories, is an American consulting and certification company. UL reviews and certifies new technologies and the drafting of safety standards for electrical devices and components and life safety products.

Viruses (*singular*: virus) – small (microscopic) infectious agent that replicates only inside the living cells of other organisms. Viruses can infect all types of life forms including animals, plants, and other microorganisms, such as bacteria. Some viruses transmitted through drinking water can cause short-term (acute) health effects.

Volatile organic compounds ("volatile organic chemicals") – are organic chemicals that have a high vapor pressure at ordinary room temperature(s) and evaporate or sublimate from liquid or solid form, respectively, and enter the surrounding air. VOCs are numerous, varied, and ubiquitous, and include both human-made (anthropogenic) and naturally occurring chemical compounds. Commonly encountered VOCs in drinking water include: benzene, fossil fuels, chlorofluorocarbons and chlorocarbons, methyl tertiary butyl ether (MTBE), and formaldehyde. Many VOCs are not

DEFINITIONS AND TERMINOLOGY (contd.)

acutely toxic (short term exposure); however, they are chronically toxic with compounding long-term health effects.

Water Quality Association (WQA) – is an international trade association representing the residential, commercial, industrial, and small community water quality treatment and improvement industries. The WQA is involved in certification of products and professionals, and also the education to professionals, and the sustainability and research associated with water to include materials, products, and chemicals.

Water storage tank – a watertight covered receptacle designed and built to receive and store clean and/or potable water.

Water treatment system – a collection of physical and chemical processes that make water more acceptable for a specific end use. A water treatment system removes contaminants or reduces their concentration so that the water becomes fit for its desired end-use. For the purpose of this BMP guidance, "water treatment system," is focused on the end-use for drinking water.

APPENDIX A: WATER SYSTEM DESIGN FLOW ESTIMATES

TABLE 1 – WATER USE DATA

SOURCE TYPE	UNIT	WATER USE FLOW RANGE IN GALLONS PER DAY (GPD) PER UNIT	TYPICAL FLOW IN GPD PER UNIT
COMMERCIAL			
Airport	Passenger	2 - 4	3
Apartment House	Person	40 - 80	50
Automotive Service Station	Vehicle	8 - 15	12
	Employee	9 - 15	13
Bar	Customer	1 - 5	3
	Employee	10 - 16	13
Hotel	Guest	40 – 60	50
	Employee	8 - 13	10
Industrial Building (Sanitary Waste only)	Employee	7 - 16	13
Laundry (Self-Service)	Machine	450 - 650	550
	Wash	45 - 55	50
Office	Employee	7 - 16	13
Public Lavatory	User	3 - 6	5
Restaurant (with Toilet)	Meal	2 - 4	3
- Conventional	Customer	8 - 10	9
- Short Order	Customer	3 - 8	6
- Bar/Cocktail Lounge	Customer	2 - 4	3
Rooming (Boarding) House	Person	25 - 60	40
Store (Department)	Toilet Room	400 - 600	500
	Employee	8 - 15	10
Shopping Center	Parking Space	1 - 3	2
	Employee	7 - 13	10
Theatre	Seat	2 - 4	3
INSTITUTIONAL			
Assembly Hall	Seat	2 - 4	3
Hospital (Medical)	Bed	125 - 240	165
	Employee	5 - 15	10
Hospital (Mental)	Bed	75 - 140	100
	Employee	5 - 15	10
Prison	Inmate	80 - 150	120
	Employee	5 - 15	10
Rest Home	Resident	50 - 120	90
	Employee	5 - 15	10
School (Day) with Cafeteria, Gym & Showers	Student	15 - 30	25
School (Day) with Cafeteria only	Student	10 - 20	15
School (Day) w/out Cafeteria, Gym or Showers	Student	5 - 17	11
School (Boarding)	Student	50 - 100	75
RECREATIONAL			
Apartment (Resort)	Person	50 - 70	60
Cabin (Resort)	Person	8 - 50	40
Cafeteria	Customer	1 - 3	2
	Employee	8 - 12	1.0
Camp Ground – Pioneer type	Person	15 - 30	25
- Children's w/central Toilet and Bath	Person	35 - 50	45
- Day Camp w/ Meals	Person	10 - 20	15
- Luxury w/ Private Baths	Person	75 - 100	90
- Trailer Camp	Trailer	75 - 150	125
Cocktail Lounge	Seat	12 - 25	20
Coffee Shop	Customer	4 - 8	6
	Employee	8 - 12	10
Country Club	Guests Onsite	60 - 130	100
	Employee	10 - 15	13
Dining Hall	Meal Served	4 - 10	7
Dormitory/Bunkhouse	Person	20 - 50	40
Fairground	Visitor	1 - 2	2
Hotel (Resort)	Person	40 - 60	50
Laundromat	Wash Machine	470 - 700	580
Picnic Park w/ Flush Toilets	Visitor	5 - 10	8
R/V Park w/ Water and Sewer Hookups	R/V Space	75 - 125	100
Store (Resort)	Customer	1 - 3	3
	Employee	8 - 12	10
Visitor Center	Visitor	4 - 8	5

Reference: 2002 EPA Design Manual

TABLE 2 – WATER SUPPLY FIXTURE UNITS AND MINIMUM FIXTURE BRANCH PIPE SIZES (3)

APPLIANCES, APPURTENANCES OR FIXTURES (2)	MINIMUM FIXTURE BRANCH PIPE SIZE (1),(4) (inches)	PRIVATE (Individual Dwelling)	PUBLIC (General Use)	ASSEMBLY (6) (Heavy Use)
Bar Sink	½	1.0	2.0	
Bathtub or Combination Bath/Shower (fill)	½	4.0	4.0	
¾ inch Bathtub Fill Valve	¾	10.0	10.0	
Bidet	½	1.0		
Clinic Sink, Faucet	½		3.0	
Clinic Sink, Flushometer Valve with or without faucet	1		8.0	
Clothes washer	½	4.0	4.0	
Dental Unit, cuspidor	½		1.0	
Dishwasher, domestic	½	1.5	1.5	
Drinking Fountain or Watercooler	½	0.5	0.50	0.75
Hose Bib	½	2.5	2.5	
Hose Bib, each additional (8)	½	1.0	1.0	
Kitchen Sink, domestic with or without dishwater	½	1.5	1.5	
Laundry Sink	½	1.5	1.5	
Lavatory	½	1.0	1.0	1.0
Lawn Sprinkler, each head (5)		1.0	1.0	
Mobile Home, each (minimum)		12.0		
Service Sink or Mop Basin	½	1.5	3.0	
Shower, per head	½	2.0	2.0	
Urinal, 1.0 GPF Flushometer Valve (7)	¾	3.0	4.0	5.0
Urinal, greater than 1.0 GPF Flushometer Valve (7)	¾	4.0	5.0	6.0
Urinal, flush tank	½	2.0	2.0	3.0
Wash fountain, circular spray	¾		4.0	
Washup Sink, each set of faucets	½		2.0	
Water Closet, 1.6 GPF Gravity Tank	½	2.5	2.5	3.5
Water Closet, 1.6 GPF Flushometer Tank	½	2.5	2.5	3.5
Water Closet, 1.6 GPF Flushometer Valve (7)	1	5.0	5.0	8.0
Water Closet, greater than 1.6 GPF Gravity Tank	½	3.0	5.5	7.0
Water Closet, greater than 1.6 GPF Flushometer Valve (7)	1	7	8	10

For SI units: 1 inch =25 mm

Notes:

1. Size of the cold branch pipe, or both the hot and cold branch pipes.
2. Appliances, appurtenances, or fixtures not referenced in this table shall be permitted to be sized by reference to fixtures having a similar flow rate and frequency of use.
3. The listed fixture unit values represent their load on the cold water building supply. The separate cold water and hot water fixture unit value for fixtures having both hot and cold water connections shall be permitted to be taken as three-quarter of the listed total value of the fixture.
4. The listed minimum supply branch pipe sizes for individual fixtures are the nominal (ID) pipe size.
5. For fixtures or supply branch connections likely to impose continuous flow demands, determine the requested flow in gallons per minute (gpm)(L/s), and add them separately to the demand in gpm (L/s) for the distribution system or portions thereof.
6. Assembly [Public Use (See Table 422.1)].
7. Where sizing flushometer systems, see Section 610.10 as well as Appendix A, Table A2.1
8. Reduced fixture unit loading for additional hose bibbs is to be used where sizing total building demand and for pipe sizing where more than one hose bibb is supplied by a segment of water distribution pipe. The fixture branch to each hose bibb shall be sized on the basis of 2.5 fixture units.

Reference: 2012 Uniform Plumbing Code

TABLE 3 – PEAK DEMAND FOR SELECTED RESIDENTIAL & COMMERCIAL AREAS

RESIDENTIAL	
0 to 5 Residences Served	8.0 gpm per residence
6 to 10 Residences Served	5.0 gpm per residence
11 to 20 Residences Served	4.3 gpm per residence
COMMERCIAL	
Barber Shop or Beauty Shop	1.5 gpm per chair
Dentist Office	2.0 gpm per chair
Department Store*	0.5 to 1.5 gpm per employee
Drug Store	3.0 gpm
With Fountain Service	add 3.0 gpm
Serving Meals	add 1.0 gpm per seat
Industrial Plant**	0.5 gpm per employee
Laundry	20 to 60 gpm
Launderette	5.0 gpm per unit
Meat Market, Super Market	1.0 gpm per 100 square feet of floor area
Motel, Hotel	2.0 gpm per unit
Office Building*	0.2 gpm per 100 square feet of floor area
Physician's Office	2.0 gpm per examining room
Restaurant	1.0 gpm per seat
Single Service	3.0 to 10.0 gpm
Drive-In	0.5 to 3.0 gpm per car space
Service Station	3.0 to 8.0 gpm per wash rack
Theater	0.3 to 2.0 gpm per seat
Drive-In	0.4 gpm per car space
Other Establishments***	0.3 to 3.0 gpm per employee

*Including customer service.
**Not including process water.
***Non-water using establishments.

Reference: 1984 Community Water Systems Source Book, Tables XIV and XV

TABLE 4 – DEMAND LOAD

Total Fixture Units	Demand (GPM) for Systems Predominantly with flush tanks	Demand (GPM) for Systems Predominantly with flushometer valves
5	5	22
10	8	27
15	12	32
20	15	35
25	18	38
30	20	42
35	23	44
40	25	47
45	27	48
50	28	51
55	31	53
60	32	55
65	34	57
70	35	57
75	37	58
80	38	60
85	40	62
90	41	64
95	42	65
100	43	67

Reference: 2012 Uniform Plumbing Code, Appendix A (Interpolation of chart A 2.1(1) Enlarged Scale Demand Load)

TABLE 5 – FRICTION LOSS

Loss of Head in Feet, Due to Friction per 100 Feet of Pipe

¾-INCH PIPE

FLOW-GPM	STEEL PIPE	COPPER PIPE	PLASTIC PIPE
5	10.5	6.57	5.66
6	14.7	9.22	7.95
7	19.6	12.2	10.6
8	25.0	15.7	13.5
9	31.1	19.5	16.8
10	37.8	23.7	20.4
11	45.1	28.2	24.4
12	53.0	33.2	28.6
13	61.5	38.5	33.2
14	70.5	44.2	38.0
16	90.2	56.6	48.6
18	112.0	70.4	60.5
20	136.0	83.5	73.5

1-INCH PIPE

FLOW-GPM	STEEL PIPE	COPPER PIPE	PLASTIC PIPE
10	11.7	6.77	6.31
12	16.4	9.47	8.85
14	21.8	12.6	11.8
16	27.9	16.2	15.1
18	34.7	20.1	18.7
20	42.1	24.4	22.8
22	50.2	28.8	27.1
24	59.0	34.0	31.9
26	68.4	39.7	36.9
28	78.5	45.5	42.5
30	89.2	51.6	48.1
35	119.0	68.7	64.3
40	152.0	88.0	82.0
45	189.0	109.0	102.0

1-1/4-INCH PIPE

FLOW-GPM	STEEL PIPE	COPPER PIPE	PLASTIC PIPE
10	3.08	1.98	1.67
12	4.31	2.75	2.33
14	5.73	3.64	3.10
16	7.34	4.68	3.96
18	9.13	5.81	4.93
20	11.1	7.10	6.00
25	16.8	10.7	9.06
30	23.5	15.0	12.7
35	31.2	20.0	16.9
40	40.0	25.6	21.6
50	60.4	38.7	32.6
60	84.7	54.1	45.6
70	114.0	72.2	61.5

1-1/2-INCH PIPE

FLOW-GPM	STEEL PIPE	COPPER PIPE	PLASTIC PIPE
20	5.24	3.31	2.83
25	7.90	5.00	4.26
30	11.1	7.00	6.00
35	14.7	9.35	7.94
40	18.9	12.00	10.2
45	23.4	14.9	12.63
50	28.5	18.1	15.4
55	34.0	21.5	18.35
60	40.0	25.3	21.6
65	46.4	29.0	25.1
70	53.2	33.8	28.7
75	60.4	38.0	32.6
80	68.1	43.1	36.8
85	76.2	47.6	41.2

Reference: John Wiley & Sons, Inc., 2007, Construction Dewatering and Groundwater Control: New Methods and Applications, Third Edition, Appendix A and STA-RITE, 2016, Pipe Friction Loss Charts, pdf.