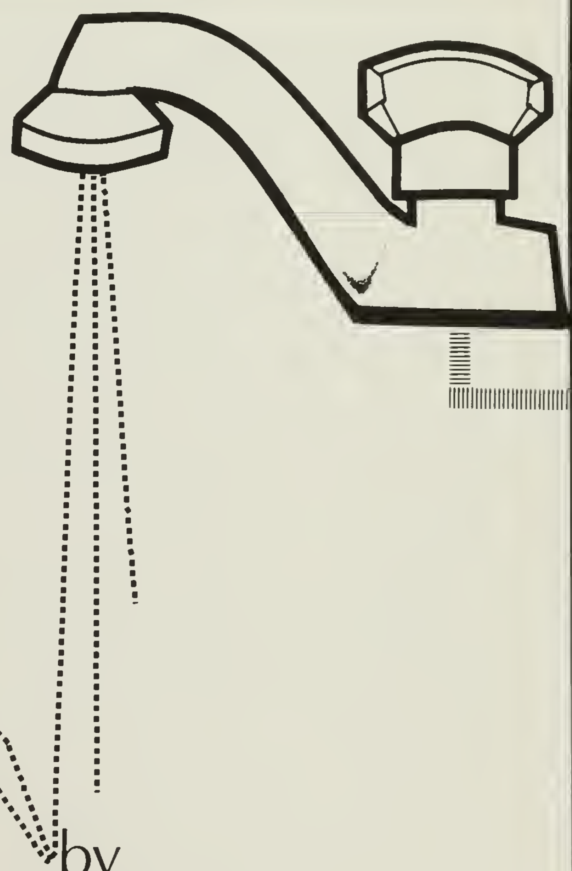
TECHNICAL NOTE 351

U.S. DEPARTMENT OF THE INTERIOR
BUREAU OF LAND MANAGEMENT



Small Water Purification Systems

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SMALL WATER PURIFICATION SYSTEMS

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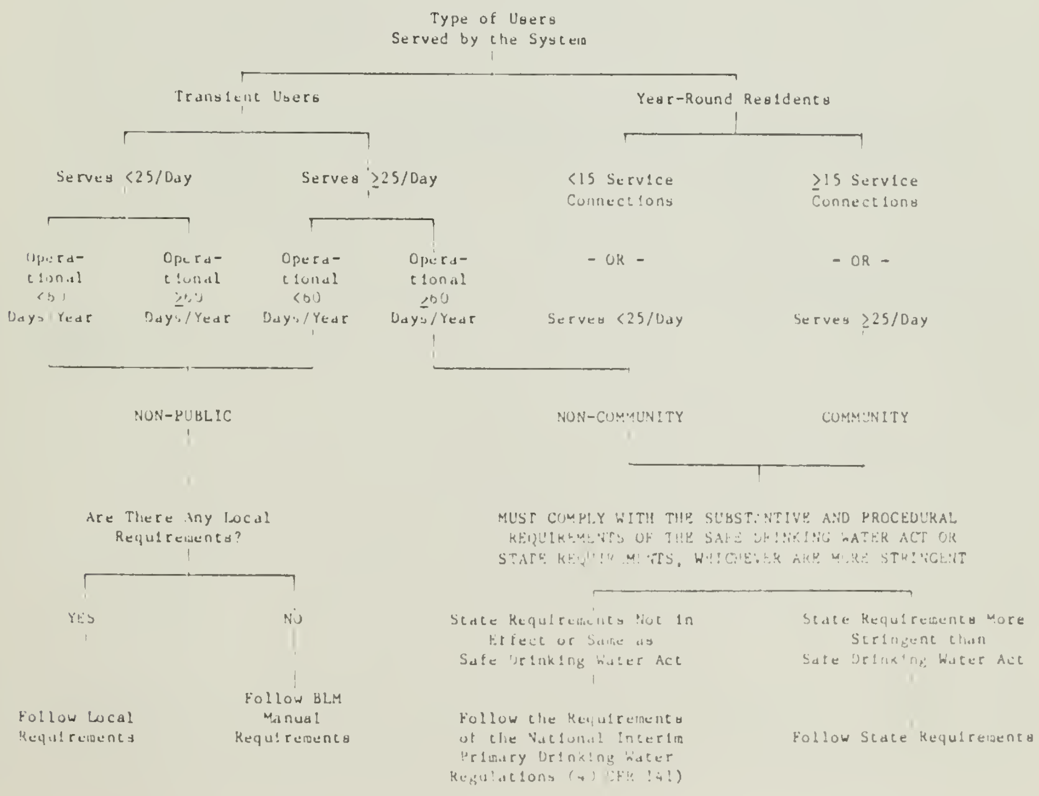
Small Water Purification Systems

I. INTRODUCTION: The Bureau of Land Management (BLM) is responsible for providing small water purification systems for remote recreational and wilderness area sites. Many of these remote areas are used on a seasonal basis, by small numbers of people (from one or two users per day to several hundred per day). Each of these facilities is required to meet all local, state, and federal public health requirements. Since there are so many types of systems and applications to choose from, BLM often has difficulty in choosing the proper system for each regulatory and site-specific situation.

This study was undertaken to investigate various common types of small domestic water purification systems that may be suitable for use at BLM sites, and to discuss the advantages and disadvantages of each type of system.

II. PUBLIC HEALTH CONSIDERATIONS: Systems that furnish water for human consumption are regulated under the Safe Drinking Water Act and the National Interim Primary Drinking Water Regulations (NIPDWR). The federal legislation and regulations establish categories of drinking water systems based on the type of use the system receives and on the number of users served:



The state governments will eventually assume the drinking water program and will promulgate their own regulations. State regulations must be at least as stringent as the Safe Drinking Water Act and the NIPDWR, but the states may impose additional requirements or more stringent requirements than the NIPDWR if they choose to do so. Regulatory requirements are most strict for systems that are in the "community" category, and are somewhat more relaxed for systems in the "non-community" category. Non-public systems are not regulated by the NIPDWR, but the individual states (and, in some cases, the counties) are free to impose requirements on non-public systems, or to require that non-public systems meet the same requirements as non-community systems. As these requirements vary from state to state and from location to location within the state, the local public health authorities should always be contacted to determine which regulations apply at a specific site and in a specific circumstance. All systems installed or operated by BLM are required by law (the Safe Drinking Water Act) to be in compliance with applicable federal, state, and local requirements:

> ". . .Each Federal agency (1) having jurisdiction over any federally owned or maintained public water system . . . shall be subject to, and comply with, all Federal, State, and local requirements, administrative authorities, and process and sanctions respecting the provision of safe drinking water . . . in the same manner, and to the same extent, as any nongovernmental entity. The preceding sentence shall apply (A) to any requirement whether substantive or procedural (including any recordkeeping or reporting requirement, any requirement respecting permits, and any other requirement whatsoever), (B) to the exercise of any Federal, State, or local administrative authority, and (C) to any process or sanction, whether enforced in Federal, State, or local courts or in any other manner. This subsection shall apply, notwithstanding any immunity of such agencies, under any law or rule of law . . ."
>
> [42 U.S.C. §300j-6]

III. CHLORINATION: Chlorine in both gaseous and liquid form is used to disinfect drinking water. Gaseous chlorine is generally used for dosing large water systems (such as municipal systems), and liquid chlorine compounds (hypochlorite) are used for disinfecting small systems. Since this study is restricted to small treatment facilities, the hypochlorite system only will be discussed.

Hypochlorite systems consist of a mixing tank, metering pump, injection device, and holding tank. Electrical power is required to operate the metering pump. Unless bacteriological testing indicates a need for maintaining a higher minimum residual chlorine concentration, the following concentrations should be maintained in the system:

1. When simple chlorination is used for disinfection, at least 0.2 parts per million (ppm) of free residual chlorine should be in contact with the water for at least 20 minutes before the water reaches the first consumer beyond the point of chlorine application. In general, it is desirable to maintain a free chlorine residual of 0.05 to 0.10 ppm at all times at the most distant points of the water distribution system.

2. When chloramine treatment is used, at least 2.0 ppm of residual chlorine should be in contact with the water for at least three hours before the water reaches the first consumer, and a minimum of 1.0 to 2.0 ppm chlorine residual should be maintained at all points in the distribution system.

3. If "breakpoint" chlorination is being considered, contact the appropriate public health authorities for the procedures to be followed in initiating this method of disinfection.

From the public health standpoint, chlorination is the disinfection method of choice. It is suitable for long-term, continuous use, and is acceptable to all public health authorities for both community and non-community systems. In many jurisdictions, testing for chlorine residual may be substituted for some of the required testing for bacteriological characteristics. A small amount of chlorine is retained in the water as a residual; this helps prevent contamination of the water in the distribution system after it leaves the point of disinfection. Chlorination is effective for disinfection only; if the water contains unacceptably high levels of inorganic or organic chemicals, radioactivity, or other contaminants, chlorination alone will not be sufficient to render the water safe for drinking, and additional filtration or treatment will be required. Both gaseous and liquid chlorine are poisonous and corrosive, and require care in storage and handling. As electrical power is required, chlorination may not be feasible or suitable for use at remote locations. The system must be checked fairly regularly, and the supply of chlorine must be replenished. Frequent sampling of the water is required both to satisfy regulatory requirements and to assure that the chlorinator is working properly and is dispensing and maintaining an adequate level of chlorine in the water.

At times of threatened or existing outbreaks of waterborne disease, such as floods or other disaster conditions, a higher residual chlorine level should be maintained in all parts of the distribution system, regardless of tastes or odors in the delivered water. Similar measures should be taken if testing shows that the water system has become contaminated, if the chlorinator has not been working properly, or if the water has not been tested regularly. Contact the appropriate public health authorities for instructions on acceptable chlorine residuals.

A detailed and accurate record of chlorination should be maintained. Such a record should include:

1. Rate of flow of water treated.
2. Gross weight of chlorine container or cylinder used.
3. Weight of chlorine used for each 24 (or other) time period.
4. Chlorinator settings.
5. Results of residual chlorine sampling, including the date, time, and other pertinent conditions.

Superchlorination-Dechlorination: "In some small water supply systems, sudden increased water demands and the relatively short distance between the point of chlorine application and the first water tap do not allow sufficient contact time for simple chlorination to be an effective disinfectant. This problem can be overcome by superchlorination-dechlorination. Chlorine is added to the water in increased amounts (superchlorination) to provide a minimum free chlorine residual of 3.0 ppm for a minimum of five minutes; the excess chlorine is then removed to eliminate objectionable chlorine odor and taste in the finished water. Dechlorination is accomplished by passing the water through activated carbon filters or by use of other commercially available methods and equipment."[1] As this method requires additional equipment and additional process steps, it should not be used unless effective chlorine disinfection cannot be attained in any other manner; often, it is more cost-effective to install a holding tank to provide sufficient detention time to allow for adequate contact time rather than to install dechlorination equipment. However, if filtration is required in addition to disinfection to achieve adequate treatment, then this method may be effectively used.

[1]From Environmental Health Practice in Recreational Areas, U.S. Department of Health, Education, and Welfare Publication No. (HSM) 72-10009; February 1972.

Small hypochlorite systems (using chlorine in liquid rather than gaseous form) are relatively inexpensive to install and maintain. Typical costs* are as follows:

1. Chemical Metering Pump (Electric)
   0.3 to 240 gallons per day.............. $ 250 - 565

2. Injector with flowmeter
   and tubing.............................. $ 290 - 830

3. Mixing Tank (30 gal. capacity).......... $ 82

4. Holding Tank (price will vary with size of system)

5. Hypochlorite solution (bleach)
   12.5% active chlorine.................. $ 3.50/gal.

*In 1980 dollars.

IV. IODINATION: Iodination may be used to disinfect drinking water systems. Of all the systems studied, the iodinator disinfection system is the easiest to install, the least expensive, has no moving parts, requires no electricity, and requires the least maintenance.

Of the four common halogens (fluorine, chlorine, bromine, and iodine), iodine has the highest atomic weight, is the least soluble in water (and is the least hydrolized by water), and is the lowest in oxidation potential. Iodine reacts less readily with organic compounds than do the other halogens. Because of its relatively low chemical reactivity, iodine is more stable and persists longer in water than do the other halogens (including chlorine); thus, it is easier to maintain a stable iodine residual. As iodine's vapor pressure is only 0.31 mm of mercury at room temperature (water at 20°C has a vapor pressure of 17.5 mm of mercury), it can be stored indefinitely in non-metallic containers under normal conditions without appreciable evaporative loss or deterioration.

The iodine residual in water is controlled by a saturated solution. The iodine saturation point in water varies with the water temperature. At a given temperature, only a corresponding maximum amount of iodine dissolves in the water, regardless of the contact time. Once the water is saturated and is removed from contact with the iodine crystals, further temperature changes have no effect on the concentration. A rapid, sensitive, and accurate colorimetric method has been developed for the measurement of the iodine residual in water.

The disinfecting efficiency of both iodine and chlorine are affected by the pH of the solution, but iodine is more effective through a wider pH range than is chlorine. Elemental iodine (I_2) is very effective as a water disinfectant. As the pH increases, I_2 reacts with water and forms hypoiodous acid (HIO), which is an effective bacteriocide. As with chlorine disinfection, a disinfectant residual can be maintained within the distribution system to help prevent contamination of the water once it leaves the point of disinfection. Iodination provides disinfection only, and will not treat or remove other impurities that may be present in the water. As is the case with chlorine disinfection, treatment beyond simple disinfection may be required if such impurities are present.

Iodine is easier to handle than chlorine, as it is stored in crystalline form rather than as a gas or liquid. Iodine, when heated, reacts vigorously with reducing materials, but is not a fire hazard and poses no danger of explosion.[2]

[2] "Iodine Dispenser for Water Supply Disinfection", U.S. Department of Agriculture, Forest Service Report 7400-1; January, 1976.

However, the use of iodine for disinfection can have adverse health effects on persons with thyroid problems or iodine sensitivity. Many public health authorities do not allow the use of iodine for disinfection of community systems, and restrict use for other systems to those that serve transient users only (i.e., users that will not be drinking the water for more than a two or three week period during a given season). Some public health authorities also require that the system be posted to alert users that iodine is being used for disinfection, and of potential health effects.

Because of the potential adverse health effects and unacceptability to public health authorities, iodination is generally not suitable for residential or other situations where members of the public or Bureau employees will be drinking the water on a long-term basis. However, due to the ease of maintenance and operation, iodination can be ideal for recreation sites and remote locations where use is transient and where electrical power is not available.

Iodinators are inexpensive to install and operate. Typical costs* are as follows:

1. One 5-lb. Iodination Unit
   (including 1 filling of iodine crystals)....... $ 260

2. Refill Iodine Crystals.................... $ 16.50/lb.

3. Three Gate Valves**:
   1 - 3/4" valve.................................$ 15
   2 - 1/4" valves................................$ 24

4. Holding Tank.............cost varies with size of tank

*In 1980 dollars.
**Prices of valves would increase as the size of the system increases.

V. OZONIZATION: Ozone (O_3) is a powerful oxidizing agent, with more than 1.5 times the oxidizing potential of chlorine. The use of ozone for purifying water has not been widely accepted in the United States, but has been applied successfully for more than 50 years in Europe.

Ozone is the only oxidizing agent that does not add a substance or a contaminant to the water, as any excess ozone quickly reverts to oxygen. Since ozone is a very strong oxidizing agent, a shorter contact time is required than is required for other agents such as chlorine or iodine. As ozone is very reactive, it is not possible to maintain a disinfectant residual within the distribution system; therefore, ozonization does not offer protection from contamination once the water leaves the point of disinfection. Ozonization provides essentially disinfection only, and does not remove or treat other impurities in the water.

Ozonization is accomplished by letting water trickle down a sterilizing tower; as the water travels down the tower, a current of ozonized air is forced through and distributed in the water. The ozone is generated by an electrical current; the principle is similar to the natural creation of ozone by lightning. Though ozonization is theoretically suitable for treating small water systems, ozone treatment has several disadvantages as compared to chlorine or iodine disinfection: electrical power is required; both electrical and mechanical equipment are required (including a sterilization tower); it is relatively expensive to install; it has higher operation and maintenance requirements and costs; and the treated water may be slightly corrosive. As ozone treatment is relatively uncommon in this country, most public health authorities do not have specific requirements for such systems, but would evaluate the acceptability of ozonization systems on a case by case basis.

An ozone system will always be more expensive than a comparable chlorination or iodination system. Generally, due to higher initial and operating costs, ozone systems would not be recommended for use as small water purification systems, so cost figures have not been supplied.

VI. ULTRAVIOLET: Ultraviolet (UV) light can be used to disinfect drinking water. The water to be treated passes in a thin film past a series of lamps that emit ultraviolet light. Quartz mercury vapor lamps are commonly used as UV emitters; reflectors are added to intensify and focus the ultraviolet light.

The maximum penetration of UV waves into water is about six inches; therefore, the depth of the incoming water must be controlled so that it does not exceed the depth of effective penetration. The incoming water must either pass past the lamps very slowly or there must be a long series of lamps to assure adequate disinfection. Also, the lamps lose their efficiency as UV emitters as time progresses, but there is no change in the amount or quality of visible light; thus, it is difficult to determine by visual inspection whether or not the UV lamps are emitting sufficient UV radiation to effectively treat the water.

Ultraviolet treatment does not provide a disinfectant residual, so the possibility exists that the water may become contaminated once it passes the point of disinfection. Ultraviolet treatment is a disinfectant only; it does not remove or treat other impurities that may be present in the water. If UV is used, it generally is applied at each tap because no residual is maintained in the system. As it is relatively cumbersome and expensive, it is not suitable for a system with several taps or outlets. UV treatment, like ozone, does not add a substance or contaminant to the water. Electrical power is required for UV systems, so installation in remote areas with no power is not feasible. As UV treatment is relatively rare, public health authorities would evaluate the acceptability of the system on a case by case basis.

Although the original installation cost of a small ultraviolet treatment system (approximately 10 gallons per minute) is not very expensive, both operating and maintenance costs are relatively high. The cost* of a small UV treatment system is as follows:

1. Complete 10 gpm UV system........................$ 550

2. Replacement lamps (each).........................$ 5

3. Electrical power costs will vary with geographic location

*In 1980 dollars.

VII. REVERSE OSMOSIS: A reverse osmosis treatment system, unlike the systems previously discussed, provides removal of many contaminants (including bacteriological contamination). Reverse osmosis may be used when the only source of water is unacceptably high in mineral content, salts, or other contaminants. As this type of system is much more expensive than simple disinfection systems like chlorination and iodination, it should only be considered when the water source has very high levels of dissolved contaminants and when treatment beyond simple disinfection is required.

Reverse osmosis systems counteract osmotic pressure through use of a pump to force incoming water through a permeator. Reverse osmosis systems contain three main components:

1. Permeator: Standard systems utilize semipermeable hollow fibers or spiral-wound membranes to separate and remove organics, dissolved solids, and bacteria from the incoming water. The impurities are collected and are flushed to a drain.

2. Pump: A pump is used to force the incoming water through the permeator. Pump pressure normally exceeds 200 psi. Electricity is required to operate the pump.

3. Controls: Most systems have readout gauges or monitors for pump discharge, permeator feed, and rejection pressures; and for output flow rate and reject flow rate.

Reverse osmosis systems are very expensive as compared to chlorination or iodination systems; however, reverse osmosis provides treatment and removal far beyond the simple disinfection provided by the other systems. Reverse osmosis is a form of microfiltration, and it provides essentially distilled water. As production of large volumes of water is very expensive, it is recommended that the purified water be used only for potable use, and that untreated or less treated water be used for bathing, laundry, etc. Reverse osmosis removes chemical impurities as well as bacteriological contamination, and furnishes very pure water. Occasionally, there may be esthetic objections to the water, because it tastes "flat"--i.e., the trace impurities that normally give water character and flavor are removed by the treatment process. As reverse osmosis is relatively rare, public health authorities would evaluate the acceptability of such systems on a case by case basis.

A commercially available reverse osmosis system with a capacity of approximately 400 gallons per day will have an initial cost (in 1980 dollars) of $2,500 to $4,500. On average, urban dwellers each use more than 100 gallons per day of water for drinking, cooking, washing, etc.; as can be seen from this comparison, use of a reverse osmosis system to provide the total water needed for even a small residential installation would be tremendously expensive. The system requires electrical power, and requires considerably more maintenance than would simple disinfection systems.

VIII. FILTRATION: If simple disinfection is not sufficient to treat or remove contaminants from drinking water, additional treatment, such as filtration, may be required. Many public health authorities require filtration for all community water systems, and may also require it for other systems if the water contains suspended solids or other impurities. In some parts of the country, particularly in the mountainous West, Giardia lamblia may present a health problem. Giardia lamblia is a protozoan that lives in the intestinal tract of warm-blooded animals. It encysts and is passed from the animal to humans when humans drink water that has been contaminated by animal activity, and it causes a debilitating form of dysentery (giardiasis). The cysts are highly resistant to disinfection and heat, and often can only be removed by filtration in addition to disinfection.

Sand Filtration: Sand filtration requires considerable attention to engineering and maintenance, and, although there are some small systems using sand filtration, it is usually not feasible for seasonal use and remote locations. In addition, full-scale sand filtration systems require equipment for flocculation, coagulation, etc., in order to realize their full filtration potential. As sand filtration would not generally be feasible for a system of the extremely small size discussed in this report, it will not be discussed in detail in this report.

Activated Carbon: Activated carbon treatment systems filter incoming water through granular or powdered carbon cartridges. Though carbon can be utilized in bed-type filters, systems utilizing the cartridge type filters are generally more suitable for small installations. Large quantities of dissolved gaseous, liquid, and finely divided solids are trapped by the filter media as the water passes through the cartridge. The length of time that the filter media remains effective varies with the volume of water passed by the filter and the amount of impurities in the water. Exhaustion of the filter media is signalled by a significant rise in the head loss across the filter. The filter media in carbon cartridges cannot be regenerated; the carbon cartridges are discarded and replaced when the filter media is exhausted. Activated carbon filtration is extremely effective for odor and taste control. The small cartridge-type units can be installed on each tap, or larger units for filtering the entire system can be installed near the headpoint of the system. As the activated carbon can remove constituents such as halogen residuals, a centralized carbon filtration system should be installed before the point of disinfection.

Diatomaceous Earth Filters: During World War II, diatomaceous earth filtration was developed by the U.S. Army Corps of Engineers for potable water use. Diatomite filters remove extremely small particles from the water, and will remove the cysts that cause amoebic dysentery (including Giardia cysts). Some of these cysts are unaffected by disinfection, and can pass through conventional sand filters, particularly if sand filters are used alone without flocculation and coagulation, or if the filtration system is not adequately maintained. Diatomaceous earth filters can be either pressure or vacuum type. The diatomaceous earth filter material is added directly to the incoming water at a rate of about 10 to 40 parts per million. A mat or cake is formed on the surface of the filter, and the water is forced through the filter surface and filter cake using either positive or vacuum pressure. Impurities are retained on the filter cake. The filter must be back-washed to remove impurities, and the filter cake must be reestablished after backwashing. A rise in the head loss across the filter as impurities accumulate on the filter signals the need for backwashing and regeneration of the filter cake.

IX. MISCELLANEOUS FACTORS: In some cases, it may be more cost effective to consider furnishing bottled water for drinking rather than installing a treatment system. This is particularly true for remote locations such as lookouts, where only one or two people are present for only a portion of the calendar year. However, this solution is usually not suitable where there is public use of the water for drinking; if taps or other outlets are provided that would encourage public use of the water for drinking, cooking, or other potable uses, the water should always (at a minimum) be disinfected.

X. SYSTEM COMPARISON:

Factor	Type of System				
	CHLORINATION	IODINATION	OZONIZATION	ULTRAVIOLET	REVERSE OSMOSIS
Original Cost of System	Inexpensive	Inexpensive	Relatively Costly	Inexpensive	Very Costly
Ease of Installation	Fairly Simple	Very Simple	Relatively Complex	Fairly Simple	Very Complex
Maintenance Required	Relatively Minimal	Minimal	Extensive	Relatively Extensive	Very Extensive
Power Required	Yes	No	Yes	Yes	Yes
Holding Tank Required	Yes	Yes	No	No	No
Acceptable for Long-Term Use	Yes	No	Yes	Yes	Yes
Disinfectant Residual	Yes	Yes	No	No	No
Furnishes Treatment Beyond Disinfection	No	No	No	No	Yes
Acceptable to Public Health Authorities	Yes	Not for Community Systems; restricted to transient use (periods not exceeding 2 - 3 weeks)	On case-by-case basis	On case-by-case basis	On case-by-case basis

XI. SUMMARY OF STATE PUBLIC HEALTH REQUIREMENTS FOR DRINKING WATER SYSTEMS

ALASKA

Treatment Requirements	PUBLIC SYSTEMS		
	Community	Non-Community	NON-PUBLIC SYSTEMS
Chlorination	Required on a case-by-case basis if there is known or suspected bacteriological contamination	Same as for community systems	No special requirements; can require testing, treatment, etc. (at the discretion of the field public health personnel)
Chloramines	No experience		
Iodination	Suitability determined on case-by-case basis		
Ozonization	No experience		
Ultraviolet (UV)	No experience		
Filtration: Sand Filters, Activated Carbon, Diatomaceous Earth	Not required		

Special Health Problems:

1. Giardia Lamblia: Have had some problems (3 or 4 outbreaks); the remedy is handled on a case-by-case basis (probably through additional disinfection/retention time rather than through filtration).
2. Viral: Minor problem in the past with hepatitis (not proven to be water-borne).
3. Radioactivity: Has been found associated with groundwater in northern Alaska; however, is not considered to be a major problem.
4. Organics (pesticides): No problems with man-made organics; however, there are problems with naturally occurring organics (with water originating in boggy or peat areas, for example).
5. Others: High arsenic levels have been detected in some individual wells in the Fairbanks area. As some areas have waters with high corrosivity, there have been some problems with high lead levels due to leaching from sweated joints in copper piping.

Posting Requirements: Check with state public health officials for posting requirements; there are no bilingual posting requirements at present, but bilingual (English/native language) posting may be required for areas with native populations.

REMARKS: The state of Alaska is planning to implement secondary standards by the end of 1981; they will be similar to the secondary standards of 40 CFR Part 143. Contact state public health officials for information.

ARIZONA

Treatment Requirements	PUBLIC SYSTEMS — Community	PUBLIC SYSTEMS — Non-Community	NON-PUBLIC SYSTEMS
Chlorination Chloramines Iodination Ozonization Ultraviolet (UV) Filtration: Sand Filters Activated Carbon Diatomaceous Earth Other	The State of Arizona has no overall treatment requirements, but considers each proposed system on a case-by-case basis	The State of Arizona has no overall treatment requirements, but considers each proposed system on a case-by-case basis	Non-public systems are excluded from regulation except where public health problems are known to exist

Special Health Problems:

1. Giardia Lamblia: The State public health department is not aware of any outbreaks of giardiasis within the State of Arizona.
2. Viral: The State public health department is not aware of any problems with viral contamination.
3. Radioactivity: Areas north of Phoenix are known to have radioactivity contamination problems.
4. Organics (pesticides): Pesticide contamination of water supplies is an increasing problem statewide.
5. Others: No other public health problems related to water supply are known to exist at this time.

Posting Requirements: Bilingual posting (English-Spanish) is required in some areas; check with the State of Arizona public health authorities for exact requirements.

REMARKS: The State of Arizona uses essentially the same primary standards as the National Interim Primary Drinking Water Regulations (NIPDWR), 40 CFR Part 141. No secondary standards have been adopted to date.

Treatment Requirements	PUBLIC SYSTEMS		NON-PUBLIC SYSTEMS
	Community	Non-Community	
Chlorination	Required for all surface sources; must also meet turbidity requirements	May be required for surface sources; check with State public health	No specific requirements; check with local authorities
Chloramines	No specific requirements	No specific requirements	
Iodination	Not allowed for community systems	Is allowed for non-community systems as long as use is transient only	
Ozonization	No specific requirements	No specific requirements	
Ultraviolet (UV)	Allowed for individual-system installations only	Allowed for individual-system installations only	
Filtration: Sand Filters Activated Carbon Diatomaceous Earth	Filtration required if turbidity standards cannot otherwise be met	May be required if turbidity standards cannot otherwise be met.	

Special Health Problems:

1. Giardia Lamblia: Some cases of giardiasis have been reported in Northern California (mountainous areas with populations of beaver).
2. Viral: None known.
3. Radioactivity: Low levels have been detected in a few instances, but is generally not a problem in the state of California.
4. Organics (pesticides): Mainly a problem in agricultural areas (particularly the San Joaquin Valley).
5. Others: Excessively high flouride is a problem in certain areas of the state (mainly in the mountains in the Los Angeles area and in desert areas). Removal and/or posting may be required, particularly if the water is regularly consumed by children under the age of 12 years.

Posting Requirements: Check state public health regulations. No bilingual posting required.

REMARKS: California has largely adopted the NIPDWR (40 CFR Part 141), but the state requirements may be more stringent in some respects. California has also adopted secondary standards. Check with the state public health department to determine treatment and testing requirements for individual systems.

Treatment Requirements	PUBLIC SYSTEMS (Class I Water Systems)		NON-PUBLIC SYSTEMS (Class II Water Systems)
	Community	Non-Community	
Chlorination	Always required for surface water sources; may also be required for groundwater sources	Same as for community systems	The State of Colorado essentially defines any system that serves water to the public as a "public water system"; therefore, the only systems that are excluded from regulation are those that serve individuals only (such as homeowners). Those that serve employees or members of the general public are considered to be public water systems. Generally, such systems will be classified as non-community systems. Contact the state public health department for monitoring and treatment requirements
Chloramines	No specific requirements	Same as for community systems	
Iodination	Not usually allowed for long-term use unless there is no other option	Same as for community systems	
Ozonization	No specific requirements	Same as for community systems	
Ultraviolet (UV)	Acceptable for individual system installation	Same as for community systems	
Filtration: Sand Filters, Activated Carbon, Diatomaceous Earth	Required for surface water sources; may be required for groundwater if turbidity standard cannot otherwise be met	Individual cartridge filters are acceptable (<1 micron pore)	

Special Health Problems:

1. Giardia Lamblia: Giardiasis is a big problem in the mountainous portions of Colorado; the five-year average of cases severe enough to be reported is 571 cases per year. Treatment for removal of Giardia cysts should be considered whenever the source is surface water originating in mountainous areas.
2. Viral: No known problems.
3. Radioactivity: Is known to be a problem in many portions of the state.
4. Organics (pesticides): No known problems.
5. Others: High nitrates have been found in the South Platte River drainage (particularly near Eden), and high selenium levels have been detected in the Arkansas River basin.

Posting Requirements: Check with the state of Colorado public health department for exact requirements.

Treatment Requirements	PUBLIC SYSTEMS		NON-PUBLIC SYSTEMS
	Community	Non-Community	
Chlorination	Required for all surface water sources; may also be required for groundwater unless good quality is documented	May be required for surface water sources	No specific requirements for non-public systems
Chloramines	No experience; would be judged on case-by-case	No experience	
Iodination	Not allowed unless there is no other option	For transient use only, unless there is no other option	
Ozonization	No experience	No experience	
Ultraviolet (UV)	No experience (probably not allowed, because no residual is achieved)	No experience	
Filtration: Sand Filters, Activated Carbon, Diatomaceous Earth	Probably required for surface sources, unless the quality of the water is documented	Need is judged on a case-by-case basis	

Special Health Problems:

1. Giardia Lamblia: Is a problem in some of the mountainous areas; new systems using surface water may require filtration.
2. Viral: None.
3. Radioactivity: Parts of southern Idaho may have problems with U series radioactivity.
4. Organics (pesticides): None.
5. Others: In some areas, high fluorides and high nitrates may be a problem. Public notification is required if there is a problem.

Posting Requirements: There are no bilingual posting requirements. For coliform violations, surface water sources are required to notify the public on the first violation; groundwater sources are required to notify if the check sample also exceeds the MCL.

MONTANA

Treatment Requirements	PUBLIC SYSTEMS		
	Community	Non-Community	NON-PUBLIC SYSTEMS
Chlorination	Required for all systems using surface water	Required for all systems using surface water	No special requirements for non-public systems
Chloramines	Acceptability judged on a case-by-case basis	Acceptability judged on a case-by-case basis	
Iodination	Not allowed for community systems	Allowed for transient and individual systems only	
Ozonization	Acceptability judged on a case-by-case basis	Acceptability judged on a case-by-case basis	
Ultraviolet (UV)	Probably not allowed (no residual)	May be acceptable for individual systems only	
Filtration: Sand Filters Activated Carbon Diatumaceous Earth	Required for new systems utilizing surface water	Required for new systems utilizing surface water	

Special Health Problems:

1. Giardia Lamblia: Is a problem in mountainous areas; filtration may be required.
2. Viral: None known.
3. Radioactivity: Little information available; does not appear to be a problem.
4. Organics (pesticides): No known problems.
5. Others: High fluorides are found in eastern Montana, and high nitrates in central Montana. High sodium levels (>250 mg/L) are found in eastern Montana. Arsenic can be a problem in some groundwater sources.

Posting Requirements: Notice is required if MCL's are exceeded. Bilingual posting is not required except on some of the Indian reservations, where EPA (rather than the state) has enforcement responsibility.

NEVADA

Treatment Requirements	PUBLIC SYSTEMS		NON-PUBLIC SYSTEMS
	Community	Non-Community	
Chlorination	Required only if bacteriological contamination is known or suspected	Required only if bacteriological contamination is known or suspected	No special requirements for non-public systems
Chloramines	No experience	No experience	
Iodination	Not allowed for community systems	Not recommended if there is any other alternative	
Ozonization	No experience	No experience	
Ultraviolet (UV)	No experience	No experience	
Filtration: Sand Filters Activated Carbon Diatomaceous Earth	Not required unless need is demonstrated by unacceptable samples	Not required	

Special Health Problems:

1. Giardia Lamblia: There have been a few problems in mountainous areas, but it seems to be limited mostly to back-country use of open surface water for drinking. The major effort so far has been directed to educating back-country users on the possibility of contracting giardiasis by drinking from streams and other unprotected sources.
2. Viral: Possibly hepatitis; no major problems.
3. Radioactivity: Has only been detected in one system in the state, and not in amounts large enough to constitute a health hazard.
4. Organics (pesticides): Little testing has been done; is not perceived as much of a problem at this time.
5. Others: A few systems have shown marginally high fluorides, and have been placed on a compliance schedule; high fluorides are associated with groundwater sources only. A few non-community systems have shown high levels of nitrates and have been placed on a compliance schedule.

Posting Requirements: Posting would be required if iodination is used. Bilingual posting is not required. Contact state public health officials for other posting requirements.

Treatment Requirements	PUBLIC SYSTEMS		NON-PUBLIC SYSTEMS
	Community	Non-Community	
Chlorination	Disinfection is not required for either surface or groundwater unless contamination problems are known to exist	Disinfection not required unless contamination problems are known to exist	No special requirements for non-public systems
Chloramines	No experience	No experience	
Iodination	Unofficially allowed for small systems; not encouraged if there is any alternative	Allowed for small systems serving transient users only.	
Ozonization	No experience	No experience	
Ultraviolet (UV)	No experience	No experience	
Filtration: Sand Filters, Activated Carbon, Diatomaceous Earth	No requirements for filtration	No requirements	

Special Health Problems:

1. Giardia Lamblia: Has been detected in the Chama area; may be a problem in other mountainous areas of the state.
2. Viral: None known.
3. Radioactivity: May be a problem in portions of the Rio Puerco drainage.
4. Organics (pesticides): Little information; does not appear to be a problem at this time.
5. Others: High fluorides are a problem in southern and eastern New Mexico. High nitrates and high selenium appear to be a problem in some localized areas.

Posting Requirements: Bilingual posting may be required in some areas; check with the state public health department.

Treatment Requirements	PUBLIC SYSTEMS		NON-PUBLIC SYSTEMS
	Community	Non-Community	
Chlorination	Required for systems utilizing surface water and where bacteriological contamination is expected	May be required for surface water systems	No special requirements for non-public systems
Chloramines	No experience	No experience	
Iodination	Only allowed for transient use	Only allowed for transient use	
Ozonization	Acceptable	No requirements	
Ultraviolet (UV)	Acceptable	No requirements	
Filtration: Sand Filters, Activated Carbon, Diatomaceous Earth	All surface water must be clarified and softened	No requirements	

Special Health Problems:

1. Giardia Lamblia: Has not been detected within the state.
2. Viral: Not detected within the state.
3. Radioactivity: Little information; has not been a problem so far.
4. Organics (pesticides): Has not been a problem so far; may be an increasing problem due to the agricultural nature of the state and the increased use of organic pesticides.
5. Others: High total suspended solids (TSS) can be a problem in many parts of the state. High fluorides are also a problem in some groundwater sources. High arsenic may be found in the southeast portion of the state.

Posting Requirements: Check with state public health authorities; bilingual posting generally not required.

Treatment Requirements	PUBLIC SYSTEMS Community	Non-Community	NON-PUBLIC SYSTEMS
Chlorination Chloramines Iodination Ozonization Ultraviolet (UV) Filtration: Sand Filters Activated Carbon Diatomaceous Earth	No state regulations; are the NIPDWR (40 CFR Part 141)	No state regulations; are the NIPDWR (40 CFR Part 141)	No special requirements for non-public systems

Special Health Problems:

1. Giardia Lamblia:
2. Viral:
3. Radioactivity:
4. Organics (pesticides):
5. Others:

Posting Requirements:

REMARKS: The State of Oregon does not have primacy at this time for enforcing the drinking water regulations. Enforcement is the responsibility of the U.S. Environmental Protection Agency (EPA), Region X, in Seattle WA. Day-to-day problems are handled by the EPA Portland field office.

Treatment Requirements	PUBLIC SYSTEMS		NON-PUBLIC SYSTEMS
	Community	Non-Community	
Chlorination Chloramines Iodination Ozonization Ultraviolet (UV) Filtration: Sand Filters Activated Carbon Diatomaceous Earth	No state regulations; are the NIPDWR (40 CF Part 141)	No state regulations; are the NIPDWR (40 CFR Part 141)	No special requirements for non-public systems

Special Health Problems:

1. Giardia Lamblia:
2. Viral:
3. Radioactivity:
4. Organics (pesticides):
5. Others:

Posting Requirements:

REMARKS: The State of South Dakota does not have primacy at this time for enforcing the drinking water regulations. Enforcement is the responsibility of the U.S. Environmental Protection Agency (EPA), Region VIII, in Denver CO.

Treatment Requirements	PUBLIC SYSTEMS Community	Non-Community	NON-PUBLIC SYSTEMS
Chlorination	Required for all systems utilizing surface water	May be required for systems utilizing surface water	No special requirements for non-public systems
Chloramines	No experience	No experience	
Iodination	Allowed only in remote locations where no other type of disinfection is feasible (requires state approval)	Allowed only for transient users (<3 weeks continuous use in any one season)	
Ozonization	Acceptability judged on a case-by-case basis	Acceptability judged on a case-by-case basis	
Ultraviolet (UV)	Not allowed for community systems	Might be allowed for individual systems; check with the state	
Filtration: Sand Filters Activated Carbon Diatomaceous Earth	Filtration, sedimentation, flocculation required for surface water systems	Not required; may be recommended for areas with quality problems	

Special Health Problems:

1. Giardia Lamblia: Is a problem in some of the mountainous areas; particularly for recreation sites utilizing surface water or infiltration galleries.
2. Viral: None.
3. Radioactivity: Is known to be a problem in southeastern Utah and in some of the mining areas; a statewide survey is being done in 1981 to determine the exact magnitude and extent of the problem.
4. Organics (pesticides): No problems are known to exist at this time.
5. Others: A few systems have detected slightly elevated fluorides; it is not a major problem. High nitrates are a problem in some areas, particularly near Cedar City in southern Utah, and near Cornish in northern Utah. High arsenic levels have been detected in the Hinckley area. High sulfates (>500 mg/L), sodium, and high total dissolved solids (TDS) (>2000 mg/L) may be a problem statewide.

Posting Requirements: There are no bilingual posting requirements; check with the state public health department for other posting requirements.

Treatment Requirements	PUBLIC SYSTEMS		NON-PUBLIC SYSTEMS
	Community	Non-Community	
Chlorination	Required for all systems not served by protected groundwater source	Required for systems not served by protected groundwater source	The State of Washington uses a different classification system than does EPA; any system that serves the public (no matter what the use level) or that serves 2 or more homes, etc. is considered to be a "Class IV" system, and is regulated as a public system. Contact the state public health department for applicable requirements
Chloramines	No experience	No experience	
Iodination	Not allowed for community systems	May be allowed if system serves transient users only	
Ozonization	No experience	No experience	
Ultraviolet (UV)	Would probably not be allowed for community systems	No experience	
Filtration: Sand Filters, Activated Carbon, Diatomaceous Earth	Required for unprotected surface sources and others that cannot otherwise meet turbidity restrictions	Required for unprotected surface sources and others that cannot otherwise meet turbidity restrictions	

Special Health Problems:

1. Giardia Lamblia: Is a problem, mostly in mountain/surface water sources.
2. Viral: No known problems.
3. Radioactivity: No known problems.
4. Organics (pesticides): No known problems with pesticides. High TTHM levels have been detected in a few instances (affects community systems only).
5. Others: High nitrates may be a problem in eastern Washington (east of the mountains). Moderately high fluorides (near the maximum allowable limit) have been detected in a few cases, but do not constitute a major problem within the state.

Posting Requirements: No bilingual posting is required; contact state public health officials for other requirements.

REMARKS: The State of Washington has adopted secondary standards similar to those contained in 40 CFR Part 143. The secondary standards are considered advisory ("should" instead of "shall") rather than absolute.

WYOMING

Treatment Requirements	PUBLIC SYSTEMS Community	Non-Community	NON-PUBLIC SYSTEMS
Chlorination Chloramines Iodination Ozonization Ultraviolet (UV) Filtration: Sand Filters Activated Carbon Diatomaceous Earth	No state regulations; are the NIPDWR (40 CFR Part 141)	No state regulations; are the NIPDWR (40 CFR Part 141)	No special requirements for non-public systems

Special Health Problems:

1. Giardia Lamblia:
2. Viral:
3. Radioactivity:
4. Organics (pesticides):
5. Others:

Posting Requirements:

REMARKS: The State of Wyoming does not have primacy at this time for enforcing the drinking water regulations. Enforcement is the responsibility of the U.S. Environmental Protection Agency (EPA), Region VIII, in Denver CO.

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