July 1, 1994
revised: January 1, 2002 (IESWTR)

SURFACE WATER TREATMENT RULE

ADMINISTRATIVE MANUAL

SAFE DRINKING WATER BRANCH
DEPARTMENT OF HEALTH
STATE OF HAWAII

Foreword

The purpose of this manual is to provide standardized procedures to the staff of the Safe Drinking Water Branch (SDWB) in the administration and implementation of the Surface Water Treatment Rule (SWTR) and Interim Enhanced Surface Water Treatment Rule (IESWTR), an integral part of the:

HAWAII ADMINISTRATIVE RULES
TITLE 11
DEPARTMENT OF HEALTH
CHAPTER 20
RULES RELATING TO POTABLE WATER SYSTEMS

The Hawaii SWTR and IESWTR have been adopted to conform in general with the Environmental Protection Agency's (EPA) Federal Regulations, but, in places, the Hawaii rules are more stringent than that of the Federal Regulations. The manual then is to be used by the staff of the SDWB in enforcing the rules as adopted with the use of the terms "shall," "must," and "require" referring to mandatory action on the part of the water purveyor.

The reference in the text to page number(s) in parenthesis relates to material found in the following documents:

1. March 1991 Edition of EPA's Guidance Manual for Compliance with the Filtration and Disinfection Requirements for Public Water Systems Using Surface Water Sources, for example (EPA Page 4-26), and

2. May 15, 1991, State of California's Surface Water Treatment Staff Guidance Manual, Office of Drinking Water, Department of Health Services, for example (CA Page 1-11) and

3. 1992 Edition, Recommended Standards for Water Works, A Report of the Committee of the Great Lakes - Upper Mississippi River Board of State Public Health and Environmental Managers, generally known as the Ten State Standards, for example (TSS Pages 39 and 40).

4. June 2001 Edition of EPA's Implementation Guidance for the Interim Enhanced Surface Water Treatment Rule.

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CHAPTER 1

GENERAL REQUIREMENTS

1. GENERAL REQUIREMENTS

I. GENERAL

A. The State Surface Water Treatment Rule (SWTR) and Interim Enhanced Surface Water Treatment Rule (IESWTR) are intended to comply with or be more stringent than EPA's Federal Regulations (40 CFR Part 141), Subpart H and Subpart P, respectively. The Federal Regulations establish treatment and performance requirements in place of maximum contaminant levels (MCLs) for Cryptosporidium, Giardia, viruses, Legionella, heterotrophic plate count (HPC) bacteria and turbidity --- filtration to remove and disinfection to inactivate or to destroy those contaminants.

B. The Federal Regulations require that all affected public water systems (PWS) which use a surface water source or groundwater under the direct influence of surface water (GWUDI) must ensure the safety of the consumer from Giardia, Cryptosporidium, viruses, Legionella and HPC by the following actions:

1. A total of 99.9 percent (3-log) removal and inactivation of Giardia,

2. A total of 99.99 percent (4-log) removal and inactivation of viruses, and

3. A total of 99 percent (2-log) removal of Cryptosporidium.

C. Although the terminology is not used in this guidance manual, an understanding of the multiple barrier concept is in order. Multiple barriers, as it relates to surface water sources, has been defined as a series of source water protection measures and water treatment processes that provide for the prevention, removal and inactivation of waterborne pathogens. Multiple barrier treatment for surface water sources includes filtration for the removal process and disinfection for the inactivation process.

II. REQUIREMENTS OF AFFECTED SYSTEMS

All affected PWS using surface water or groundwater under the direct influence of surface water shall meet the following SWTR and IESWTR requirements:

1. Filtration criteria.

2. Disinfection criteria.

3. Monitoring requirements.

4. Reporting requirements.

III. COMPLIANCE DEADLINES

A. Existing SWTR Compliance (40 CFR 141 Subpart H): all PWS utilizing surface water or GWUDI sources prior to January 1, 2002 shall comply with HAR 11-20-46 <u>Filtration and Disinfection (Surface Water Treatment Rule)</u>.

B. IESWTR Compliance (40 CFR 141 Subpart P): in addition to Item III.A., all PWS utilizing surface water or GWUDI sources and serving at least 10,000 people shall comply with HAR 11-20-46.1 Enhanced Filtration and Disinfection beginning January 1, 2002.

C. In addition to Item III.A., all PWS utilizing surface water or GWUDI sources and serving less than 10,000 people shall comply with the Long Term 1 (LT1 ESWTR) Enhanced Surface Water Treatment Rule, (40 CFR 141 Subpart T) beginning January 14, 2005. Early implementation of TTHM/HAA5 sampling (to determine the need for subsequent disinfection profiling) is required of all affected systems by July 1, 2003.

IV. CRITERIA FOR DETERMINING GROUNDWATER UNDER THE DIRECT INFLUENCE OF SURFACE WATER AND SUBJECT TO THE SWTR AND IESWTR (REMOVAL BY FILTRATION AND INACTIVATION BY DISINFECTION OF CRYPTOSPORIDIUM, GIARDIA ANDVIRUSES)

A. The director has the responsibility for determining which groundwater source must meet the requirements of the SWTR and IESWTR. However, it is the responsibility of the water purveyors to provide the director with the information needed to make this determination. If there still is a question on the status of a groundwater source, the water purveyor will have to show that there is no direct influence of surface water on that groundwater source. Otherwise, the director's decision will have to err on the side of safety and filtration will be required. The director's determination will then be made on the following basis:

1. Conditions under which filtration and disinfection will not be required for a groundwater source.
   a. Groundwater source not subject to periods of turbidity exceeding 1.0 NTU, and
   b. Groundwater source nowhere near or connected to a surface water body, and
   c. Groundwater source which may be connected to a surface water body, but whose turbidity, temperature, pH, etc. do not reflect similar changes observed in that surface water body, during heavy rainfall and runoff, and
   d. Groundwater source shows absence of Giardia or Cryptosporidium as demonstrated by tests for Giardia and Cryptosporidium, and
   e. Groundwater source shows absence of live diatoms or live bluegreen, green, or other chloroplast containing algae requiring sunlight for their metabolism as demonstrated by microscopic particulate analysis (MPA).

2. Conditions under which filtration and disinfection shall be required for a groundwater source.
   a. Groundwater source shows presence of Giardia or Cryptosporidium as demonstrated by testing for Giardia and Cryptosporidium, or
   b. Groundwater source subject to periods of turbidity exceeding 1.0 NTU, or
   c. Groundwater source which may be connected to a surface water body, and whose turbidity, temperature, pH, etc. reflect similar changes observed in that surface water body, during heavy rainfall and runoff, or
   d. Groundwater source shows presence of live diatoms or

live bluegreen, green, or other chloroplast containing algae requiring sunlight for their metabolism as demonstrated by microscopic particulate analysis(MPA).

3. Groundwater sources which are not subject to the conditions listed in the previous item 2, but which may be at risk to contamination from bacteria and human enteric viruses, will be regulated either under the Total Coliform Rule or by the forthcoming Groundwater Rule.

4. Sanitary survey data will also be used as supportive evidence for determining surface water influence.

B. Definitions for Groundwater Sources:

1. Shallow Wells have less than 50 feet of sanitary seal.

2. Deep Wells have a minimum 50 feet of sanitary seal.

3. Springs are formed when water perched on a clay or other impervious layer overflows that layer and exits at the ground surface.

4. Infiltration Galleries consist of horizontally buried, perforated pipes or French drains (open-joint pipes in porous material), leading collected water to a sump with a pump to lift the water into the transmission and distribution piping. A line of shallow, closely spaced wells may also be used as the infiltration gallery. These collection systems are placed parallel to the banks of rivers, streams, and lakes (also reservoirs). They are installed at a depth a few feet below the level of the surface water bed and in a direction perpendicular to the groundwater flowing towards the surface water body. The infiltration galleries are also installed in fairly permeable material such as alluvial sand or gravel as to help the percolation of groundwater into the pipes or wells. The problem here is that in times of low groundwater flows, surface water could end up being the major source of water being collected in the infiltration galleries.

5. Ranney Type Collectors are dug wells about a dozen or more feet in diameter. They are generally installed on river or stream banks in saturated sand or gravel material. Because the well is installed below the level of the groundwater table, the dug hole has to be dewatered as it is excavated. A caisson (a watertight, reinforced concrete chamber) is sunk into the dug hole and backfilled below the level of the groundwater table with sand and gravel. Well points are attached to perforated pipes and are driven in a radial pattern about 200 feet out from the caisson. The perforated pipes are connected to pumps and are initially pumped to waste to flush out the fines surrounding the perforated pipes. Left behind is a gravel layer which then surrounds the pipe.

6. Tunnels, in Hawaii, are unlined horizontal collectors excavated into the mountainside, either breaching impermeable dike compartments; or gravity transported, water laid, older alluvium, including talus; or weathered bedrock (lava rock),

and developing for use the water collected in the excavated hole.

7. Shafts, in Hawaii, are inclined, vertical, or a combination of horizontal and vertical tunnels leading to horizontal collectors developing:
   a. Unconfined basal water at sea level (Maui type shaft, U. S. Navy Waiawa Shaft).
   b. Dike confined water at sea level (Oahu type shaft, Honolulu BWS Makaha Shaft).
   c. Dike confined water at high level elevations (Lanai type shaft, U. S. Army Schofield Shaft).

C. Specific Guidelines For Determining Groundwater Subject to the SWTR and IESWTR.

1. Shallow Wells
   a. Shallow wells will be subject to the SWTR and the IESWTR, unless
   b. The water purveyor can demonstrate no direct surface water influence by confirming:
      (1) No turbidity level exceeding 1.0 NTU, and
      (2) No chemistry changes (turbidity, temperature, pH, etc.) during heavy rainfall and runoff, and
      (3) No presence of Giardia or Cryptosporidium, and
      (4) No presence of live diatoms or live bluegreen, green, or other chloroplast containing algae requiring sunlight for their metabolism.

2. Deep Wells are not subject to the SWTR and IESWTR if (EPA Page 2-6):
   a. The well is constructed with a sanitary seal (watertight casing) using bentonite clay, cement, or other acceptable material in the annular space between the drilled hole and the outer wall of the casing; sanitary seal to start at ground surface and run a minimum distance of 50 feet along the length of the well casing.
   b. Water quality records indicate:
      (1) No history of turbidity problems unless problem occurred because of unusual or unpredictable circumstances, and
      (2) No history of known or suspected outbreak of Giardia, Cryptosporidium or other pathogenic organisms associated with surface water contamination of the well water.

3. Springs are not subject to the SWTR and IESWTR if onsite inspection confirms that:
   a. Collection point is protected by proper construction, and
   b. No direct influence by surface water runoff (EPA Page 2-6 and item IV.A.1. of this chapter).

4. Infiltration Galleries and Ranney Type Collectors will be subject to the SWTR and the IESWTR, unless the water purveyor can demonstrate no direct influence by surface water by meeting the criteria in item IV.A.1. of this chapter.

5. <u>Tunnels</u> that meet the criteria of item IV.A.1. of this chapter will not be subject to the SWTR and IESWTR.

6. <u>Shafts</u> are not subject to the SWTR and IESWTR.

7. If Giardia, Cryptosporidium, live diatoms, or live bluegreen, green, or other chloroplast containing algae requiring sunlight for their metabolism are subsequently found in the water of any groundwater source, that source shall comply with the filtration and disinfection criteria of the SWTR and the IESWTR.

CHAPTER 2

FILTRATION CRITERIA

2. FILTRATION CRITERIA

I. GOAL

The overall objective of the filtration criteria is to provide control of: Giardia; Cryptosporidium; viruses; heterotrophic plate count (HPC) bacteria; Legionella; and turbidity by assuring a high probability that filtration plants are well-operated and achieving maximum removal efficiencies of the above parameters.

II. FILTRATION PLANTS

A. General Description of Acceptable Filtration Processes (EPA Page 4-2)

1. Conventional Treatment: A series of processes including coagulation, flocculation, sedimentation, and filtration (Figure 2-1).

2. Direct Filtration: A series of processes including coagulation, flocculation, and filtration, but excluding sedimentation (Figure 2-2).

3. Slow Sand Filtration: A process which involves passage of water through a bed of sand at low velocity, generally less than 0.4 meters/hour (1.2 feet/hour) and at a flow rate of less than 6 cubic meters per second per square meter (0.10 gallons per minute per square foot), resulting in substantial particulate removal by physical and biological mechanisms.

4. Diatomaceous Earth Filtration: A process that meets the following conditions:
   a. A precoat cake of diatomaceous earth filter media is deposited on a support membrane (septum), and
   b. The water is filtered by passing it through the cake on the septum; additional filter media, known as body feed, is continuously added to the feed water in order to maintain the permeability of the filter cake.

5. Alternate Technologies: Any filtration process other than those listed above shall demonstrate their acceptability through pilot studies in accordance with the SDWB's Pilot Testing of Surface Waters and Groundwaters Under the Direct Influence of a Surface Water (GWUDI) for Unapproved Alternative Filtration Technologies. However, pilot studies may not be needed if EPA has conducted their own studies and has accepted that technology. Available alternate filtration technologies include, but are not limited to:
   a. Package Plants.
   b. Cartridge Filters.

6. Existing In-line Filtration: A series of processes including coagulation and filtration, but excluding flocculation and sedimentation. The system may be accepted based on performance criteria.

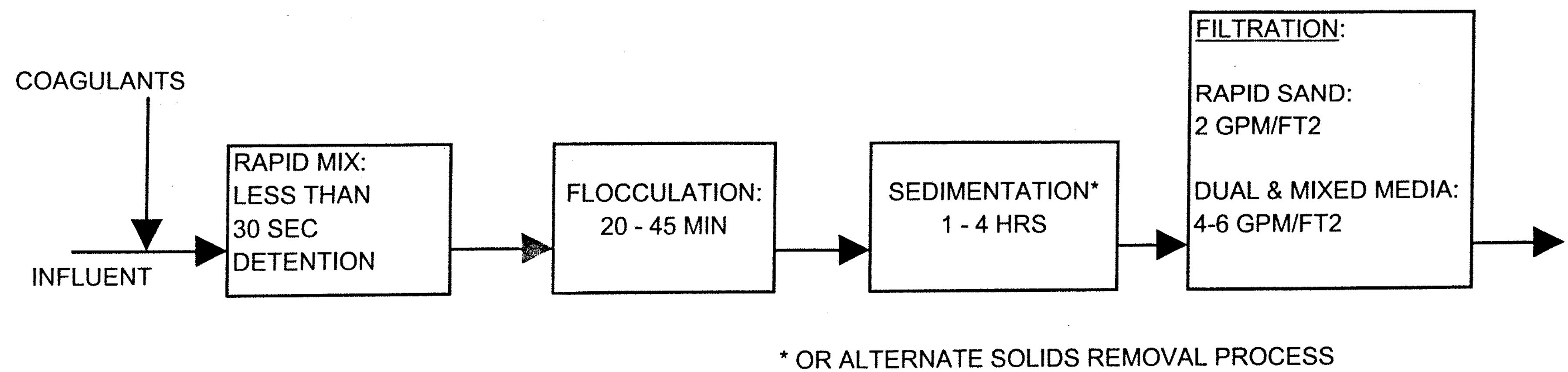


FIGURE 2-1
FLOW SHEET OF A TYPICAL CONVENTIONAL WATER TREATMENT PLANT

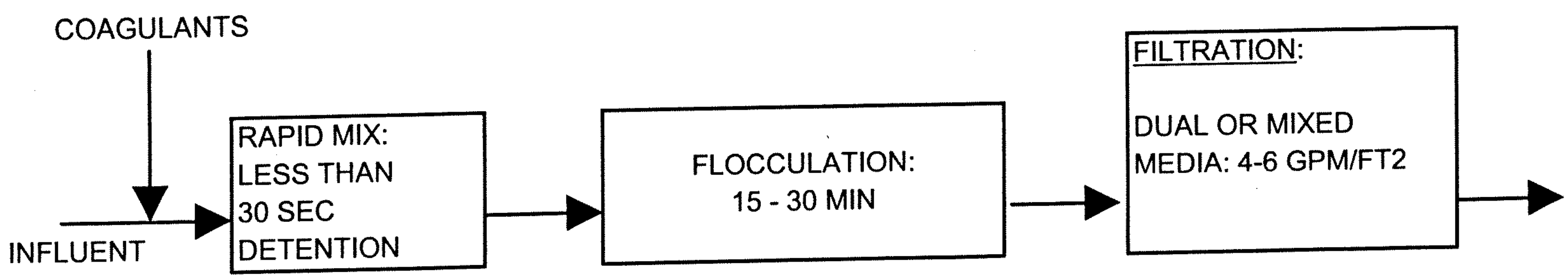


FIGURE 2-2
FLOW SHEET OF A TYPICAL DIRECT FILTRATION PLANT

B. Log Removals of Giardia, Viruses, and Total Coliforms by Filtration (without disinfection)

TABLE 2-1 (Follows EPA page 4-4)
LOG REMOVAL CAPABILITIES OF FILTRATION PROCESSES

Process	*Giardia*	*Viruses*	*Total Coliform*
Conventional Treatment	2	1	>4
Direct Filtration	2	1	1
Slow Sand Filtration	2	1	1
Diatomaceous Earth Filtration			
Filtration	2	1	1

C. Raw Water Quality Conditions and Applicable Filtration Technology

TABLE 2-2 (Follows EPA page 4-8)
GENERALIZED CAPABILITY OF FILTRATION SYSTEMS
TO ACCOMMODATE RAW WATER QUALITY CONDITIONS

Treatment	*Total Coliforms (#/100ml)*	*Turbidity (NTU)*	*Color (CU)*
Conventional w/ predisinfection	<20,000	No restrictions	<75
Conventional without predisinfection	<5,000	No restrictions	<75
Direct Filtration	<500	<7-14	<40
In-line Filtration	<500	<7-14	<10
Slow Sand Filtration	<800	<10	<5
Diatomaceous Earth Filtration	<50	<5	<5

Note: Turbidity criteria for direct and in-line filtration depends on algae population, alum, or cationic polymer coagulation. These criteria are general guidelines. Periodic occurrences of raw water coliform, turbidity or color levels in excess of the values presented should not preclude the selection or use of a particular filtration technology. For example, the following alternatives are available for responding to occasional raw water turbidity spikes:

1. Direct Filtration
   a. Continuous monitoring and coagulant dose adjustment.
   b. More frequent backwash of filters.
   c. Use of presedimentation.

2. Slow Sand Filtration
   a. Use of a roughing filter.
   b. Use of an infiltration gallery.

3. Diatomaceous Earth Filtration
   a. Use of a roughing filter.
   b. Use of excess body feed.

III. DESIGN OF FILTRATION PLANTS

The 1992 edition of Recommended Standards for Water Works (Great Lakes), generally known as the Ten State Standards and as amended in this manual, shall be followed in the design of filtration plants.

A. General Requirements for Filtration Plants.

1. An engineering report shall be prepared for all new facilities proposing to treat surface water sources or groundwater under the direct influence of a surface water (GWUDI) sources. Existing treatment facilities requiring significant modifications to comply with surface water treatment rules shall also prepare an engineering report. The contents of the report shall be in accordance with the SDWB's Guidelines for Preparation of Engineering Reports for Surface Water or Groundwater Under the Direct Influence of a Surface Water Sources.

2. Treatment plant should be designed so it can operate without frequent shutdowns and startups or rapid changes in filtration rates. Frequent shutdowns and startups allow trapped particulates to pass through the filters. These problems are more prevalent with the smaller systems where the plants either operate on demand or an inadequate clearwell storage cycles the plant on and off whenever the demand goes up and then down. These treatment plant problems can be corrected by sizing the plant components and the clearwell storage to allow for one startup period per day. Smaller sized, multiple filters are better than one larger sized filter. Multiple filters allow one filter to be serviced while the others are operated (CA Pages 4-13 and 4-14).

3. The design of direct, slow sand, or diatomaceous earth filtration plants should include plans for the possible future addition of pretreatment facilities. This is required in the event of changes in the water quality conditions due to unforeseen incidents or developments in the watershed. This is especially so where controls over the watershed are either lacking or developments may be a permitted or conditional use in that watershed. It is always prudent to consider expansion of the plant in the future and the addition of unit processes as they become necessary (CA Page 4-9).

4. The filtration plant must be designed to meet the max day demand of the system that it serves. The source serving that filtration plant must have a capacity equal to or greater than the max day demand of that system. The use of treated water storage to meet peak hour and/or fire flow demand is acceptable, but that same storage should not be used to help a underdesigned filtration plant to meet the max day demand.

5. The water treatment facilities shall be designed so as to be free of structural and domestic wastewater hazards. Common wall construction between raw water and treated water basins is an example of an unacceptable structural hazard. Also, domestic wastewater handling facilities (sewer collection lines, wastewater treatment, and disposal) should be properly designed. These wastewater facilities, while operating or upon failure, should not be able to contaminate either raw or treated water at the water treatment plant (CA Page 4-6).

6. Disinfection equipment shall be sized for the full range of flow conditions expected, and should be capable of feeding accurately at all flow rates. The middle range of the feeding equipment is much more accurate than the low or high side of the feeding equipment. Another problem related to the accuracy of the feeding equipment refers to the following:
   a. If the actual amount of disinfectant fed is low, the inactivation or destruction of pathogens is inadequate, and
   b. If the actual feed rate is too high, the formation of trihalomethanes (THM), taste, odor, and corrosion of facilities metal parts may become a problem (CA Page 4-10).

7. The water treatment facility should be designed with security in mind. The site shall be fully enclosed by fencing. The treatment plant should be housed or covered if feasible.

8. All filtration plants shall have, at the minimum, two operating units per treatment process (coagulation or rapid mix, flocculation, sedimentation or clarification, rapid sand filter, slow sand filter, and diatomaceous earth filter). This is to assure complete and continuous treatment of the source water at all times, even if one of the units is shut down for repair, service, or backwash. The 1992 Ten State Standards requires a minimum of two filter units. Where only two filter units are provided, each unit must be capable of meeting the maximum daily demand. If more than two filter units are available, the rest of the filter units must be able to meet the maximum daily demand, at the approved filtration rate, when any one of the units is removed from service (TSS Page 41).

B. Conventional Treatment and Direct Filtration Plants.

1. The sedimentation process in conventional treatment should include other methods of solids removal such as dissolved air flotation. Plate separation and upflow-solids contact clarifiers included in the 1992 Ten State Standards (respectively pages 39 and 40, and pages 36 through 39) should also be considered (EPA Page 4-14).

2. Coagulation must always take place whenever rapid sand filters are being operated. Failure to maintain optimum coagulation can result in poor filter performance with the breakthrough of cysts and viruses. Therefore, to assure optimum coagulation upon startup of the filtration plant, the process selection for coagulation shall be based on pilot plant or laboratory scale jar tests. These tests should be over the full range of expected water quality conditions for identifying design parameters. Parameters to be learned would include the type(s) of coagulant chemicals to be used, where and when to add the coagulant, requirements for rapid mixing, and dose rates to optimize the process (CA Pages 4-11). Larger sized direct and in-line (Figure 2-3) filtration plants with gravity filters require the use of open rapid-mix basins with mechanical mixers (EPA Page 4-17).

3. Flow measuring and recording equipment should be installed on influent and effluent lines and lines leading to the various unit processes, such as lines for the backwash water. A continuous record of the treated water flowing to the system is needed. Chemicals are added at various points in the treatment plant. The ability to adequately calculate dosages of chemicals used is essential for proper operation of all treatment plants (CA Page 4-7).

4. Provide reasonable access for inspection, maintenance, and monitoring of all unit processes. This will permit essential processes such as coagulation, flocculation, filtration, and disinfection to be inspected and serviced when needed. Of particular concern are clear wells which should be cleaned at least annually or earlier as needed, and pressure filters which need to be constructed so as to allow for annual or more frequent inspection of the filter media. All treatment processes need to be inspected so as to trouble shoot plant problems as they occur. Adequate working space around mechanical equipment is needed for repair and maintenance (CA Page 4-8).

5. Filter-to-waste provisions shall be provided for each new filter and may be required for existing filters. Turbidity spikes are normally seen after a filter is backwashed and returned to service without filtering-to-waste. Studies have shown that this initial turbidity spike can contain high level of pathogens that have been removed and stored in the filter CA Pages 4-8 and 4-9), a 0.2 to 0.3 NTU increase in the turbidity during the first period of the filter run can be associated with rises in Giardia concentrations of twenty to forty fold (EPA Page 4-11).

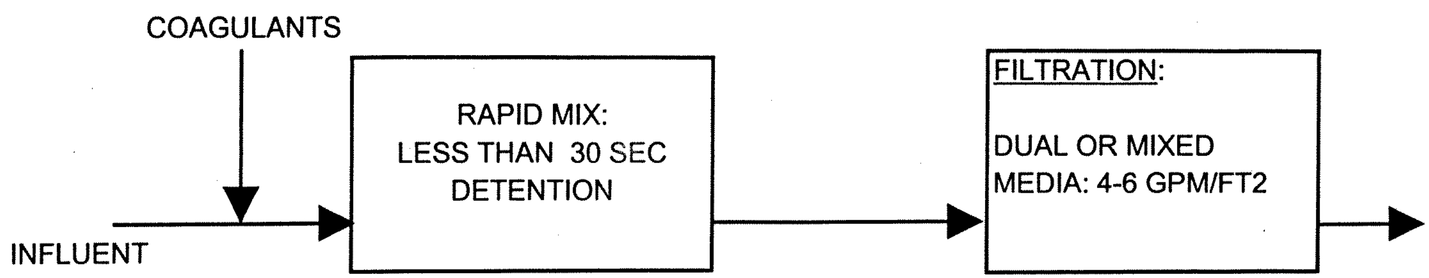


FIGURE 2-3
FLOW SHEET OF A TYPICAL IN-LINE FILTRATION PLANT

6. Inadequate backwashing of filters often causes water quality problems. Fifteen or more gpm/square foot is generally required. Air or water or a combination of both may be used to provide this backwash rate and surface or subsurface wash facilities (CA Page 4-8).

7. Design parameters for conventional treatment process units are as follows (Figure 2-1):
   a. Rapid mix unit detention time is less than 30 seconds.
   b. Flocculation unit detention time is 20 to 45 minutes.
   c. Sedimentation unit or alternate solid removal process detention time is 1 to 4 hours.
   d. (1) Rapid sand, 2 gpm/square foot.
      (2) Dual and mixed media, 4 to 6 gpm/square foot.

8. Design parameters for direct filtration process units are as follows (Figure 2-2):
   a. Rapid mix unit detention time is 30 seconds to 2 minutes.
   b. Flocculation unit detention time is 15 to 30 minutes.
   c. Filtration unit flow rate (note that direct filtration cannot use the single sand bed for its filters, but must use either the dual-media or mixed-media beds) is 4 to 6 gpm/square foot.

9. Those systems relying solely on surface water sources shall be required to have reliability features. The need for these same features for those systems served both by surface sources and groundwater sources will be determined by the director.

   The reliability features that are required are as follows:
   a. Pressure sensing devices on the discharge of all chemical feed equipment signaling a failure of chemical feed pumps and motors or power outages.
   b. Alarms which signal general interruption of all electrical power to plant facilities.
   c. Devices which sense level of chemicals in storage tank which will indicate a loss of chemical supply.
   d. Continuous monitoring equipment that includes streaming current detectors (equipment that analyzes the charged condition of treated water and sends a signal permitting close-loop control of coagulant dosage) for coagulation process, disinfectant residual analyzers for the disinfection process, and turbidity monitoring equipment for the filtration process.
   e. Water level sensors in the plant clearwell which indicate a loss of production capacity or a shutdown condition.
   f. Telemetered alarm to an answering service which in turn will contact a certified operator or supervisor; portable, electronic communication device, such as a cellular telephone or beeper; or telemetered alarm to two or more certified operator's residence shall be required for those filtration plants which will not be manned round-the-clock. These are the filtration plants operated or controlled by a certified operator for eight hours during a work day each week, weekend

and holidays excepted. A portable, electronic communication device is recommended over a telemetered alarm to an operator's residence for the following reasons:

(1) Operator will be on call even when he is away from his residence, and

(2) The portable, electronic communication device can be turned over for use by another operator when the first operator is sick, on vacation, or off-island.

C. Slow Sand Filtration Plants.

The minimum design criteria presented in the 1992 Ten State Standards shall be used except as follows (EPA Page 4-19):

1. Raw water limitations should be changed to reflect the values given in Table 2-2.

2. The effective sand size should be between 0.15 mm to 0.35 mm rather than the current 0.30mm to 0.45 mm.

3. Depth of water over sand bed should be between between 3 to 6 feet with head loss guage set at 3.5 to 5 feet.

D. Diatomaceous Earth Filtration Plants.

The minimum design criteria presented in the 1992 Ten State Standards shall be used except as follows (EPA Page 4-22):

1. The recommended quantity of precoat is 1 kg/m2 (0.2 pounds per square foot) of filter area, and the minimum thickness of the precoat filter cake is 3mm to 5mm (1/8 to 1/5 inch).

2. Treatment plants should provide a coagulant coating (alum or suitable polymer) of the body feed to improve removals of viruses, bacteria, and turbidity.

IV. OPERATION OF FILTRATION PLANTS.

A. Operations Plan (CA Pages 5-8 and 5-9).

Water purveyors shall submit to the director for review and approval an operations plan for each existing treatment plant that treats a surface water source or groundwater under the direct influence of a surface water. For future treatment plants, an engineering report shall be submitted to the director prior to the construction of the proposed treatment plant. An operations plan could be submitted to the director at the same time for review, but the operations plan could only receive tentative approval subject to the submittal of an acceptable, updated operations plan before the treatment plant goes into operation.

An updated operations plan shall be submitted to the director for information in July of the year following approval of the original operations plan. Future submittals shall take place in the month of July every two years thereafter. However, the status and dates for any personnel changes or revisions to operational procedures shall be immediately reported to the Safe Drinking Water Branch with a confirmation letter to follow. The operations plan shall include dates when any of the above changes were initiated. The operations plan should include the following information:

1. The names, grades, operator's certification number, telephone numbers (home, work) of all plant personnel.

2. Monitoring locations and sampling frequency for all parameters of concern (turbidity, pH, CT values, coliform, chemicals, etc.).

3. Criteria for length of filter run and filter backwash process.

4. Startup procedures for filters.

5. Shutdown procedures for filters.

6. Backwash procedures for filters.

7. Methods for determining appropriate chemical dosages (jar test procedure).

8. Procedures for adjustment of chemical dosages and methods for accurately monitoring chemical feed equipment.

9. Emergency disinfection procedures (refer to Chapter 3 for outline).

10. Names, addresses, and telephone numbers for chemical and equipment suppliers whose products are used regularly.

11. Preventative maintenance program.

12. Standardization procedures for all monitoring equipment.

13. Date of pressure filter inspection and frequency of inspection.

14. Frequency and dates for clearwell cleaning activities.

15. Increased monitoring that may be provided as an alternative reliability feature at small water systems (SWS).

B. Conventional Treatment and Direct Filtration Plants.

1. The application of a coagulant and the maintenance of effective coagulation and flocculation are required at all times when a treatment plant is in operation. Proper process control procedures should be used at the plant to assure that chemical feed are adjusted and maintained in response to variations in raw water temperature and turbidity (EPA Pages 4-15 and 4-16). Aluminum sulfate (alum) or ferric chloride are the typical coagulants used in the coagulation and flocculation processes. Polymers may also be used to enhance the coagulation and flocculation

processes. Natural occurring polymers are a product of activated silica while polyelectrolytes (polymeric flocculants) are synthetic polymers. Jar tests are to be conducted to verify the acceptance of the coagulation process taking place.

2. Proper chemical conditioning of the water ahead of the filter to assure adequate turbidity removal through the filter.

3. Control of the flow rates and elimination of rapid changes in flow rate applied to the filter.

4. Backwashing of filters before the filtered water quality is degraded to the point that the plant fails to meet the turbidity requirements of the SWTR and IESWTR as applicable. Initiate backwash based on filter effluent turbidity values rather then by headloss and run time. Electronic effluent turbidity monitoring equipment should be set to initiate filter backwash at an effluent value of less than 0.5 NTU (SWTR) or 0.3 NTU (IESWTR). Also, any filter removed from service shall be backwashed upon startup.

5. After backwash, bringing the clean filters back on-line so that excessive turbidity spikes in the filtered water are not created.

6. All filtration systems should be concerned with peak turbidity levels in the filtered water after backwashing and make every attempt to operate the filters to minimize the magnitude and duration of these turbidity spikes. Individual filters should be monitored by either continuous turbidity monitoring or grab samples every four hours. If excessive turbidity spikes are found, corrective actions should be taken. During these turbidity peaks, Giardia and other pathogens may be passed into the finished water. There is evidence that a 0.2 to 0.3 NTU increase in the turbidity during the first period of the filter run can be associated with rises in Giardia concentrations by factors of twenty to forty. Special studies should be conducted to determine the extent of the turbidity spike problems.

   For most high rate granular bed filters, there is a period of conditioning, or break-in immediately following backwashing, during which turbidity and particle removal is at a minimum, referred to as the break-in period. The turbidity peaks are thought to be caused by remnants of backwash water within the pores, of and above the media, passing through the filter, and floc breakup during the filter ripening period before it can adequately remove influent turbidity.

   There are basically four approaches available for correcting problems with turbidity spikes after backwashing. These approaches are as follows:

   a. Proper chemical conditioning of the influent water to the filter can minimize the magnitude and duration of these turbidity spikes. This could include proper control of the primary coagulant chemicals such as alum or iron compounds. In some cases, filter aids using polymers may be needed to control the turbidity spikes.

b. Gradually increasing the filtration rate in increments when placing the filter in operation. Starting the filter at a low flow rate and then increasing the flow in small increments over 10 to 15 minutes has been shown to reduce the turbidity spikes in some cases.

c. Addition of coagulants to the backwash water has also been shown to reduce the extent of turbidity spikes after backwash. Typically the same primary coagulant used in the plant is added to the backwash water. Polymers alone or in combination with the primary coagulant may also be used.

d. Filter-to-waste may be practiced if the necessary valves and piping are available, whereby a portion of the filtered water immediately after starting the filter is wasted. HOWEVER, some knowledge is needed to determine how long the filter-to-waste need be conducted to eliminate any turbidity spikes. Since this is a difficult value to determine, the individual filters shall only be placed back into service after turbidity measurements (assuming the use of a conventional treatment or direct filtration plant) read less than 0.5 NTU (SWTR) or 0.3 NTU (IESWTR). Turbidity measurements may be obtained from a direct readout from a recording instrument for a continuous turbidimeter or analysis of a grab sample (EPA Pages 4-11 to 4-12).

7. For raw water spikes, such as periodic occurrences of raw water coliform, turbidity, or color levels in excess of the values presented for direct filtration in Table 2-2, mitigative measures to be taken are (EPA Page 4-9):

a. Continuous monitoring and coagulant dose adjustment.

b. More frequent backwash of filters.

c. Use of presedimentation.

C. Slow Sand Filtration Plants.

Two major operational tasks are as follows (EPA Page 4-20):

1. Removal of the top 2 to 3 cm (0.8 to 1.2 inches) of the surface of the sand bed when the headloss exceeds 1 to 1.5 m (3.3 to 5 feet). Following scraping, slow sand filters produce poorer quality filtrate at the beginning of a run. A filter-to-waste or ripening period is recommended before use of the filter to supply the system. Wasting should continue for a few days to a week or more to lower the coliform reading and reach the acceptable turbidity reading of 1 NTU or less. The ripening period is an interval of time immediately after a scraped filter bed is put back on-line, when the results of turbidity or particle counts are significantly higher than the corresponding values for the operating filter. During this time, the microorganisms multiply and attain equilibrium in the "schmutzdecke" or gelatinous coating covering the sand bed. Monitoring filter

effluent for turbidity readings of 1 NTU or less should be used to indicate when the filter bed can be placed back on-line.

2. Replacement of the sand shall take place when repeated scrapings have reduced the depth of the sand to approximately one-half of its designed depth. The replacement procedure should include removal of the remaining sand down to the gravel support; the addition of new sand to one-half of the design depth; and placement of the sand previously removed on top of the new sand. This procedure results in clean sand being placed in the bottom half of the filter bed and biologically active sand being placed in the top half of the filter bed. This procedure reduces the amount of time needed for the curing period. It also provides for a complete exchange of sand over time, alleviating potential problems of excessive silt accumulation and clogging of the filter bed.

   The amount of time for the biological population to mature in a new sand filter (curing period) and to provide stable and full treatment varies. The World Health Organization reported that curing requires a few weeks to a few months. Another study found that about 30 days were required to bring particle and bacterial counts down to a stable level. All researches agree that a curing time for a new filter is required before the filter operates at its fullest potential.

   The filter must be operated to waste during the curing period. A key measurement for determining the end of the curing period is turbidity. Once the turbidity measurement drops below 1 NTU, the filtered water may be placed into the system. This is the reason for the emphasis on the recommended need for continuous monitoring or grab samples every four hours for each individual filter for turbidity.

3. For raw water spikes, periodic occurrences of raw water coliform, turbidity, or color levels in excess of the values presented for slow sand filters in Table 2-2, mitigative measures are (EPA Page 4-9):
   a. Use of a roughing filter. Roughing filters are rapid sand filters having a coarser sand bed and operated at higher rates (up to 130 gpm/ft2) than a standard rapid sand filter. Because the roughing filter acts as a prefilter, the capacity of the slow sand filter may even be doubled, along with possible longer filter runs between cleanings. The clearwater storage basin for the roughing filter than permits a constant inflow to the slow sand filter. The storage basin's prefiltered water also permits a higher rate of flow through the slow sand filter, enabling it to better meet fluctuating rates of demand.
   b. Use of an infiltration gallery. An infiltration gallery consists of horizontally buried, perforated pipes or French drains (open-joint pipes in porous material), leading collected water to a sump with a pump to lift the water into the transmission and

distribution piping. A line of shallow, closely spaced wells may also be used as the infiltration gallery. These collective systems are placed parallel to the banks of rivers, streams, and lakes (also reservoirs). They are installed at a depth a few feet below the level of the surface water bed and in a direction perpendicular to the groundwater flowing towards the surface water body. The infiltration galleries are also installed in fairly permeable material such as alluvial sand or gravel as to help the percolation of groundwater into the pipes or wells. The problem here is that in times of low groundwater flows, surface water could end up being the major source of water being collected in the infiltration galleries.

D. Diatomaceous Earth Filtration

1. Diatomaceous earth (DE) filtration, also known as precoat or diatomite filtration is appropriate for direct treatment of surface water for removal of relatively low levels of turbidity (<5NTU) and microorganisms (<50 coliforms/100 ml).

   Diatomite filters consist of a layer of DE about 3 mm (1/8 inch) thick supported on a septum or filter element. The thin precoat layer of DE must be supplemented by a continuous body feed of diatomite, which is used to maintain the porosity of the filter cake. If no body feed is added, the particles filtered out will build up on the surface of the filter cake and cause rapid increases in headloss. The problems inherent in maintaining the proper film of DE on the septum have restricted the use of diatomite filters for municipal purposes, except under certain favorable raw water quality conditions, for example, low turbidity and good bacteriological quality.

2. Operating requirements specific to DE filters include (EPA Page 4-22):
   a. Preparation of body feed and precoat.
   b. Verification that dosages are proper.
   c. Periodic backwashing and disposal of spent filter cake.
   d. Periodic inspection of the septum(s) for cleanliness or damage.
   e. Verification that the filter is producing a filtered water that meets the performance criteria.

3. For raw water spikes, periodic occurrences of raw water coliform, turbidity, or color levels in excess of the values presented for DE filters in Table 2-2, mitigative measures are (EPA Page 4-9):
   a. Use of roughing filters.
   b. Use of excess body feed.

CHAPTER 3

DISINFECTION CRITERIA

3. DISINFECTION CRITERIA

I. GOAL

The overall objective of the disinfection criteria is to provide control in conjunction with filtration of: Cryptosporidium, Giardia; viruses; heterotrophic plate count (HPC) bacteria; and Legionella by assuring the required disinfection and achieving the acceptable inactivation of the above parameters.

II. DISINFECTION REQUIREMENTS

A. Disinfection must be provided to ensure that the total treatment process (filtration plus disinfection) for the system achieves at least a 2-log (99 percent) removal of Cryptosporidium, 3-log (99.9 percent) removal and inactivation of Giardia and a 4-log (99.99 percent) removal and inactivation of viruses. The director must determine what leval of disinfection is required for each system to meet this criteria.

If the proper filtration process is selected for the quality of raw water to be treated; if proper coagulation, flocculation, and filtration takes place for conventional treatment and direct filtration; and if slow sand and diatomaceous earth filters are properly operated, all of the previous four filtration processes can achieve a 3-log removal of Giardia (EPA Pages 4-3 and 4-40). However, for conservative reasons, all four filtration processes are assumed to only achieve a 2-log removal of Giardia and a 1-log removal of viruses. This approach will assure that the treatment facility has adequate capability to respond to non-optimum performance due to changes in raw water quality, plant upsets, etc. The balance of the required removal and inactivation of Giardia would be achieved through the application of appropriate disinfection (EPA Page 4-7). The following table lists the recommended log inactivations that are required, based on the conservatively assumed 2-log removal of Giardia by all of the four filtration processes.

TABLE 3-1 RECOMMENDED MINIMUM DISINFECTION				
Expected Log Removals (log inactivations)			*Recommended Disinfection (log inactivations)*	
Filtration	*Giardia*	*Viruses*	*Giardia*	*Viruses*
Conventional	2	2	1	2
Direct	2	1	1	3
Slow Sand	2	2	1	2
Diatomaceous Earth	2	1	1	3

The discussion on the removal and inactivation actions by filtration and disinfection touches heavily on their effect on Giardia while referring lightly to viruses. This is because less disinfectant is required to inactivate viruses than is required to inactivate Giardia. For example, a comparison of EPA Tables E-1 through E-6 with Table E-7 (tables found in Chapter 5) indicate that systems which achieve a 0.5-log inactivation of Giardia, using free chlorine, will achieve greater than a 4-log inactivation of viruses (EPA Page 4-26). Also, a 3-log removal and inactivation of Giardia and a 4-log removal and inactivation of viruses will also provide protection from Legionella and HPC (EPA Page 2-14).

A survey was conducted of water sources to characterize the level of Giardia occurrence for "polluted" and "pristine" waters. Polluted waters are defined as waters in the vicinity of sewage and agricultural wastes. Pristine waters are those originating from protected watersheds with no significant sources of microbiological contamination from human activities (EPA Page 4-27). The following recommendations which take these conditions into consideration are based on EPA's selected risk of less than one case of microbiologically-caused illness per year per 10,000 persons.

TABLE 3-2 RECOMMENDED LOG REMOVAL AND INACTIVATION AS A FUNCTION OF RAW WATER QUALITY (EPA Page 5-11)			
Allowable daily average Giardia concentration per 100 L (geometric mean)	*≤1*	*>1-10*	*>10-100*
Giardia (EPA Pages 4-27 and 4-28)	3-log	4-log	5-log
Viruses (EPA Page 4-29)	4-log	5-log	6-log

B. The system must demonstrate by continuous monitoring and recording that a disinfectant residual in the water entering the distribution system is never less than 0.2 mg/L for more than 4 hours. If at any time the residual falls below 0.2 mg/L for more than 4 hours, the system is in violation. The system must notify the director by 4:00 p.m. that same day, or no later than 10:00 a.m. of the next business day, whenever the residual falls below 0.2 mg/L. The director must also be informed, following the same time constraints, when the residual returns to 0.2 mg/L or higher or if the residual remains below 0.2 mg/L for more than 4 hours. In the latter case, the system is now in a Tier 2 violation of a treatment technique and a public notification takes place as discussed in Appendix D, Public Notification. If there is a failure in the continuous monitoring equipment, the system may substitute grab sample monitoring every 4 hours for up to 5 working days following the equipment failure.

The system shall prepare an emergency plan, for implementation in the event of disinfection failure, to prevent delivery to the distribution system of any undisinfected or inadequately disinfected water. The plan shall be posted in the treatment plant or other place readily accessible to the plant operator, including a copy of the plan at the water purveyor's office. The initial plan shall be forwarded to the director for review and approval and, thereafter, shall be forwarded to the director in July of every year that an Operations Plan update (Chapter 2 Item V.A.) is submitted. The plan shall include the following items:

1. Procedures to be followed until corrections are made, for example,
   a. Plant shutdown until problem is corrected.
   b. Manual chlorination at the plant and in distribution reservoirs until repairs are completed.
   c. Increased bacteriological sampling of water delivered to consumers.

2. Emergency telephone numbers of Health Department officials.

3. Emergency telephone numbers of technicians needed to make the repairs.

4. Flushing of the distribution system to remove unchlorinated water.

5. Use of alternate sources and implementation of water conservation measures until the problem is solved.

6. Implementation of the public emergency notification plan, if necessary.

C. The system must demonstrate detectable disinfectant residuals or HPC levels of 500 or fewer colonies/ml in at least 95 percent of the samples from the distribution system each month for any two consecutive months. Measurements for the disinfectant residuals or HPC must be made at the same frequency and locations at which total coliform measurements are made, unless a modified sampling schedule is approved by the director (EPA Pages 5-9 and 5-10).

D. A redundant disinfection system shall be required where a system is solely dependent upon a surface water source. Recommendations for providing redundant disinfection are as follows (EPA Pages 3-32 and 3-33) and are detailed in Appendix E, Redundant Disinfection Capability:

1. All components shall have backup units with capacities equal to or greater than the largest unit on-line.

2. A minimum of two storage units of disinfectant which can be used alternately, for example, two cylinders of chlorine gas or two tanks of hypochlorite solution shall be available.

3. Where the disinfectant is generated on-site, such as ozone, backup units shall be available with a capacity equal to or greater than that of the largest unit on-line.

4. Automatic switchover equipment shall be available to change the feed from one storage unit to the other before the first empties or becomes inoperable.

5. Feed systems shall be available with backup units with

capacities equal to or greater than the largest unit on-line.

6. An alternate power supply such as a standby generator shall be available with the capability of running all the electrical equipment at the disinfection station. The generator should be on-site and functional with the capability of automatic start-up upon power failure.

E. CT is the factor used to determine the inactivation by disinfection. CT or the inactivation efficiency is defined as C, the residual disinfectant concentration(s) in mg/L multiplied by T, the contact time(s) in minutes. The contact time is measured from the point of disinfectant application to the point of residual measurement or between points of residual measurement at the time of peak hourly flow (EPA Pages 5-14 through 5-16). Temperature and, if chlorine is the disinfectant, pH(s) of the disinfected water are also measured. EPA Tables E-1 through E-6 (found in Chapter 5) can be used to determine the disinfection inactivation for free chlorine.

In pipelines, the contact time can be assumed equivalent to the hydraulic detention time and is calculated by dividing the internal volume of the pipeline by the peak hourly flow rate through the pipeline. In mixing basins and storage reservoirs, the hydraulic detention time generally does not represent the actual disinfectant contact time because of short circuiting. The contact time in such chambers should be determined by tracer studies or an equivalent demonstration. The time determined from the tracer studies to be used for calculating CT is T10. T10 represents the time that 90 percent of the water (and the microorganisms in the water) will be exposed to disinfection within the disinfectant contact chamber. Refer to Appendicies F and G, Determination of T10 By Conducting Tracer Studies and Determination of T10 Without Conducting Tracer Studies.

CHAPTER 4

MONITORING REQUIREMENT

4. MONITORING REQUIREMENT

I. GENERAL

Monitoring plays an important part in determining whether performance requirements are being met. The State SWTR and IESWTR establish performance requirements for filtration and disinfection. If a performance requirement is not met, a failure to comply with a prescribed treatment technique occurs and public notification is required for a Tier 2 violation. Refer to Appendix D, Public Notification.

II. TURBIDITY MONITORING REQUIREMENTS INCLUDING SAMPLING POINTS AND FREQUENCY

A. Raw Water Influent to Filtration Plant.

A daily grab sample shall be collected whenever the filtration plant is in operation. If there are more than one shift per day, a grab sample should be collected each shift. Additional grab samples are also recommended for operational control when there are changes in raw water quality as during a storm.

Effective coagulation and flocculation are the only assurance that proper pathogen (Cryptosporidium, Giardia and viruses) removal is provided by conventional or direct filtration plants. Therefore, coagulation and flocculation must take place at all times that the filtration units are in operation. In practice, it has been shown that effective coagulation and flocculation with conventional or direct filtration, can remove a minimum of 80 percent or higher (95 percent plus) of raw water turbidity (CA Page 5-6). For raw water turbidity of less than 2.5 NTU, effective coagulation and flocculation can provide a turbidity reading of less than 0.1 NTU in the final product water. This performance can be determined by comparing the monthly average effluent turbidity with the monthly average raw water turbidity.

B. Individual Filter Effluent

The effluent from each individual filter shall be monitored as follows:

1. Continuous monitoring with a turbidimeter and recording chart is required for all filtration plants, other than slow sand filtration or diatomaceous earth filtration, serving a population of atleast 10,000 as of January 1, 2002. Calibration of the continuous turbidimeter must be verified at least twice per week according to the procedure established in Method 214A of the 16th Edition of Standard Methods. Each four-hour period counts as one sample.

2. A less recommended alternative is grab sampling every four hours during the operation of the filtration plant.

C. Combined Filter Effluent Prior to Entry Into a Clearwell.

Continuous monitoring with turbidimeter and recording chart, or collection of grab sample every four hours that the filtration plant is in operation, is recommended for operational control.

D. Clearwell Effluent.

Continuous monitoring with turbidimeter and recording chart, or collection of grab sample every four hours that the filtration plant is in operation, is recommended for operational control. Carry-over settleable solids from the filter into the clearwell should be removed as soon as practical. If settleable solids are allowed to be built up in the clearwell, their possible disturbance and carry-over to the distribution system can cause turbidity and disinfection problems.

E. Plant Effluent or Immediately Prior to Entry Into the Distribution System.

<u>This is a required sampling point</u> and either continuous monitoring with turbidimeter and recording chart, or collection of grab sample every four hours, shall be performed. Sampling of the plant effluent is acceptable if there are no storage tanks between the sampling point and entry into the distribution system. Grab sampling once per day may be approved by the director if he determines that less frequent monitoring is sufficient to indicate effective filtration performance for the following:

1. Slow sand filtration, or

2. Filtration technologies other than conventional treatment, direct, or diatomaceous earth filtration, or

3. Systems serving 500 or fewer persons.

III. DISINFECTION MONITORING REQUIREMENTS

A. Sampling Points.

1. Entrance to distribution system (before first consumer).

2. Representative points in the distribution system.

B. Sampling Frequency.

1. Continuous monitoring and recording of the disinfectant residual as it enters the distribution system and recording the lowest disinfectant residual each day shall be required. If there is a failure in the continuous monitoring equipment, the system may substitute grab sample monitoring every four hours for up to five working days following the equipment failure.

Each system must also measure the disinfectant residual in the distribution system at the same frequency and locations at which total coliform measurements are made pursuant to the requirements in the Total Coliform Rule (54 FR 27544: June 29, 1989). For systems which use both surface and groundwater sources, the director may allow substitute sampling sites which are more representative of the treated surface water supply (EPA Page 5-9).

CHAPTER 5

REPORTING REQUIREMENT

5. REPORTING REQUIREMENT

I. GENERAL

The State SWTR establishes treatment and performance requirements to ensure the safety of the consumer when they consume treated surface water which may contain Cryptosporidium, Giardia and viruses. Reports are then required to record how well the system is meeting the filtration and disinfection criteria in the SWTR.

II. WHAT IS REPORTED

Monthly reports shall be submitted by the tenth day of the following month to the director for compliance with the reporting requirements of the SWTR. These reports shall include the following parameters.

A. CT or the inactivation efficiency.

B. Disinfectant residual entering the distribution system.

C. Disinfectant residuals throughout the distribution system.

D. Treated water turbidity.

III. HOW TO RECORD AND REPORT THE REQUIRED DATA

A. Table 5-1, CT Determination For Filtered Systems -- Monthly Report to Director (attached).

The importance of the CT determination, which results in the calculated value for the inactivation ratios, informs the water purveyor as to whether he is meeting the requirement to inactivate Giardia. Using conventional treatment as an example, a well operated plant is capable of a 3-log removal of Giardia, the required figure for the combined removal and inactivation of Giardia by filtration and disinfection. However, because of unscheduled changes in source water quality and operational problems, a 2-log removal and a 1-log inactivation of Giardia are recommended. The turbidity requirement for conventional treatment is 0.5 NTU or less in 95 percent of the measurements per month for the filtered water. The SWTR does permit turbidity readings up to 5 NTU in the remaining 5 percent for that month's measurements. Corresponding compliance values under the IESWTR are 0.3 NTU or less in 95 percent of monthly measurements, and a maximum of 1 NTU in the remaining 5 percent. Meeting the inactivation requirement during the period with higher turbidity readings becomes critical. High turbidity periods are a reflection of the subpar operation of the filtration process and the inactivation by disinfection is needed to supplement the removal of Giardia by filtration. The inactivation of Giardia can then only be confirmed by the determination for CT.

1. Use a separate form for each disinfectant point and sampling site. Most systems will have one disinfectant point following filtration and one sampling site at or before the point-of-entry to the distribution system or the first consumer.

2. Enter disinfectant and sequence of application in the heading for Table 5-1. This information is needed for inserting data onto Table 5-2 and for deciding which of the EPA's CT tables are to be used.

3. Measurements should be taken for disinfectant concentration, C (mg/L), at peak hourly flow. "Peak hourly flow" should be considered as the greatest volume of water passing through the system during any one hour in a consecutive 24-hour period. Thus, it is not meant to be the absolute peak flow occurring at any instant during the day (EPA Page 3-7).

4. Disinfectant contact time T (minutes) is calculated by dividing the internal volume of the pipeline from the disinfectant point to the sampling site by the peak hourly flow rate through that section of pipeline.

5. CTcalc is determined by multiplying C (mg/L) times T (minutes).

6. pH measurements are required only if the disinfectant is free chlorine and are to be taken at the same time and site where the disinfectant concentration C (mg/L) measurements are taken.

7. Water temperature measurements are also to be taken at the same time and site where the disinfectant concentration and pH measurements are taken.

8. CT values for the seventh column are to be obtained from the attached EPA "E" tables. The EPA "E" tables cover the use of free chlorine, chlorine dioxide, ozone, chloramine, and ultraviolet (UV) light as disinfectants to inactivate Giardia and viruses. If the disinfectant used is free chlorine, EPA Tables E-1 to E-6 are to be used to obtain the CT values, the actual table selected being dependent on the measured water temperature. If the disinfectant used is ozone, EPA Table E-10 is to be used to obtain the CT value. No matter which disinfectant is used, the SWTR requires a 3-log removal and inactivation of Giardia. A conservative approach of assuming a 2-log removal of Giardia by filtration leaves a balance of 1-log for inactivation by disinfection. Therefore, the CT value selected should be for 1-log inactivation and at the respective measured water temperature and pH readings as required by the disinfectant used.

   In using the EPA "E" tables, for example EPA Tables E-1 to E-6, measured values for temperature, pH, and the chlorine concentration must be obtained from the same sampling point at the same time. EPA Table E-5 was developed for a temperature reading of 20 degrees Centigrade or 68 degrees Fahrenheit. Likewise, EPA Table E-6 represents temperatures respectively at 25 degrees Centigrade or 77 degrees Fahrenheit. For all three measurements taken (temperature, pH, and the chlorine concentration), the values obtained more than likely will not be exactly the same as are found in the tables. Assume measured readings for temperature of 24 degrees Centigrade, pH of 6.7, and a chlorine concentration of 0.5 mg/L, you may interpolate (estimate values of a function between two known values) between and within tables to obtain CT values for the selected log inactivation. However, to simplify or eliminate the calculation by fractions, you may use the lower value for temperature (20 degrees Centigrade) and higher values for pH (7.0) and chlorine concentration (0.6 mg/L). These assumptions can be made taking the following facts into consideration when using the tables:

a. The CT values in the 20 degree Centigrade table are higher than their respective values in the 25 degree Centigrade table.

b. The CT values for a pH of 7.0 in any one of the "E" tables are always higher than their respective values in the same table for a pH of 6.5.

c. The CT values for a chlorine concentration of 0.6 mg/L are always higher than a chlorine concentration of 0.4 mg/L in any one of the EPA "E" tables or at any pH value.

d. Therefore, if a lower temperature reading and higher pH and chlorine concentration values are used, a higher CT value will always be obtained from the selected EPA "E" table.

e. The efficiency of the inactivation is measured by the value obtained by dividing the calculated CT (chlorine concentration times the contact time from the disinfectant point to the point of measurement) by the CT obtained from the EPA "E" tables. The required inactivation ratio is 1.0 or higher. Therefore, by following the above approach and obtaining a higher CT value from the selected EPA "E" table, the disinfection procedure becomes even more important. The point of disinfection; the disinfectant dosage for the quality of the treated water; and the available contact time decides whether the calculated CT numerator continues to be at least equal to or larger than the CT denominator from the EPA "E" tables. This approach not only eliminates the mathematical calculations that are required with interpolations, but it provides a more conservative way to determine whether you are meeting the required log inactivation of Giardia and viruses.

9. 1-log inactivation is equivalent to 90 percent inactivation and is represented by CT90. CTcalc divided by CT90 provides the numerical value for column 8 or the inactivation ratio for that disinfection sequence.

Each copy of Table 5-1 records a single disinfection sequence. If there is only one disinfection sequence, only that one filled-in form need be completed and forwarded to the director on a monthly basis. If there are more than one disinfection sequence, individual copies of Table 5-1 need be used to record each disinfection sequence. All of these copies must then be forwarded to the director on a monthly basis. No matter whether there is only one or more disinfection sequences, the individual or sum of their inactivation ratios must be equal to 1.0 or greater. If this requirement can be maintained, then the filtered and disinfected source water can continue to be used. If the sum of the inactivation ratios cannot be maintained at 1.0 or greater, then the inactivation ratios for the disinfection sequences in mixing basins, storage reservoirs, and other treatment plant process units must be determined and added on to the original sum of the inactivation ratios. If the new summation value is still less than 1.0, the following steps must then be taken:

a. Review whether the filtration plant and transmission main can be modified and the sum of their anticipated inactivation ratios be made to equal 1.0 or greater. If this cannot be done, immediate steps must be taken to replace this surface water source, by:
   (1) Purchasing an alternate supply of water from an acceptable source to serve the consumers, or

   (2) Develop an acceptable groundwater source to serve the consumers.

Inactivation ratios for treatment plant process units are determined by conducting tracer studies for each process unit to obtain T10 designated as the detention time at which 90 percent of the water passing through the unit is retained within the basin (EPA Page C-1). The tracer studies are complicated and should be conducted by a consultant who is at least somewhat familiar with the required operation. For example, tracer studies must be conducted for at least four flow rates for each section (flow rates separated by approximately equal intervals with one near average flow, two greater than average [the highest test flow rate must be at least 91 percent of the flow rate through that section], and one flow rate less than average) (EPA Page C-2). A discussion on the "Determination of T10 by Conducting Tracer Studies" is found in Appendix F.

"Determination of T10 Without Conducting a Tracer Study" is discussed in Appendix G. When conducting tracer studies may be impractical or prohibitively expensive, the director may allow the use of the "rule of thumb" fraction multiplied by the theoretical detention time to obtain an approximation for T10 (EPA Page C-24).

B. Table 5-2, Disinfection Information For Filtered Systems - Monthly Report To Director (Attached)

1. The required minimum disinfectant residual at the point-of-entry to the distribution system is 0.2 mg/L. If the residual drops below 0.2 mg/L, the lowest reading and duration of the period, for example, 0.1-3 hrs, must be reported. It is important to report the duration of the period for the residual reading of less than 0.2 mg/L. This is because the director must be verbally informed whenever the residual reading drops below 0.2 mg/L, and the time it takes to bring the residual back to 0.2 mg/L or higher. Should it take four hours or more to raise the residual back to the required level, a treatment technique violation has occurred. A Tier 2 public notification must then be issued. Refer to Appendix D, Public Notification.

2. The next six columns are for reporting up to six disinfectant sequences. If additional columns are needed, renumber another copy of Table 5-2 (for example, Disinfectant Sequence 1st through 6th would now be numbered 7th through 12th) and enter data accordingly.

3. The ninth column is a summation of the inactivation ratio for each of the disinfectant sequences. Please note that in the discussion for Table 5-1, the summation of the inactivation ratio for each of the disinfectant sequences must equal 1.0 or greater. Otherwise, the source may have to be replaced. However, the continued use of Table 5-2 indicates that the system has already proven that it can meet the filtration and disinfection criteria, subject to possible subpar performance due to changes in raw water quality and operational problems with the treatment process. Therefore, the summation of inactivation ratios in the ninth column of Table 5-2 could temporarily drop below a value of 1.0.

4. For column 10, if a "yes" response is entered to reflect a summation value of less than 1.0, a treatment technique violation has occurred and a Tier 2 public notification is required. The system must notify the director by 4:00 p.m. that same day, or no later than 10:00 a.m. of the next business.

C. Table 5-3, Distribution System Disinfectant Residual Data For Filtered Systems, Monthly Report to Director (attached)

1. This report evaluates the performance of the filtration and disinfection treatment of the water serving the distribution system through the apparent low bacterial activity. HPC bacterial levels can not be >500/ml in more than 5 percent of the monthly measurements.

2. HPC bacteria represents heterotrophic plate count bacteria, a broad class of aerobic and anaerobic organisms which use organic nutrients for growth. This group includes many innocuous (harmless) bacteria as well as virtually all of the bacteria pathogens (harmful) and those bacteria infect (harmful) when the host defenses are weakened.

3. The daily logging of data in columns 3 through 6 is self explanatory. The data in columns 3 through 6 are totaled at the end of the month. These figures are then inserted into the formula shown on the bottom of the form and the V or value is then calculated. The looked-for value or V is 5 percent or less, or 100 percent minus V is 95 percent or higher (EPA Page 5-10). Should the value be greater than 5 percent, the water purveyor is advised to improve the performance of the disinfection treatment for the coming month. Should the value or V be greater than 5 percent for two consecutive months, a violation of a treatment technique would occur and a Tier 1 public notification would be required.

D. Table 5-4, Daily Data Sheet For Filtered System (attached). For system use only, retain in file for five years.

1. Table 5-4 is an operator's tool to record the quality of treatment provided.

2. Column 2., report only last disinfectant added prior to entering distribution system. If less than 0.2 mg/L, the residual and the duration of the period must be reported, for example, "0.1-3 hrs."

3. Column 3., report raw water turbidity daily when treatment plant is in operation.

4. Column 4., turbidity measurements are recommended for each individual filter. A separate sheet will be required for each filter.

5. Column 5. is self explanatory.

6. Column 6. is self explanatory.

7. Column 7., turbidity measurements may be made at the plant effluent if there are no storage reservoirs between the plant effluent and the distribution system. If there is a storage reservoir, the turbidity measurement must be made prior to entry into the distribution system.

8. Column 8., report number of turbidity measurements made excluding turbidity measurements for the raw water.

9. Column 9., report the number turbidity measurements

made that are equal to or less than the required turbidity reading for the treatment plant as follows:

a. $\leq$0.5 NTU (SWTR) or $\leq$0.3 NTU (IESWTR), conventional treatment and direct filtration.

b. $\leq$ 1 NTU, slow sand and diatomaceous earth filtration (respectively EPA Page 5-7).

c. $\leq$ 0.5 NTU (SWTR) or $\leq$0.3 NTU (IESWTR), other filtration technologies (package plants, cartridge filters, reverse osmosis, etc.).

10. Column 10, report all turbidity measurements exceeding 5 NTU (SWTR) or 1 NTU (IESWTR). Maximum turbidity limit for slow sand and diatomaceous earth filtration remains at 5 NTU.

E. Table 5-5, Monthly Report To Director For Compliance Determination - Filtered Systems (attached).

1. Data from Tables 5-4.

2. The required "Turbidity Performance Criteria" for item "C" is 95 percent or better (EPA Page 5-5).

3. The required "Disinfection Performance Criteria" for item "B" is 5 percent or less.

F. Table 5-6, Daily Turbidity Data (attached). (For system use only, retain on file for five years).

1. The turbidity of the filtered water as it leaves the conventional treatment, direct filtration, or diatomaceous earth filtration plants, or before the filtered water reaches the first consumer, must be monitored every four hours by grab sampling or by continuous recording turbidimeter (EPA Page 5-2).

2. The four-hour turbidity readings shall be initially recorded on this form.

3. The maximum daily turbidity reading shall be rerecorded on Table 5-4 and, the number of turbidity readings made shall be included in the total number of turbidity readings used in calculating the turbidity performance criteria in Table 5-5.

Table 5-1

CT DETERMINATION FOR FILTERED SYSTEMS (1.0 log inactivation)
MONTHLY REPORT TO DIRECTOR

Month ______________________ System & Treatment Plant ______________________
Year ______________________ PWS ______________ Purveyor ______________________
Disinfectant/Sequence of Application ______________________

Date	DRC Operator	Disinfectant[2] Concentration C (mg/l)	Disinf.[2] Contact Time (min.)	CT calc[3]	pH[4]	Water[2] Temp. (deg. C)	CT 90[5]	Inactivation Ratio CT calc/CT 90
1								
2								
3								
4								
5								
6								
7								
8								
9								
10								
11								
12								
13								
14								
15								
16								
17								
18								
19								
20								
21								
22								
23								
24								
25								
26								
27								
28								
29								
30								
31								

Prepared by: ______________________ Date: ______________________

Notes:

1. Use a separate form for each disinfectant/sampling site. Enter disinfectant and sequence position, for example, "ozone/1st" or "Cl02/3rd".
2. Measurement taken at peak hourly flow.
3. CT calc = C (mg/l) X T (min.)
4. The pH reading may be required, depending on which EPA table (E-1 through E14) is used.
5. The CT 90 value is from EPA tables E-1 through E-14.

Table 5-2

DISINFECTION INFORMATION
FOR FILTERED SYSTEMS - MONTHLY REPORT TO DIRECTOR

Month ____________________ System & Treatment Plant ____________________

Year ____________________ PWS _____ Purveyor ____________________

Date	Minimum Disinfectant Residual at Point-of-Entry to Distribution System (mg/L)	(Ct_{calc} / CT_{90}) from Table 5-1 Disinfectant Sequence 1st	2nd	3rd	4th	5th	6th	Sum (Ct_{calc} / CT_{90})	Sum (Ct_{calc} / CT_{90}) < 1 ? (yes / no)
1									
2									
3									
4									
5									
6									
7									
8									
9									
10									
11									
12									
13									
14									
15									
16									
17									
18									
19									
20									
21									
22									
23									
24									
25									
26									
27									
28									
29									
30									
31									

Prepared by: ____________________ Date: ____________________

Notes:

1. If less than 0.2 mg/L, the lowest level and duration of the period must be reported, for example, "0.1-3 hrs".
2. To determine SUM (Ct_{calc}/CT_{90}), add (Ct_{calc}/CT_{90}) values from the first disinfectant sequence to the last.
3. If SUM (Ct_{calc}/CT_{90}) < 1, a treatment technique violation has occurred, and a "yes" response must be entered.

TABLE 5-3

DISTRIBUTION SYSTEM HETEROTROPHIC PLATE COUNT (HPC) DATA FOR FILTERED SYSTEMS MONTHLY REPORT TO DIRECTOR						
Month ________		System & Treatment Plant ______________________				
Year __________PWS ID No. ______		Water Purveyor ______________________				
Date	No. of Routine Total Coliform Samples Collected	No. of Instances in Which HPC > 500				
1						
2						
3						
4						
5						
6						
7						
8						
9						
10						
11						
12						
13						
14						
15						
16						
17						
18						
19						
20						
21						
22						
23						
24						
25						
26						
27						
28						
29						
30						
31						
Total						
V = No. of Instances in Which HPC > 500 colonies/ml X 100 -- No. of Routine (scheduled) total coliform samples collected						
= _____ X 100 = ______%		Prepared by: ______________________				
		Date: ______________________				

TABLE 5-4

DAILY DATA SHEET FOR FILTERED SYSTEMS

PWS#		Purveyor	
Month		System & Treatment Plant	
Year		Filtration Technology	
		Turbidity Limit (NTU)*	

* *5 NTU for Slow Sand & Diatomaceous Earth filters only. All other technologies shall meet 1 NTU.*

Date	Minimum [1] Disinfectant Residual at Point-of-Entry to Distribution System(mg/L)	<<< ---------- Turbidity Measurements --------- >>>							
			Maximum Filtered Water Turbidity(NTU)						
		Raw[2] Water	Filter[3] No.	Combined Filter Effluent	Clearwell[3] Effluent	Plant[4] Effluent	Total[6] No.(A)	No.< Turbidity Limit(B)	No.> [7] Turbidity Limit (=A-B)
1									
2									
3									
4									
5									
6									
7									
8									
9									
10									
11									
12									
13									
14									
15									
16									
17									
18									
19									
20									
21									
22									
23									
24									
25									
26									
27									
28									
29									
30									
31									

Notes:

1. If less than 0.2 mg/L, include duration as follows, "0.1-3hrs".
2. Report daily when plant is in operation.
3. Conventional treatment and direct filtration, use separate sheet for each filter.
4. Plant effluent or entry to distribution system.
5. For continuous turbidimeters, count each four-hour period as one sample.
6. "A" = sum of measurements at plant effluent or entry to distribution system.
7. Include turbidity values, for example, "3-5.6, 6.2, 8.0".

TABLE 5-5

MONTHLY REPORT TO DIRECTOR FOR COMPLIANCE DETERMINATION - FILTERED SYSTEMS

Month		System & Treatment Plant	
Year		Filtration Technology	
		95% Turbidity Limit (NTU)*	
PWS ID #		Water Purveyor	

** 1 NTU for Slow Sand (SSF) & Diatomaceous Earth (DE) filters only. All other technologies shall meet 0.3 NTU.*

Turbidity Performance Criteria

A. Total no. of filtered water turbidity measurements =

B. Total no. of filtered water turbidity measurements that are less than or equal to the 95% Turbidity Limit for the filtration technology employed.

C. The percentage of turbidity measurements meeting the 95% Turbidity Limit =
[B/A} X 100 = [_____/_____] X 100 = _____%.

D. Record the date and turbidity value for any measurements exceeding Max Turbidity Limit:

	Date	Turbidity, NTU
- 5 NTU for SSF & DE filtration		
- 1 NTU for all others		
- if no exceedances, enter "none"		

Disinfection Performance Criteria

A. Point-of-Entry Minimum Disinfectant Residual Criteria

Date	Min. Disinfectant Residual at Point-of-Entry to Distribution System (mg/L)	Date	Min. Disinfectant Residual at Point-of-Entry to Distribution System (mg/L)	Date	Min. Disinfectant Residual at Point-of-Entry to Distribution System (mg/L)
1		11		21	
2		12		22	
3		13		23	
4		14		24	
5		15		25	
6		16		26	
7		17		27	
8		18		28	
9		19		29	
19		20		30	
				31	

Days the Residual was < 0.2 mg/L

Day	Duration of Low Level (hrs.)	Date Reported to Director

B. Distribution System HPC Criteria

$$V = \frac{\text{Number of Instances in which HPC > 500 colonies/ml}}{\text{Number of Routine total coliform samples collected}} \text{ X 100 } = \_\_\_\_\_\_\_\_\_\_ \%$$

For the previous month, V = ______%

Prepared by ____________

Date ____________

TABLE 5-6

DAILY TURBIDITY DATA

CONTINUOUS RECORDING TURBIDIMETER OR GRAB SAMPLE EVERY 4 HOURS

PWS# ____________ System & Purveyor ____________

Month ____________ Treatment Facility ____________

Year ____________ Turbidity Limit (NTU)* ____________

** 5 NTU for Slow Sand & Diatomaceous Earth filters only. All other technologies shall meet 1 NTU.*

	Turbidity, NTU					
	Time (4-hour interval)					
Date	Midnight	4:00 a.m.	8:00 a.m.	Noon	4:00 p.m.	8:00 p.m.
1						
2						
3						
4						
5						
6						
7						
8						
9						
10						
11						
12						
13						
14						
15						
16						
17						
18						
19						
20						
21						
22						
23						
24						
25						
26						
27						
28						
29						
30						
31						

Dates Calibration Performed: ____________ Range: 10 NTU

(SWTR Admin Man., Pg 4-1)

Total No. of Samples: ____________ Total Number of Samples ≤ Turbidity Limit ____________

Date Called Director to Report Violation: ____________

Date Public Notice Issued to - Radio/TV/Newspaper(circle all that apply): ____________

Prepared By: ____________ Date: ____________

Table 6-3

CT DETERMINATION FOR UNFILTERED SYSTEMS (3.0 log inactivation)
MONTHLY REPORT TO DIRECTOR

Month ______________________ System & Treatment Plant ______________________

Year ______________________ PWS ______________ Purveyor ______________

Disinfectant/Sequence of Application ______________________

Date	DRC Operator	Disinfectant[2] Concentration C (mg/l)	Disinfectant[2] Contact Time T (min.)	CT calc[3]	pH[4]	Water[2] Temp. (deg. C)	CT 99.9 [5]	Inactivation Ratio CT calc/CT 99.9
1								
2								
3								
4								
5								
6								
7								
8								
9								
10								
11								
12								
13								
14								
15								
16								
17								
18								
19								
20								
21								
22								
23								
24								
25								
26								
27								
28								
29								
30								
31								

Prepared by: ______________________ Date: ______________________

Notes:

1. Use a separate form for each disinfectant/sampling site. Enter disinfectant and sequence position, for example, "ozone/1st" or "Cl02/3rd".
2. Measurement taken at peak hourly flow.
3. CT calc = C (mg/l) X T (min.)
4. The pH reading may be required, depending on which EPA table (E-1 through E14) is used.
5. The CT 99.9 (3-log) value is from EPA tables E-1 through E-14.

TABLE E-1
CT VALUES FOR INACTIVATION
OF GIARDIA CYSTS BY FREE CHLORINE
AT 0.5°C OR LOWER (32.9°F)

CHLORINE CONCENTRATION	pH<6 Log Inactivations						pH=6.5 Log Inactivations						pH=7.0 Log Inactivations					
(mg/L)	0.5	1.0	1.5	2.0	2.5	3.0	0.5	1.0	1.5	2.0	2.5	3.0	0.5	1.0	1.5	2.0	2.5	3.0
≤0.4	23	46	69	91	114	137	27	54	82	109	136	163	33	65	98	130	163	195
0.6	24	47	71	94	118	141	28	56	84	112	140	168	33	67	100	133	167	200
0.8	24	48	73	97	121	145	29	57	86	115	143	172	34	68	103	137	171	205
1.0	25	49	74	99	123	148	29	59	88	117	147	176	35	70	105	140	175	210
1.2	25	51	76	101	127	152	30	60	90	120	150	180	36	72	108	143	179	215
1.4	26	52	78	103	129	155	31	61	92	123	153	184	37	74	111	147	184	221
1.6	26	52	79	105	131	157	32	63	95	126	158	189	38	75	113	151	188	226
1.8	27	54	81	108	135	162	32	64	97	129	161	193	39	77	116	154	193	231
2.0	28	55	83	110	138	165	33	66	99	131	164	197	39	79	118	157	197	236
2.2	28	56	85	113	141	169	34	67	101	134	168	201	40	81	121	161	202	242
2.4	29	57	86	115	143	172	34	68	103	137	171	205	41	82	124	165	206	247
2.6	29	58	88	117	146	175	35	70	105	139	174	209	42	84	126	168	210	252
2.8	30	59	89	119	148	178	36	71	107	142	178	213	43	86	129	171	214	257
3.0	30	60	91	121	151	181	36	72	109	145	181	217	44	87	131	174	218	261

Note:
CT_{68} = CT for 0.5 log inactivation
CT_{90} = CT for 1.0 log inactivation
$CT_{96.8}$ = CT for 1.5 log inactivation
CT_{99} = CT for 2.0 log inactivation
$CT_{99.7}$ = CT for 2.5 log inactivation
$CT_{99.9}$ = CT for 3.0 log inactivation
$CT_{99.99}$ = CT for 4.0 log inactivation

TABLE E-[illegible]TINUED)
CT VALUES F[illegible]ACTIVATION
OF GIARDIA CYSTS BY FREE CHLORINE
AT 0.5°C OR LOWER (32.9°F)

CHLORINE CONCENTRATION	pH=7.5 Log Inactivations						pH=8.0 Log Inactivations						pH=8.5 Log Inactivations					
(mg/L)	0.5	1.0	1.5	2.0	2.5	3.0	0.5	1.0	1.5	2.0	2.5	3.0	0.5	1.0	1.5	2.0	2.5	3.0
≤0.4	40	79	119	158	198	237	46	92	139	185	231	277	55	110	165	219	274	329
0.6	40	80	120	159	199	239	48	95	143	191	238	286	57	114	171	228	285	342
0.8	41	82	123	164	205	246	49	98	148	197	246	295	59	118	177	236	295	354
1.0	42	84	127	169	211	253	51	101	152	203	253	304	61	122	183	243	304	365
1.2	43	86	130	173	216	259	52	104	157	209	261	313	63	125	188	251	313	376
1.4	44	89	133	177	222	266	54	107	161	214	268	321	65	129	194	258	323	387
1.6	46	91	137	182	228	273	55	110	165	219	274	329	66	132	199	265	331	397
1.8	47	93	140	186	233	279	56	113	169	225	282	338	68	136	204	271	339	407
2.0	48	95	143	191	238	286	58	115	173	231	288	346	70	139	209	278	348	417
2.2	50	99	149	198	248	297	59	118	177	235	294	353	71	142	213	284	355	426
2.4	50	99	149	199	248	298	60	120	181	241	301	361	73	145	218	290	363	435
2.6	51	101	152	203	253	304	61	123	184	245	307	368	74	148	222	296	370	444
2.8	52	103	155	207	258	310	63	125	188	250	313	375	75	151	226	301	377	452
3.0	53	105	158	211	263	316	64	127	191	255	318	382	77	153	230	307	383	460

TABLE E-1 (CONTINUED)
CT VALUES FOR INACTIVATION
OF GIARDIA CYSTS BY FREE CHLORINE
AT 0.5°C OR LOWER (32.9°F)

pH<9.0

CHLORINE CONCENTRATION	Log Inactivations					
(mg/L)	0.5	1.0	1.5	2.0	2.5	3.0
≤0.4	65	130	195	260	325	390
0.6	68	136	204	271	339	407
0.8	70	141	211	281	352	422
1.0	73	146	219	291	364	437
1.2	75	150	226	301	376	451
1.4	77	155	232	309	387	464
1.6	80	159	239	318	398	477
1.8	82	163	245	326	408	489
2.0	83	167	250	333	417	500
2.2	85	170	256	341	426	511
2.4	87	174	261	348	435	522
2.6	89	178	267	355	444	533
2.8	91	181	272	362	453	543
3.0	92	184	276	368	460	552

TABLE E-2
CT VALUES FOR INACTIVATION OF GIARDIA CYSTS BY FREE CHLORINE AT 5°C (41°F)

CHLORINE CONCENTRATION	pH<6 Log Inactivations						pH=6.5 Log Inactivations						pH=7.0 Log Inactivations					
(mg/L)	0.5	1.0	1.5	2.0	2.5	3.0	0.5	1.0	1.5	2.0	2.5	3.0	0.5	1.0	1.5	2.0	2.5	3.0
≤0.4	16	32	49	65	81	97	20	39	59	78	98	117	23	46	70	93	116	139
0.6	17	33	50	67	83	100	20	40	60	80	100	120	24	48	72	95	119	143
0.8	17	34	52	69	86	103	20	41	61	81	102	122	24	49	73	97	122	146
1.0	18	35	53	70	88	105	21	42	63	83	104	125	25	50	75	99	124	149
1.2	18	36	54	71	89	107	21	42	64	85	106	127	25	51	76	101	127	152
1.4	18	36	55	73	91	109	22	43	65	87	108	130	26	52	78	103	129	155
1.6	19	37	56	74	93	111	22	44	66	88	110	132	26	53	79	105	132	158
1.8	19	38	57	76	95	114	23	45	68	90	113	135	27	54	81	108	135	162
2.0	19	39	58	77	97	116	23	46	69	92	115	138	28	55	83	110	138	165
2.2	20	39	59	79	98	118	23	47	70	93	117	140	28	56	85	113	141	169
2.4	20	40	60	80	100	120	24	48	72	95	119	143	29	57	86	115	143	172
2.6	20	41	61	81	102	122	24	49	73	97	122	146	29	58	88	117	146	175
2.8	21	41	62	83	103	124	25	49	74	99	123	148	30	59	89	119	148	178
3.0	21	42	63	84	105	126	25	50	76	101	126	151	30	61	91	121	152	182

TABLE E-2 (CONTINUED)
CT VALUES FOR INACTIVATION
OF GIARDIA CYSTS BY FREE CHLORINE
AT 5°C (41°F)

CHLORINE CONCENTRATION	pH=7.5 Log Inactivations						pH=8.0 Log Inactivations						pH=8.5 Log Inactivations					
(mg/L)	0.5	1.0	1.5	2.0	2.5	3.0	0.5	1.0	1.5	2.0	2.5	3.0	0.5	1.0	1.5	2.0	2.5	3.0
≤0.4	28	55	83	111	138	166	33	66	99	132	165	198	39	79	118	157	197	236
0.6	29	57	86	114	143	171	34	68	102	136	170	204	41	81	122	163	203	244
0.8	29	58	88	117	146	175	35	70	105	140	175	210	42	84	126	168	210	252
1.0	30	60	90	119	149	179	36	72	108	144	180	216	43	87	130	173	217	260
1.2	31	61	92	122	153	183	37	74	111	147	184	221	45	89	134	178	223	267
1.4	31	62	94	125	156	187	38	76	114	151	189	227	46	91	137	183	228	274
1.6	32	64	96	128	160	192	39	77	116	155	193	232	47	94	141	187	234	281
1.8	33	65	98	131	163	196	40	79	119	159	198	238	48	96	144	191	239	287
2.0	33	67	100	133	167	200	41	81	122	162	203	243	49	98	147	196	245	294
2.2	34	68	102	136	170	204	41	83	124	165	207	248	50	100	150	200	250	300
2.4	35	70	105	139	174	209	42	84	127	169	211	253	51	102	153	204	255	306
2.6	36	71	107	142	178	213	43	86	129	172	215	258	52	104	156	208	260	312
2.8	36	72	109	145	181	217	44	88	132	175	219	263	53	106	159	212	265	318
3.0	37	74	111	147	184	221	45	89	134	179	223	268	54	108	162	216	270	324

TABLE E-2 (CONTINUED)
CT VALUES FOR INACTIVATION
OF GIARDIA CYSTS BY FREE CHLORINE
AT 5°C (41°F)

pH<9.0

CHLORINE CONCENTRATION	Log Inactivations					
(mg/L)	0.5	1.0	1.5	2.0	2.5	3.0
≤0.4	47	93	140	186	233	279
0.6	49	97	146	194	243	291
0.8	50	100	151	201	251	301
1.0	52	104	156	208	260	312
1.2	53	107	160	213	267	320
1.4	55	110	165	219	274	329
1.6	56	112	169	225	281	337
1.8	58	115	173	230	288	345
2.0	59	118	177	235	294	353
2.2	60	120	181	241	301	361
2.4	61	123	184	245	307	368
2.6	63	125	188	250	313	375
2.8	64	127	191	255	318	382
3.0	65	130	195	259	324	389

TABLE E-3
CT VALUES FOR INACTIVATION
OF GIARDIA CYSTS BY FREE CHLORINE
AT 10°C (50°F)

CHLORINE CONCENTRATION	pH<6 Log Inactivations						pH=6.5 Log Inactivations						pH=7.0 Log Inactivations					
(mg/L)	0.5	1.0	1.5	2.0	2.5	3.0	0.5	1.0	1.5	2.0	2.5	3.0	0.5	1.0	1.5	2.0	2.5	3.0
≤0.4	12	24	37	49	61	73	15	29	44	59	73	88	17	35	52	69	87	104
0.6	13	25	38	50	63	75	15	30	45	60	75	90	18	36	54	71	89	107
0.8	13	26	39	52	65	78	15	31	46	61	77	92	18	37	55	73	92	110
1.0	13	26	40	53	66	79	16	31	47	63	78	94	19	37	56	75	93	112
1.2	13	27	40	53	67	80	16	32	48	63	79	95	19	38	57	76	95	114
1.4	14	27	41	55	68	82	16	33	49	65	82	98	19	39	58	77	97	116
1.6	14	28	42	55	69	83	17	33	50	66	83	99	20	40	60	79	99	119
1.8	14	29	43	57	72	86	17	34	51	67	84	101	20	41	61	81	102	122
2.0	15	29	44	58	73	87	17	35	52	69	87	104	21	41	62	83	103	124
2.2	15	30	45	59	74	89	18	35	53	70	88	105	21	42	64	85	106	127
2.4	15	30	45	60	75	90	18	36	54	71	89	107	22	43	65	86	108	129
2.6	15	31	46	61	77	92	18	37	55	73	92	110	22	44	66	87	109	131
2.8	16	31	47	62	78	93	19	37	56	74	93	111	22	45	67	89	112	134
3.0	16	32	48	63	79	95	19	38	57	75	94	113	23	46	69	91	114	137

TABLE E-3 (CONTINUED)
CT VALUES FOR INACTIVATION OF GIARDIA CYSTS BY FREE CHLORINE AT 10°C (50°F)

CHLORINE CONCENTRATION	pH=7.5 Log Inactivations						pH=8.0 Log Inactivations						pH=8.5 Log Inactivations					
(mg/L)	0.5	1.0	1.5	2.0	2.5	3.0	0.5	1.0	1.5	2.0	2.5	3.0	0.5	1.0	1.5	2.0	2.5	3.0
≤0.4	21	42	63	83	104	125	25	50	75	99	124	149	30	59	89	118	148	177
0.6	21	43	64	85	107	128	26	51	77	102	128	153	31	61	92	122	153	183
0.8	22	44	66	87	109	131	26	53	79	105	132	158	32	63	95	126	158	189
1.0	22	45	67	89	112	134	27	54	81	108	135	162	33	65	98	130	163	195
1.2	23	46	69	91	114	137	28	55	83	111	138	166	33	67	100	133	167	200
1.4	23	47	70	93	117	140	28	57	85	113	142	170	34	69	103	137	172	206
1.6	24	48	72	96	120	144	29	58	87	116	145	174	35	70	106	141	176	211
1.8	25	49	74	98	123	147	30	60	90	119	149	179	36	72	108	143	179	215
2.0	25	50	75	100	125	150	30	61	91	121	152	182	37	74	111	147	184	221
2.2	26	51	77	102	128	153	31	62	93	124	155	186	38	75	113	150	188	225
2.4	26	52	79	105	131	157	32	63	95	127	158	190	38	77	115	153	192	230
2.6	27	53	80	107	133	160	32	65	97	129	162	194	39	78	117	156	195	234
2.8	27	54	82	109	136	163	33	66	99	131	164	197	40	80	120	159	199	239
3.0	28	55	83	111	138	166	34	67	101	134	168	201	41	81	122	162	203	243

TABLE E-3 (CONTINUED)
CT VALUES FOR INACTIVATION OF GIARDIA CYSTS BY FREE CHLORINE AT 10°C (50°F)

pH<9.0

CHLORINE CONCENTRATION (mg/L)	Log Inactivations 0.5	1.0	1.5	2.0	2.5	3.0
≤0.4	35	70	105	139	174	209
0.6	36	73	109	145	182	218
0.8	38	75	113	151	188	226
1.0	39	78	117	156	195	234
1.2	40	80	120	160	200	240
1.4	41	82	124	165	206	247
1.6	42	84	127	169	211	253
1.8	43	86	130	173	216	259
2.0	44	88	133	177	221	265
2.2	45	90	136	181	226	271
2.4	46	92	138	184	230	276
2.6	47	94	141	187	234	281
2.8	48	96	144	191	239	287
3.0	49	97	146	195	243	292

TABLE E-4
CT VALUES FOR INACTIVATION
OF GIARDIA CYSTS BY FREE CHLORINE
AT 15°C (59°F)

CHLORINE CONCENTRATION	pH<6 Log Inactivations						pH=6.5 Log Inactivations						pH=7.0 Log Inactivations					
(mg/L)	0.5	1.0	1.5	2.0	2.5	3.0	0.5	1.0	1.5	2.0	2.5	3.0	0.5	1.0	1.5	2.0	2.5	3.0
≤0.4	8	16	25	33	41	49	10	20	30	39	49	59	12	23	35	47	58	70
0.6	8	17	25	33	42	50	10	20	30	40	50	60	12	24	36	48	60	72
0.8	9	17	26	35	43	52	10	20	31	41	51	61	12	24	37	49	61	73
1.0	9	18	27	35	44	53	11	21	32	42	53	63	13	25	38	50	63	75
1.2	9	18	27	36	45	54	11	21	32	43	53	64	13	25	38	51	63	76
1.4	9	18	28	37	46	55	11	22	33	43	54	65	13	26	39	52	65	78
1.6	9	19	28	37	47	56	11	22	33	44	55	66	13	26	40	53	66	79
1.8	10	19	29	38	48	57	11	23	34	45	57	68	14	27	41	54	68	81
2.0	10	19	29	39	48	58	12	23	35	46	58	69	14	28	42	55	69	83
2.2	10	20	30	39	49	59	12	23	35	47	58	70	14	28	43	57	71	85
2.4	10	20	30	40	50	60	12	24	36	48	60	72	14	29	43	57	72	86
2.6	10	20	31	41	51	61	12	24	37	49	61	73	15	29	44	59	73	88
2.8	10	21	31	41	52	62	12	25	37	49	62	74	15	30	45	59	74	89
3.0	11	21	32	42	53	63	13	25	38	51	63	76	15	30	46	61	76	91

TABLE E-4 (CONTINUED)
CT VALUES FOR INACTIVATION
OF GIARDIA CYSTS BY FREE CHLORINE
AT 15°C (59°F)

CHLORINE CONCENTRATION	pH=7.5 Log Inactivations						pH=8.0 Log Inactivations						pH=8.5 Log Inactivations					
(mg/L)	0.5	1.0	1.5	2.0	2.5	3.0	0.5	1.0	1.5	2.0	2.5	3.0	0.5	1.0	1.5	2.0	2.5	3.0
≤0.4	14	28	42	55	69	83	17	33	50	66	83	99	20	39	59	79	98	118
0.6	14	29	43	57	72	86	17	34	51	68	85	102	20	41	61	81	102	122
0.8	15	29	44	59	73	88	18	35	53	70	88	105	21	42	63	84	105	126
1.0	15	30	45	60	75	90	18	36	54	72	90	108	22	43	65	87	108	130
1.2	15	31	46	61	77	92	19	37	56	74	93	111	22	45	67	89	112	134
1.4	16	31	47	63	78	94	19	38	57	76	95	114	23	46	69	91	114	137
1.6	16	32	48	64	80	96	19	39	58	77	97	116	24	47	71	94	118	141
1.8	16	33	49	65	82	98	20	40	60	79	99	119	24	48	72	96	120	144
2.0	17	33	50	67	83	100	20	41	61	81	102	122	25	49	74	98	123	147
2.2	17	34	51	68	85	102	21	41	62	83	103	124	25	50	75	100	125	150
2.4	18	35	53	70	88	105	21	42	64	85	106	127	26	51	77	102	128	153
2.6	18	36	54	71	89	107	22	43	65	86	108	129	26	52	78	104	130	156
2.8	18	36	55	73	91	109	22	44	66	88	110	132	27	53	80	106	133	159
3.0	19	37	56	74	93	111	22	45	67	89	112	134	27	54	81	108	135	162

TABLE E-4 (CO ED)
CT VALUES FOR IN ATION
OF GIARDIA CYSTS BY FREE CHLORINE
AT 15°C (59°F)

pH<9.0

CHLORINE CONCENTRATION	Log Inactivations					
(mg/L)	0.5	1.0	1.5	2.0	2.5	3.0
≤0.4	23	47	70	93	117	140
0.6	24	49	73	97	122	146
0.8	25	50	76	101	126	151
1.0	26	52	78	104	130	156
1.2	27	53	80	107	133	160
1.4	28	55	83	110	138	165
1.6	28	56	85	113	141	169
1.8	29	58	87	115	144	173
2.0	30	59	89	118	148	177
2.2	30	60	91	121	151	181
2.4	31	61	92	123	153	184
2.6	31	63	94	125	157	188
2.8	32	64	96	127	159	191
3.0	33	65	98	130	163	195

TABLE E-5
CT VALUES FOR INACTIVATION
OF GIARDIA CYSTS BY FREE CHLORINE
AT 20°C (68°F)

CHLORINE CONCENTRATION	pH<6 Log Inactivations						pH=6.5 Log Inactivations						pH=7.0 Log Inactivations					
(mg/L)	0.5	1.0	1.5	2.0	2.5	3.0	0.5	1.0	1.5	2.0	2.5	3.0	0.5	1.0	1.5	2.0	2.5	3.0
≤0.4	6	12	18	24	30	36	7	15	22	29	37	44	9	17	26	35	43	52
0.6	6	13	19	25	32	38	8	15	23	30	38	45	9	18	27	36	45	54
0.8	7	13	20	26	33	39	8	15	23	31	38	46	9	18	28	37	46	55
1.0	7	13	20	26	33	39	8	16	24	31	39	47	9	19	28	37	47	56
1.2	7	13	20	27	33	40	8	16	24	32	40	48	10	19	29	38	48	57
1.4	7	14	21	27	34	41	8	16	25	33	41	49	10	19	29	39	48	58
1.6	7	14	21	28	35	42	8	17	25	33	42	50	10	20	30	39	49	59
1.8	7	14	22	29	36	43	9	17	26	34	43	51	10	20	31	41	51	61
2.0	7	15	22	29	37	44	9	17	26	35	43	52	10	21	31	41	52	62
2.2	7	15	22	29	37	44	9	18	27	35	44	53	11	21	32	42	53	63
2.4	8	15	23	30	38	45	9	18	27	36	45	54	11	22	33	43	54	65
2.6	8	15	23	31	38	46	9	18	28	37	46	55	11	22	33	44	55	66
2.8	8	16	24	31	39	47	9	19	28	37	47	56	11	22	34	45	56	67
3.0	8	16	24	31	39	47	10	19	29	38	48	57	11	23	34	45	57	68

TABLE E-5 (CONTINUED)
CT VALUES FOR INACTIVATION
OF GIARDIA CYSTS BY FREE CHLORINE
AT 20°C (68°F)

CHLORINE CONCENTRATION	pH=7.5						pH=8.0						pH=8.5					
	Log Inactivations						Log Inactivations						Log Inactivations					
(mg/L)	0.5	1.0	1.5	2.0	2.5	3.0	0.5	1.0	1.5	2.0	2.5	3.0	0.5	1.0	1.5	2.0	2.5	3.0
≤0.4	10	21	31	41	52	62	12	25	37	49	62	74	15	30	45	59	74	89
0.6	11	21	32	43	53	64	13	26	39	51	64	77	15	31	46	61	77	92
0.8	11	22	33	44	55	66	13	26	40	53	66	79	16	32	48	63	79	95
1.0	11	22	34	45	56	67	14	27	41	54	68	81	16	33	49	65	82	98
1.2	12	23	35	46	58	69	14	28	42	55	69	83	17	33	50	67	83	100
1.4	12	23	35	47	58	70	14	28	43	57	71	85	17	34	52	69	86	103
1.6	12	24	36	48	60	72	15	29	44	58	73	87	18	35	53	70	88	105
1.8	12	25	37	49	62	74	15	30	45	59	74	89	18	36	54	72	90	108
2.0	13	25	38	50	63	75	15	30	46	61	76	91	18	37	55	73	92	110
2.2	13	26	39	51	64	77	16	31	47	62	78	93	19	38	57	75	94	113
2.4	13	26	39	52	65	78	16	32	48	63	79	95	19	38	58	77	96	115
2.6	13	27	40	53	67	80	16	32	49	65	81	97	20	39	59	78	98	117
2.8	14	27	41	54	68	81	17	33	50	66	83	99	20	40	60	79	99	119
3.0	14	28	42	55	69	83	17	34	51	67	84	101	20	41	61	81	102	122

TABLE E-5 (CONTINUED)
CT VALUES FOR INACTIVATION OF GIARDIA CYSTS BY FREE CHLORINE AT 20°C (68°F)

pH<9.0

CHLORINE CONCENTRATION	Log Inactivations					
(mg/L)	0.5	1.0	1.5	2.0	2.5	3.0
≤0.4	18	35	53	70	88	105
0.6	18	36	55	73	91	109
0.8	19	38	57	75	94	113
1.0	20	39	59	78	98	117
1.2	20	40	60	80	100	120
1.4	21	41	62	82	103	123
1.6	21	42	63	84	105	126
1.8	22	43	65	86	108	129
2.0	22	44	66	88	110	132
2.2	23	45	68	90	113	135
2.4	23	46	69	92	115	138
2.6	24	47	71	94	118	141
2.8	24	48	72	95	119	143
3.0	24	49	73	97	122	146

TABLE E-6
CT VALUES FOR INACTIVATION OF GIARDIA CYSTS BY FREE CHLORINE AT 25°C (77°F)

CHLORINE CONCENTRATION	pH<6						pH=6.5						pH=7.0					
	Log Inactivations						Log Inactivations						Log Inactivations					
(mg/L)	0.5	1.0	1.5	2.0	2.5	3.0	0.5	1.0	1.5	2.0	2.5	3.0	0.5	1.0	1.5	2.0	2.5	3.0
≤0.4	4	8	12	16	20	24	5	10	15	19	24	29	6	12	18	23	29	35
0.6	4	8	13	17	21	25	5	10	15	20	25	30	6	12	18	24	30	36
0.8	4	9	13	17	22	26	5	10	16	21	26	31	6	12	19	25	31	37
1.0	4	9	13	17	22	26	5	10	16	21	26	31	6	12	19	25	31	37
1.2	5	9	14	18	23	27	5	11	16	21	27	32	6	13	19	25	32	38
1.4	5	9	14	18	23	27	6	11	17	22	28	33	7	13	20	26	33	39
1.6	5	9	14	19	23	28	6	11	17	22	28	33	7	13	20	27	33	40
1.8	5	10	15	19	24	29	6	11	17	23	28	34	7	14	21	27	34	41
2.0	5	10	15	19	24	29	6	12	18	23	29	35	7	14	21	27	34	41
2.2	5	10	15	20	25	30	6	12	18	23	29	35	7	14	21	28	35	42
2.4	5	10	15	20	25	30	6	12	18	24	30	36	7	14	22	29	36	43
2.6	5	10	16	21	26	31	6	12	19	25	31	37	7	15	22	29	37	44
2.8	5	10	16	21	26	31	6	12	19	25	31	37	8	15	23	30	38	45
3.0	5	11	16	21	27	32	6	13	19	25	32	38	8	15	23	31	38	46

TABLE E-6 (CONTINUED)
CT VALUES FOR INACTIVATION OF GIARDIA CYSTS BY FREE CHLORINE AT 25°C (77°F)

CHLORINE CONCENTRATION	pH=7.5 Log Inactivations						pH=8.0 Log Inactivations						pH=8.5 Log Inactivations					
(mg/L)	0.5	1.0	1.5	2.0	2.5	3.0	0.5	1.0	1.5	2.0	2.5	3.0	0.5	1.0	1.5	2.0	2.5	3.0
≤0.4	7	14	21	28	35	42	8	17	25	33	42	50	10	20	30	39	49	59
0.6	7	14	22	29	36	43	9	17	26	34	43	51	10	20	31	41	51	61
0.8	7	15	22	29	37	44	9	18	27	35	44	53	11	21	32	42	53	63
1.0	8	15	23	30	38	45	9	18	27	36	45	54	11	22	33	43	54	65
1.2	8	15	23	31	38	46	9	18	28	37	46	55	11	22	34	45	56	67
1.4	8	16	24	31	39	47	10	19	29	38	48	57	12	23	35	46	58	69
1.6	8	16	24	32	40	48	10	19	29	39	48	58	12	23	35	47	58	70
1.8	8	16	25	33	41	49	10	20	30	40	50	60	12	24	36	48	60	72
2.0	8	17	25	33	42	50	10	20	31	41	51	61	12	25	37	49	62	74
2.2	9	17	26	34	43	51	10	21	31	41	52	62	13	25	38	50	63	75
2.4	9	17	26	35	43	52	11	21	32	42	53	63	13	26	39	51	64	77
2.6	9	18	27	35	44	53	11	22	33	43	54	65	13	26	39	52	65	78
2.8	9	18	27	36	45	54	11	22	33	44	55	66	13	27	40	53	67	80
3.0	9	18	28	37	46	55	11	22	34	45	56	67	14	27	41	54	68	81

TABLE E-6 (CONTINUED)
CT VALUES FOR INACTIVATION
OF GIARDIA CYSTS BY FREE CHLORINE
AT 25°C (77°F)

pH<9.0

CHLORINE CONCENTRATION (mg/L)	Log Inactivations 0.5	1.0	1.5	2.0	2.5	3.0
≤0.4	12	23	35	47	58	70
0.6	12	24	37	49	61	73
0.8	13	25	38	50	63	75
1.0	13	26	39	52	65	78
1.2	13	27	40	53	67	80
1.4	14	27	41	55	68	82
1.6	14	28	42	56	70	84
1.8	14	29	43	57	72	86
2.0	15	29	44	59	73	88
2.2	15	30	45	60	75	90
2.4	15	31	46	61	77	92
2.6	16	31	47	63	78	94
2.8	16	32	48	64	80	96
3.0	16	32	49	65	81	97

TABLE E-7
CT VALUES FOR INACTIVATION
OF VIRUSES BY FREE CHLORINE

Temperature (degrees C)	pH = 6 - 9 Log Inactivations 2.0	3.0	4.0	pH = 10 Log Inactivations 2.0	3.0	4.0
0.5	6	9	12	45	66	90
5	4	6	8	30	44	60
10	3	4	6	22	33	45
15	2	3	4	15	22	30
20	1	2	3	11	16	22
25	1	1	2	7	11	15

Notes:

1. Data adapted from Sobsey (1988) for inactivation of Hepatitus A Virus (HAV) at pH = 6, 7, 8, 9 and 10 and temperature = 5 C. CT values include a safety factor of 3.

2. CT values adjusted to other temperatures by doubling CT for each 10 C drop in temperature.

TABLE E-8
CT VALUES FOR INACTIVATION
OF GIARDIA CYSTS BY CHLORINE DIOXIDE
(pH 6 - 9)

Log Inactivation	Temperature (degrees C) ≤1	5	10	15	20	25
0.5	10	4.3	4	3.2	2.5	2
1	21	8.7	7.7	6.3	5	3.7
1.5	32	13	12	10	7.5	5.5
2	42	17	15	13	10	7.3
2.5	52	22	19	16	13	9
3	63	26	23	19	15	11

TABLE E-9
CT VALUES FOR INACTIVATION
OF VIRUSES BY CHLORINE DIOXIDE
(pH 6 - 9)

Log Inactivation	Temperature (degrees C) ≤1	5	10	15	20	25
2	8.4	5.6	4.2	2.8	2.1	1.4
3	25.6	17.1	12.8	8.6	6.4	4.3
4	50.1	33.4	25.1	16.7	12.5	8.4

Notes:

1. Data adapted from Sobsey (1988) for inactivation of Hepatitus A Virus (HAV) at pH = 6.0 and temperature = 5 C. CT values include a safety factor of 2.

2. CT values adjusted to other temperatures by doubling CT for each 10 C drop in temperature.

TABLE E-10
CT VALUES FOR INACTIVATION
OF GIARDIA CYSTS BY OZONE
(pH 6 - 9)

Log Inactivation	Temperature (degrees C) ≤1	5	10	15	20	25
0.5	0.48	0.32	0.23	0.16	0.12	0.08
1	0.97	0.63	0.48	0.32	0.24	0.16
1.5	1.5	0.95	0.72	0.48	0.36	0.24
2	1.9	1.3	0.95	0.63	0.48	0.32
2.5	2.4	1.6	1.2	0.79	0.60	0.40
3	2.9	1.9	1.43	0.95	0.72	0.48

TABLE E-11
CT VALUES FOR INACTIVATION
OF VIRUSES BY OZONE

Log Inactivation	Temperature (degrees C) ≤1	5	10	15	20	25
2	0.9	0.6	0.5	0.3	0.25	0.15
3	1.4	0.9	0.8	0.5	0.4	0.25
4	1.8	1.2	1.0	0.6	0.5	0.3

Notes:

1. Data adapted from Sobsey (1988) for inactivation of poliovirus for pH = 7.2 and temperature = 5 C. CT values include a safety factor of 3.

2. CT values adjusted to other temperatures by doubling CT for each 10 C drop in temperature.

TABLE E-12
CT VALUES FOR INACTIVATION
OF GIARDIA CYSTS BY CHLORAMINE
(pH = 6 - 9)

Log Inactivation	Temperature (degrees C) ≤1	5	10	15	20	25
0.5	635	365	310	250	185	125
1	1,270	735	615	500	370	250
1.5	1,900	1,100	930	750	550	375
2	2,535	1,470	1,230	1,000	735	500
2.5	3,170	1,830	1,540	1,250	915	625
3	3,800	2,200	1,850	1,500	1,100	750

TABLE E-13
CT VALUES FOR INACTIVATION
OF VIRUSES BY CHLORAMINE

Log Inactivation	Temperature (degrees C) ≤1	5	10	15	20	25
2	1,243	857	643	428	321	214
3	2,063	1,423	1,067	712	534	356
4	2,883	1,988	1,491	994	746	497

Notes:

1. Data adapted from Sobsey (1988) for inactivation of Hepatitus A Virus (HAV) at pH = 8.0 and temperature = 5 C, and assumed to apply for pHs in the range from 6.0 to 10.0.

2. CT values adjusted to other temperatures by doubling CT for each 10 C drop in temperature.

3. This table of CT values applies for systems using combined chlorine where chlorine is added prior to ammonia in the treatment sequence. CT values in this table should not be used for estimating the adequacy of disinfection in systems applying preformed chloramines or ammonia ahead of chlorine.

TABLE E-14
CT VALUES FOR INACTIVATION
OF VIRUSES BY UV

Log Inactivation 2.0	3.0
21	36

1. Data adapted from Sobsey (1988) for UV inactivation of Hepatitus A Virus (HAV). Units of CT values are mW-sec/cm. CT values include a safety factor of 3.

CHAPTER 6

EXEMPTIONS AND VARIANCES

6. EXEMPTIONS AND VARIANCES

I. GENERAL

The dictionary defines exemption as the act of being released or delivered from some liability or requirement to which others are subject to. Variance is then defined as a license to do some act contrary to the usual rule. For the SWTR, the granting of an exemption allows a public water system to comply with a treatment technique requirement (filtration) at a later date by following an implementation schedule adopted by public hearing. Note that there is no exemption from disinfection. Also, no variance will be granted from having to meet the requirements of the EPA's SWTR, Part 141, Subpart H - Filtration and Disinfection and IESWTR, Part 141, Subpart P - Enhanced Filtration and Disinfection, as applicable.

II. OVERVIEW OF EXEMPTION REQUIREMENTS

A. Requirement For An Exemption To Be Considered

1. Due to compelling factors (which may include economic factors), the public water system is unable to comply with the treatment technique requirement;

2. The public water system was in operation on the effective date of the treatment technique requirement or, for a system that was not in operation by that date, only if no reasonable alternative source of drinking water is available to the new system; and

3. The granting of the exemption will not result in an unreasonable risk to health.

B. Schedule Prescribed By Director At The Time An Exemption Is Granted By Public Hearing

1. Compliance (Including increments of progress) by the public water system with each treatment technique requirement with respect to which the exemption was granted; and

2. Implementation by the system of such control measures as the director may require during the period the exemption is in effect.

C. Exemption Period

1. One year.

2. Exemption may be extended by public hearing for a period not to exceed 3 years from the date exemption was originally granted, if the system meets the following requirements:

   a. System in compliance with the monthly coliform MCL.

   b. System disinfects to achieve at least a 3-log inactivation of Giardia when it presently provides no filtration, or

   c. System maintains a disinfectant residual or a heterotrophic plate count (HPC) bacterial reading of less than or equal to 500 bacterial colonies per milliliter in the distribution system at least in 95 percent of the measured sites, and

   d. System does not have any evidence of waterborne disease outbreaks attributable to itself at the end of the first exemption period.

   e. Should the system fail to meet any one of the previous conditions at any point during the extended exemption period, the director may withdraw the exemption and initiate enforcement action.

APPENDIX A

SDWB LETTER DECEMBER 24, 1990

TO SURFACE WATER SUPPLIERS

December 24, 1990

CERTIFIED MAIL

Dear Water Purveyor:

You are hereby notified that you have a surface water source(s) that is subject to the requirement of the Surface Water Treatment Rule (SWTR). The United States Environmental Protection Agency (EPA) initiated the SWTR which was made into law in 40 CFR (Code of Federal Regulations) Part 141, Subpart H. EPA's SWTR becomes effective December 31, 1990 and regulates both surface water sources and groundwater sources under the direct influence of surface water.

All surface water sources, unfiltered or filtered, must meet the SWTR's filtration criteria, disinfection criteria, monitoring requirements, and reporting requirements by June 29, 1993. Essentially, all public water systems utilizing a surface water source shall either install or modify their filtration and disinfection system (with the director's approval), and have it operating and in compliance by the June 29, 1993 deadline.

We have attached papers on filtration criteria, disinfection criteria, monitoring requirements, and reporting requirement so as to assist you in bringing your unfiltered or filtered source into compliance with the SWTR by June 29, 1993. The existing interim turbidity standard (1 NTU) for all existing surface water sources continues in effect until June 29, 1993.

The Hawaii State Department of Health is seeking delegation of authority from EPA to enforce its own SWTR. The director's SWTR is proposed for review, public hearing, and adoption in calendar year 1991. Meanwhile, failure to meet EPA's SWTR compliance deadline of June 29, 1993, for an operating filtration and disinfection system approved by the director, shall subject you to enforcement action by the director pursuant to HRS 340E-8.

If you have any questions, please call the Safe Drinking Water Branch (SDWB) in Honolulu (543-8258) or the Drinking Water Sanitarian on your island:

Glenn Tomori (935-4372), Paul Okuna (322-0033) on Hawaii, Gordon Muraoka (243-5278) on Maui, and Harold Eichelberger (241-3323) on Kauai. Purveyors located on Molokai should call the SDWB in Honolulu (543-8258).

Very truly yours,

JOHN C. LEWIN, M.D.
Director of Health

Attachments

PURVEYOR LIST

WATER PURVEYOR	SYSTEM	PWS I.D. #
Hawaii DWS	Hilo	101
	South Kohala	130
Hamakua Sugar	Paauhau	137
DLNR State Parks	Maunakea State Park	143
	Kokee State Park	425
U.S. Army	Pohakuloa	145
Kapalua Water Co.	Kapalua	204
Pioneer Mill	Olowalu	204
	Kauaula	210
	Kanaha	211
DWS Maui	Makawao	213
	Lahaina	214
	Upper Kula	215
	Hana	217
	Honokohau	218
	Lower Kula	247
	Kaunakakai	234
BSA	Camp Maluhia	221
DOE	Lahainaluna School	228
Molokai Ranch	Kualapuu	229
	Maunaloa	231
Kalua Koi Corp.	Kalua Koi	236
Mililani Memorial Park	Mililani Memorial Park	320
BWS	Honolulu-Windward-Pearl Harbor	331
Dept. of Corrections	Waiawa Correctional Facility	348
DW Kauai	Kalaheo Treatment Plant	405
Grove Farm	Koloa	421

APPENDIX B

SDWB LETTER OF JANUARY 16, 1991

ALL PURVEYORS, GROUNDWATER UNDER

THE INFLUENCE, LATER DETERMINATION

January 16, 1991

CERTIFIED MAIL

Dear Water Purveyors:

You are hereby notified that all public water systems are subject to the Surface Water Treatment Rule (SWTR) as of January 1, 1991. The United States Environmental Protection Agency (EPA) has promulgated the SWTR pursuant to authority in 40 CFR (Code of Federal Regulations) Parts 141, Subpart H and 142. EPA's SWTR became effective December 31, 1990 and regulates both surface water sources and groundwater sources under the direct influence of surface water.

You will be notified at a later date if you have a subsurface or groundwater source under the direct influence of surface water. All groundwater sources determined to be under the direct influence of surface water will have to comply with the following requirements of the SWTR as follows:

1. Filtration criteria (install and operate an approved filtration plant).
2. Disinfection criteria (install and operate an approved disinfection system).
3. Monitoring requirement.
4. Reporting requirement.

The Hawaii State Department of Health is seeking delegation of authority from EPA to enforce its own SWTR. The director's SWTR is proposed for review, public hearing, and adoption in calendar year 1991.

If you have any questions, please call the Safe Drinking Water Branch (SDWB) in Honolulu (543-8258) or the Drinking Water Sanitarian on your islands Glenn Tomori (935-4372), Paul Okuna (322-0033) on Hawaii, Gordon Muraoka (243-5228) on Maui, and Harold Eichelberger (241-3323) on Kauai, Purveyors located on Molokai should call the SDWB in Honolulu (543-8258).

Very truly yours,

JOHN C. LEWIN, M.D.
Director of Health

bcc: Glenn Tomori, SDW Sanitarian, Hilo
Paul Okuna, SDW Sanitarian, Kona
Gordon Muraoka, SDW Sanitarian, Maui
Harold Eichelberger, SDW Sanitarian, Kauai

January 23, 1991
WATER PURVEYOR LIST

WATER PURVEYOR	SYSTEM	PWS I.D. #
DWS Hawaii	Laupahoehoe-Kapahu	102
	Ninole	103
	Ookala	104
	Honomu	105
	Pepeekeo	106
	Papaikou	107
	Waiohinu-Naalehu	108
	Pahala	109
	Kalapana	110
	Pahoa	111
	Olaa-Mountain View	112
	Halaula	128
	North Kohala	129
	North Kona	131
	South Kona	132
	Kukuihaele	133
	Paauilo	134
	Niulii	139
	Hakalau-Wailea	154
	Kapoho	155
Punaluu Development Inc.	Punaluu	114
Maunaloa Macadamia Nut	Maunaloa Macadamia Nut	115
Miller and Lieb Water Co.	Hawaiian Beaches	117
Hamakua Sugar Co.	Papaaloa	119
	Ookala	122
	Paauilo	141
	Big Island Meat Co.	157
Chin Chuck Community Assn.	Hakalau	123
Hilo Coast Processing Co.	Pepeekeo	125
Waikoloa Water Co., Inc.	Waikoloa	135
AIRCO	Kona Village	140
U.S. Army	Kilauea Military Camp	144
U.S. Department of Interior	Hawaii Volcanos Ntnl Park	146
Puuwaawaa Water Works	Puuwaawaa Water Works	150
Kohala Ranch Water Co.	Kohala Joint Venture	151
Department of Social Svcs.	Kulani Correctional Center	153
Hawaiian Shores Assn.	Hawaiian Shores	156
Hana Water Resources	Hana Town Water System	201
Hana Water Co.	Kaeleku Agricultural Park	243
Ohanui Corp.	Kailua	203
Kaanapali Water Corp.	Kaanapali	205

WATER PURVEYOR	SYSTEM	PWS I.D. #
DWS Maui	Wailuku	212
	Kaanae	219
	Nahiku	220
	Ualapue	233
	Kalae	235
National Park Service	Haleakala National Park	222
	Visitor Center	232
	Kalaupapa National History	239
Dept. of Hawaiian Home Lands	Hoolehua	230
	Anahola Farm Lots	432
Koele Co.	Lanai City	237
	Manele Bay	238
Ed Robinson-Nordic Construc.	Iao Valley Lodge	240
U.S. Air Force	Haleakala Optical Station	244
Molokai Ranch	Kipu (Hawn Homes Source)	245
DLNR - State Parks	Waialala	246
	Kahana State Park	327
	Polihale State Park	426
Dole Packaged Foods, Inc.	Dole Cannery	301
PPI Del Monte Fresh Products	PPI Del Monte Fresh Products	303
Hawaii County Club	Hawaii Country Club	304
Department of Health	Waimano Training School	306
Waialua Sugar Co., Inc.	Waialua Sugar Pump 2	309
	Waialua Sugar Pump 17	310
The Queen's Medical Center	The Queen's Medical Center	312
Roman Catholic Church	St. Stephen's Diocesan Center	314
Campbell Estates	Kahuku Air Base	315
	Malaekana	316
Kam School-Bishop Estate	Kamehameha Schools	319
Oahu Sugar Co.	Oahu Sugar Waipahu	321
	Oahu Sugar Ewa	322
Pacific Club	Pacific Club	323
Punahou School	Punahou School	324
Zions Securities Corp.	Laie	325
Mokuleia Land Co.	Mokuleia Land Co.	326
Dairy Co., Inc.	Dairy Co.	328
Kyo-Ya Co., Ltd.	Sheraton Hotels	330
BWS Honolulu	Waialua	332
	Wahiawa	333
	Waipio Heights	334
	Waipahu-Ewa-Waianae	335
	Kahuku	365
	Waialee	366
	Mililani	367

WATER PURVEYOR	SYSTEM	PWS I.D. #
Navy Public Works Center	Aliamanu	337
	Fort Kamehameha	340
	Camp Stover	354
	Barbers Point	355
	NAVCAMS EASTPAC	357
	NAVMAG Lualualei	358
	NAVMAG Waikele	359
	Pearl Harbor	360
	Radford Terrace	361
Department of Transportation	Dillingham	338
Directorate of Facility Eng.	Fort Shafter	341
	Kahuku	342
	Kapalama	343
	Schofield	345
	Tripler	346
	Waianae	347
15th Air Base Wing/CC, Hickam	Hickam	350
	Wheeler	352
Housing, Finance & Dev. Corp.	Waiahole	368
DW Kauai	Anahola	401
	Anini	402
	Hanalei	403
	Hanapepe-Eleele	404
	Kekaha	406
	Kilauea	407
	Koloa-Poipu	408
	Lawai-Omao	409
	Lihue	410
	Puhi	412
	Wailua-Kapaa	413
	Waimea	414
	Haena-Wainiha	415
	Kalaheo Deep Well	434
Gay and Robinson	Pakala-Kaawanui	417
Kekaha Sugar Co., Ltd.	Kekaha	418
Hawaii Air National Guard	Kokee Air Guard	420
Seventh Day Adventist	Kahili Mountain Park	422
Lihue Plantation Co.	Kealia	423
U.S. Department of the Navy	Kaneohe Marine Corps Air Stn.	356
	PMRF Housing	430
McBryde Sugar Co.	Wahiawa	424
Olokele Sugar Co., Ltd.	Olokele	427
Princeville Utilities Co.	Princeville	428
Alexander and Baldwin	Port Allen	433

APPENDIX C

(Not Used)

APPENDIX D

PUBLIC NOTIFICATION

United States Environmental Protection Agency | Office of Water (4606) | EPA 816-F-00-023 May 2000

EPA

The Public Notification Rule
A Quick Reference Guide

Highlights

- Revises timing and distribution requirements — notice must be provided within 24 hours (Tier 1, instead of 72 hours), 30 days (Tier 2, instead of 14 days), or one year (Tier 3, instead of 90 days), based on the potential severity of the situation
- Expands list of violations and situations requiring immediate notification and broadens applicability of the public notice to other situations
- Simplifies mandatory health effects language and adds standard language for monitoring violations and for encouraging notice distribution
- Consolidates public notification requirements previously found in other parts of drinking water regulations
- Increases primacy agency flexibility
- Amends Consumer Confidence Report (CCR) regulations to conform to changes made in public notification regulations

Title

Revisions to the Public Notification Regulations for Public Water Systems (40 CFR Part 141, subpart Q), published May 4, 2000 (65 *FR* 25981)

Purpose

To notify the public any time a water system violates national primary drinking water regulations or has other situations posing a risk to public health

Effective Date

Rule is effective **June 5, 2000**
PWSs in jurisdictions directly implemented by EPA must meet these revised requirements **October 31, 2000**
PWSs in primacy states must meet these revised requirements **May 6, 2002** or when the state adopts the revised regulations, whichever is sooner

Applicability

All PWSs violating national primary drinking water regulations, operating under a variance or exemption, or having other situations posing a risk to public health

Timing and Distribution

Notices must be sent within 24 hours, 30 days, or one year depending on the tier to which the violation is assigned (see page 2). The clock for notification starts when the PWS learns of the violation. Notices must be provided to persons served (not just billing customers).

Multilingual Requirements

Where the PWS serves a large proportion of non-English speakers, the PWS must provide information in the appropriate language(s) on the importance of the notice or on how to get assistance or a translated copy

Printed on Recycled Paper

Tier 1 (Immediate Notice, Within 24 Hours)

Notice as soon as practical or within 24 hours via radio, TV, hand delivery, posting, or other method specified by primacy agency, along with other methods if needed to reach persons served. PWSs must also initiate consultation with primacy agency within 24 hours. Primacy agency may establish additional requirements during consultation.

- Fecal coliform violations; failure to test for fecal coliform after initial total coliform sample tests positive
- Nitrate, nitrite, or total nitrate and nitrite MCL violation; failure to take confirmation sample
- Chlorine dioxide MRDL violation in distribution system; failure to take samples in distribution system when required
- Exceedance of maximum allowable turbidity level, if elevated to Tier 1 by primacy agency
- Special notice for non-community water systems (NCWSs) with nitrate exceedances between 10 mg/L and 20 mg/L, where system is allowed to exceed 10 mg/L by primacy agency
- Waterborne disease outbreak or other waterborne emergency
- Other violations or situations determined by the primacy agency

Tier 2 (Notice as Soon as Possible, Within 30 Days)

Notice as soon as practical or within 30 days. Repeat notice every three months until violation is resolved. CWSs: Notice via mail or direct delivery. NCWSs: Notice via posting, direct delivery, or mail. Primacy agencies may permit alternate methods. All PWSs must use additional delivery methods reasonably calculated to reach other consumers not notified by the first method.

- All MCL, MRDL, and treatment technique violations, except where Tier 1 notice is required
- Monitoring violations, if elevated to Tier 2 by primacy agency
- Failure to comply with variance and exemption conditions

* **Turbidity consultation:** Where PWSs have a treatment technique violation resulting from a single exceedance of the maximum allowable turbidity limit or an MCL violation resulting from an exceedance of the two-day turbidity limit, they must consult their primacy agency within 24 hours. Primacy agencies will then determine whether a Tier 1 notice is necessary. If consultation does not occur within 24 hours, violations are automatically elevated to Tier 1.

Tier 3 (Annual Notice)

Notice within 12 months; repeated annually for unresolved violations. Notices for individual violations can be combined into an annual notice (including the CCR, if public notification requirements can still be met). CWSs: Notice via mail or direct delivery. NCWSs: Notice via posting, direct delivery, or mail. Primacy agencies may permit alternate methods. All PWSs must use additional delivery methods reasonably calculated to reach other consumers not notified by the first method.

- Monitoring or testing procedure violations, unless primacy agency elevates to Tier 2
- Operation under a variance and exemption
- Special public notices (fluoride secondary maximum contaminant level (SMCL) exceedance, availability of unregulated contaminant monitoring results)

Requirements for Ongoing Violations

All new billing units and customers must be notified of ongoing violations or situations requiring notice

Relationship to the CCR

Where appropriate, the public notification and CCR requirements are consistent:
- Health effects language for MCL, MRDL, and treatment technique violations are the same
- Multilingual and certification requirements are similar
- CCR may be used for Tier 3 notification, provided public notification timing, content, and delivery requirements are met

Reporting and Record Keeping

- PWSs have ten days to send a certification of compliance and a copy of the completed notice to the primacy agency
- PWS and primacy agency must keep notices on file for three years
- Primacy agencies must report public notification violations to EPA on a quarterly basis

Primacy Requirements

- Primacy agencies must submit complete and final requests for approval of program revisions in order to maintain primacy for public notification
- Primacy agencies have up to 2 years to adopt the new regulations
- Primacy agencies must establish enforceable requirements and procedures if they choose to use any of the flexibilities allowed them in the public notification regulation (e.g., if they allow a PWS to use a different notification method or if they elevate a Tier 2 violation to Tier 1)

Materials Available to Support This Rule

EPA/ASDWA *Public Notification Handbook* provides sample notice templates for water systems and other aids for water systems preparing notices

Primacy Guidance for the Public Notification Rule provides guidance and formats for states preparing primacy program revisions to adopt public notification rule

For More Information

Safe Drinking Water Hotline
1-800-426-4791

Office of Ground Water and Drinking Water Web Site
http://www.epa.gov/safewater/pn.html

Contents of Notice
(see sample notice on last page)

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

1) A description of the violation or situation, including contaminant levels, if applicable
2) When the violation or situation occurred
3) Any potential adverse health effects (using standard health effects language from Appendix B of the public notification rule or the standard monitoring language, see below)
4) The population at risk
5) Whether alternative water supplies should be used
6) What actions consumers should take
7) What the system is doing to correct the violation or situation
8) When the water system expects to return to compliance or resolve the situation
9) The name, business address, and phone number of the water system owner or operator
10) A statement (see below) encouraging distribution of the notice to others, where applicable

** These elements do not apply to notices for fluoride SMCL exceedances, availability of unregulated contaminant monitoring data, and operation under a variance or exemption. Content requirements for these notices are specified in the rule.*

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

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

Sample Public Notice

DRINKING WATER WARNING

Springfield water has high levels of nitrate

4 - The population at risk

DO NOT GIVE THE WATER TO INFANTS UNDER SIX MONTHS OLD OR USE IT TO MAKE INFANT FORMULA

AVISO
NO USE EL AGUA PARA PREPARAR ALIMENTOS PARA BEBES

Este informe contiene información muy importante sobre su agua potable. Hable con alguien que lo entienda bien o llame al teléfono 555-1200 para hablar en español sobre este aviso.

Information for Spanish speakers

2 - When the violation or situation occurred

1 - A description of the violation or situation

Water sample results received June 22, 1999 showed nitrate levels of 12 milligrams per liter (mg/l). This is above the nitrate standard, or maximum contaminant level (MCL), of 10 mg/l. Nitrate in drinking water is a serious health concern for infants less than six months old.

3 - Potential health effects

What should I do?
DO NOT GIVE THE WATER TO INFANTS. *Infants below the age of six months who drink water containing nitrate in excess of the MCL could become seriously ill and, if untreated, may die. Symptoms include shortness of breath and blue baby syndrome.* Blue baby syndrome is indicated by blueness of the skin. Symptoms in infants can develop rapidly, with health deteriorating over a period of days. If symptoms occur, seek medical attention immediately.

5 - Whether alternate water supplies should be used

6 - Actions consumers should take

Water, juice, and formula for children <u>under six months of age</u> should not be prepared with tap water. Bottled water or other water low in nitrates should be used for infants until further notice. Springfield Water Company and the Springfield Health Department are providing free bottled water to families with infants. Water is available between 9 a.m. and 5 p.m. Monday through Friday at the Health Department office at the Town Hall. Water will be provided until the nitrate problem is resolved.

Do not boil the water. Boiling, freezing, filtering, or letting water stand does not reduce the nitrate level. Excessive boiling can make the nitrates more concentrated, because nitrates remain behind when the water evaporates.

Adults and children older than six months can drink the tap water (nitrate is a concern for infants because they can't process nitrates in the same way adults can). However, if you are pregnant or have specific health concerns, you may wish to consult your doctor.

What happened? What is being done?
Nitrate in drinking water can come from natural, industrial, or agricultural sources (including septic systems and run-off). Levels of nitrate in drinking water can vary throughout the year. We'll let you know when the amount of nitrate is again below the limit.

7 - What is being done to correct the violation or situation

8 - When the system expects to return to compliance

We are investigating water treatment and other options. These may include drilling a new well or mixing the water with low-nitrate water from another source. We anticipate resolving the problem by July 15.

9 - Name, phone number, and business address for more information

For more information, please contact John Smith of the Springfield Water Company at (602) 555-1212. This notice was prepared and distributed by the Springfield Water Company, 500 Main Street, Springfield.

10 - Standard distribution language

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

APPENDIX E

REDUNDANT DISINFECTION CAPABILITIES

REDUNDANT DISINFECTION CAPABILITY

I. INTRODUCTION

Redundance of the disinfection system(s) is to ensure that the overall treatment requirement of 2-log Cryptosporidium, 3-log Giardia and 4-log virus removal and inactivation is achieved, and a continuous disinfectant residual is maintained entering the distribution system. Redundancy of components is therefore necessary to allow for disinfection during routine repairs, maintenance and inspection and possible failures of the primary disinfection system.

In reviewing water disinfection facilities for compliance with redundancy requirements, the following items should be checked:

II. GENERAL

A. Are the capacities of all components of both the primary system and the backup system equal to or greater than the required capacities?

Some systems may have two or more units that provide the required dosage rates when all units are operating. In these cases, an additional unit is needed as backup, during the down time of any of the operating units. The backup must have a capacity equal to or greater than that of the largest on-line unit.

B. Are adequate safety precautions being followed, relative to the type of disinfectant being used?

C. Are redundant components being exercised or alternated with the primary components?

D. Are all components being properly maintained?

E. Are critical spare parts on hand to repair disinfection equipment?

F. Are spare parts available for components that are indispensable for disinfecting the water?

III. DISINFECTANT STORAGE

A minimum of two storage units capable of being used alternately should be provided. The total combined capacity of the storage units should provide as a minimum the system design capacity.

A. Chlorine

Storage for gaseous chlorine will normally be in 150-lb cylinders, 2,000-lb containers, or larger on-site storage vessels.

1. Is there automatic switchover equipment if one cylinder or container empties or becomes inoperable?

2. Is the switching equipment in good working order, (manually tested on a regularly scheduled basis), and are spare parts on hand?

3. Are the scales adequate for at least two cylinders or containers.

B. Hypochlorite

Storage of calcium hypochlorite or sodium hypochlorite is normally provided in drums or other suitable containers. Redundancy requirements are not applicable to these by themselves, as long as the required minimum storage quantity is on hand at all times.

C. Ammonia

Anhydrous ammonia is usually stored in cylinders as a pressurized liquid. Aqua ammonia is usually stored as a solution of ammonia and water in a horizontal pressure vessel.

1. Is the available storage volume divided into two or more usable units?

2. Is automatic switching equipment in operation to change over from one unit to another when one is empty or inoperable?

3. Are there spare parts for the switching equipment?

IV. GENERATION

Ozone and chlorine dioxide are not stored on-site. Rather, because of their reactivity, they are generated and used immediately.

To satisfy the redundancy requirements for these disinfectants it is recommended that two generating units, or two sets of units, capable of supplying the required feed rate be provided. In systems where there is more than one generation system, a standby unit should be available for times the on-line units need repair. The backup unit should have a capacity equal to or greater than the unit(s) it may replace.

A. Chlorine Dioxide

Chlorine, sodium chlorite, or sodium hypochlorite should be stored in accordance with storage guidelines previously described.

B. Ozone

Are all generation components present and in working order for both the primary and the redundant units (whether using air or oxygen)?

C. Common

Is switchover and automatic start-up equipment installed and operable to change from the primary generating unit(s) to the redundant unit(s)?

V. FEED SYSTEMS

Redundancy in feed systems requires two separate units, or systems, each capable of supplying the required dosage of disinfectant. If more than one unit is needed to apply the required feed rate, a spare unit should be available to replace any of the operating units during times of malfunction. The replacement unit should, therefore, have a capacity equal to or greater than that of the largest unit which it may replace. This requirement applies to all disinfection methods, and is best implemented by housing the on-line and redundant components in separate rooms, enclosures, or areas, as appropriate.
In reviewing these systems for redundancy, the following components should be checked:

A. Chlorine

1. Evaporators
2. Chlorinators
3. Injectors

B. Hypochlorite

1. Mixing tanks and mixers
2. Chemical feed pumps and controls
3. Injectors

C. Ozone

1. Dissolution equipment, including compressor and delivery piping systems.

D. Chlorine Dioxide

1. Chlorine feed equipment
2. Sodium chlorite mixing and metering equipment
3. Dry tank and mixer
4. Metering pumps
5. If a package C102 unit is used, two must be provided

E. Chloramination

1. Chlorine feed equipment
2. Ammonia feed equipment, including applicable equipment for either:

   a. Anhydrous ammonia (gas)
   b. Aqua ammonia (solution)

VI. Residual Monitoring

The best method of monitoring a disinfection facility for continuous operation is by continuous recording equipment. To improve reliability, it is suggested that duplicate continuous monitors are present for backup in the event of monitor failure. However, if there is a failure in the monitoring system for indicating that a continuous residual is being maintained, the SWTR allows systems to take grab samples every four hours for up to five days during monitor repair. For systems without 24-hour staffing it will not be practical to take grab samples and redundant monitoring equipment is recommended. Failure of continuous monitoring would be a violation of a monitoring requirement, not a treatment requirement.

A. Chlorine

1. Does the facility have a continuous monitor for chlorine residual at the disinfection system site with an alarm or indicator to show when the monitor is not functioning? For added assurance, the provision of a backup monitoring unit is also recommended.

2. Is there instrumentation in place to automatically switch from one monitor to the other if the first one fails?

B. Hypochlorite

Same as for chlorine system.

C. Ozone

1. Does the facility have a continuous ozone monitor with automatic switchover capability and alarms?

2. Does the facility have a continuous ozone residual monitor with automatic switchover capability and alarms?

D. Chlorine Dioxide

1. Does the facility have a continuous chlorine dioxide monitor with automatic switchover capability and alarms?

2. Does the facility have a continuous chlorine dioxide residual monitor with automatic switchover capability and alarms?

E. Chloramination

1. Does the facility have a continuous ammonia monitor with automatic switchover capability and alarm?

2. Does the facility also have a continuous chlorine residual monitor on-site with automatic switchover capability and alarms?

VII. Power Supply

A permanently installed standby generator, capable of running all electrical equipment at the disinfection station, and equipped for automatic start-up on power failure, should be on-site and functional.

Alternatives to a standby generator, such as a feed line from a different power source, are acceptable if they can be shown to have equal reliability.

VIII. Alarms

Indicators and alarms, both local and remote, should be capable of promptly alerting operating and supervisory personnel of problem conditions.

A. Local

Lights, buzzers, and horns should be installed and functioning to alert on-site personnel to problem conditions.

B. Remote

Alarm signals should be relayed to a central control panel which is manned 24 hours per day and whose operators can notify response personnel immediately.

C. Problem Conditions

A minimum list of problem conditions which should have indicators and alarms, both locally and at a 24-hour per day switchboard, are as follows:

1. Disinfectant leak
2. Feeder pump failure
3. Power outage
4. Generator or alternate power source on
5. Disinfectant residual less than setpoint value

IX. Facility Layout

Maximum reliability is ensured when redundant units are separated from primary units. The type of separation should be appropriate to the type of potential malfunction. For example, any area within a building subject to a chlorine leak should have primary components separated from redundant components by an airtight enclosure, i.e., separate rooms of varying sizes.

X. Separate Facility

Under certain conditions, such as location of a disinfection facility in an area of high earthquake potential, the most reliable means of providing redundant facilities may be to house them in a completely separate structures at a different site.

APPENDIX F

DETERMINATION OF T_{10} BY

CONDUCTING TRACER STUDIES

DETERMINATION OF T10 BY CONDUCTING TRACER STUDIES

T10 = Detention time at which 90 percent of the water passing through the unit is retained within the basin. Detention time is then synonymous with contact time.

1. For pipelines, <u>all</u> fluids passing through the unit is assumed to have a detention time equal to the theoretical detention or mean residence time at a particular flow rate or, contact time equals volume divided by peak hourly flow rate.

2. However, because of short circuiting in containers other than pipelines, actual and theoretical detention times are not the same. Therefore, tracer studies are required to determine detention time for mixing basins, storage tanks, reservoirs, and other treatment plant process units.

Detention time is proportional to flow but is not a linear function. Therefore, tracer tests should be performed for at least four flow rates for a section.

Flow rates should be separated by approximately equal intervals with one near average flow, two greater than average (the highest test flow rate must be at least 91 percent of the highest flow rate for that section), and one less than average.

If only one tracer study is performed per section, the test must be performed at a flow rate not less than 91 percent of the highest flow rate expected at that section. That single detection time may be used to calculate a conservative estimate for detention times for that section for all flow rates less than or equal to the tracer test flow rate. T10 is <u>inversely</u> proportional to flow rate, therefore, the T10 at a flow rate other than that which the tracer study was conducted (T10S) can be determined by multiplying the T10 from the tracer study (T10T) by the ratio of the tracer study flow rate to the desired flow rate, for example:

$$T10S = T10T \times \frac{QT}{QD} \text{ where}$$

T10S = T10 at system flow rate

T10T = T10 at tracer flow rate

QT = tracer study flow rate

QD = system flow rate

If tracer tests cannot be obtained when there is constant flow through the section during the course of the test (most accurate results), then T10 should be recorded at the average flow rate over that same period of time.

Tracer studies should be conducted at water levels at or slightly below, but not above, the normal minimum operating level. If the water level during a test is higher than the normal operating level, an erroneously high detention time will be obtained.

Conversely, extremely low water levels during testing may lead to an overly conservative or low detention time.

If the water level in a section is expected to vary between high and low levels in response to system demand (for example, clearwell and storage tanks), the tracer study should be conducted during a period when the water level in the section is falling (flow out greater than flow in).

In order to minimize the time needed to conduct studies on each section, the tracer studies should be initiated at the section nearest the first consumer and end at the section nearest to the raw water inlet to the plant. This procedure should prevent the interference of residual tracer material with subsequent studies.

Chloride and fluoride are the most common tracer chemicals used in the step-dose method. However, the high density of concentrated salt solutions and their potential for inducing density currents, usually precludes chloride and fluoride as the selected chemical for slug-dose tracer tests.

Rhodamine WT can be used as a fluorescent tracer in water flow studies. However, because of its toxicity, there are restrictions in its use (EPA Page C-9.

Allowances must be made for the fact that fluoride is absorbed on floc and settles out of the water when used as a tracer in clarifiers.

Fluoride should be used as a tracer only when fluoridation feed equipment is already in place.

For the step-dose method, tracer addition and sampling should usually be continued for a period of two to three times the theoretical detention time for that section with the following dosages:

1. Chloride - 20 mg/L where background chloride level is less than 10 mg/L.

2. Fluoride - as low as 1.0 to 1.5 mg/L where the raw water fluoride level is not significant.

For the slug-dose method, samples should be collected for at least twice the section's theoretical detention time, or until tracer concentrations are detected near background levels.

1. Tracer addition should be instantaneous (dosing time should not exceed 2 percent of the section's theoretical detention time), and provide uniformly mixed distribution of the chemical (for example, applying the chemical by gravity flow through a funnel and hose apparatus).

2. Should chloride or fluoride be used as the tracer in the slug-dose method, their dosages are comparable to the constant dose applied in the step-dose tracer tests.

3. The tracer used is diluted as required to apply an instantaneous dose and minimize density effects.

A process unit consisting of one compartment is considered as one section. If the process unit is designed with two or more separate compartments, each compartment is considered as a section, but tracer studies need be conducted for only one section if they are all identical. The T10 for the process unit is then the T10 for one section multiplied by the number of sections. An example for sectioning is the fact that, regardless of the extent of agitation, baffled flocculation basins with two or more compartments may be considered to possess average baffling conditions (T10/T = 0.5). Also, unbaffled, single-compartment flocculation basins are characteristic of poor baffling conditions (T10/T = 0.3)) Page C-29).

A minimum of four tracer studies per section has been already noted. A curve can be obtained by plotting detention time versus its accompanying flow (see attached Figure F-1). The curve can then be used to calculate CT for any day. Knowing the peak hourly flow for a particular day, the curve can then be used to obtain the detention or contact time. This value times the disinfectant residual will give you the CT for that section.

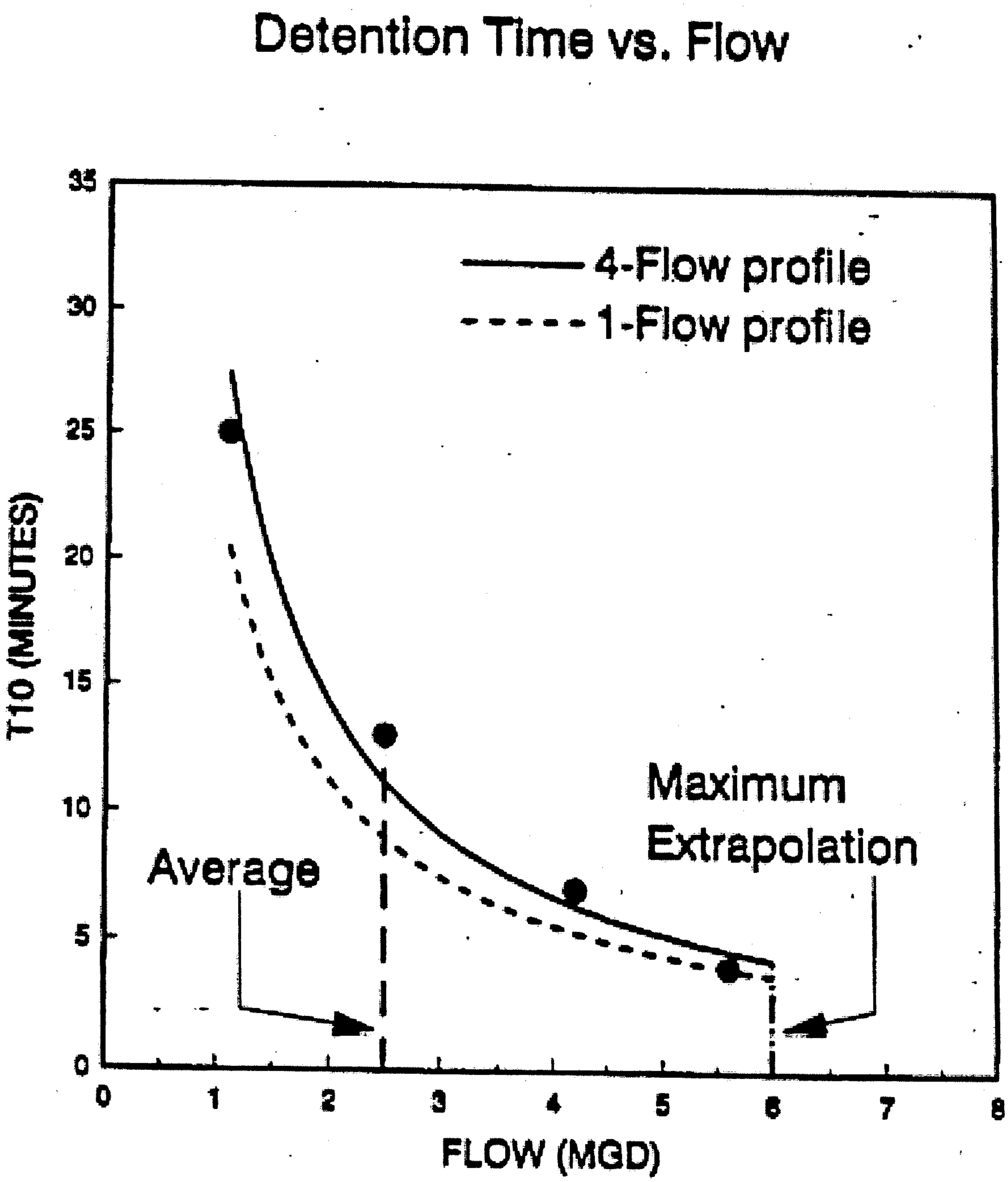


FIGURE F-1
DETENTION TIME vs FLOW

APPENDIX G

DETERMINATION OF T_{10} WITHOUT

CONDUCTING TRACER STUDIES

DETERMINATION OF T10 WITHOUT CONDUCTING A TRACER STUDY

T10	=	Detention time at which 90 percent of the water passing through the unit is retained within the basin.
T	=	Actual contact time.
Theoretical Detention Time	=	Volume of mixing basin, storage tanks and reservoirs divided by the Q or peak hourly flow rate.
CT	=	Inactivation efficiency.
T10/T	=	"Rule of thumb" fraction.

When conducting tracer studies may be impractical or prohibitively expensive, the director may allow the use of the "rule of thumb" fraction multiplied by the theoretical detention time to obtain an approximation for T10. T10/T or the "rule of thumb" fraction was developed following multiple tracer studies on chlorine contact chambers and flocculators/settling basins with various forms of baffles and without any baffles at all. The studies concluded that the effectiveness of baffling in achieving a high T10/T fraction is more related to the geometry and baffling of the basin than the fraction of the basin (see attached Table G-1 and Figures G-1 to G-6).

The significant design characteristics include: length-to-width ratio, the degree of baffling within the basins, and the effect of inlet baffling and outlet weir configuration. These physical characteristics of the contact basins affect their hydraulic efficiencies in terms of dead space, plug flow, and mixed flow proportions. The dead space zone of a basin is referred to as basin volume, through which no flow occurs. The remaining volume where flow occurs is comprised of plug flow and mixed flow zones. The plug flow zone is the portion of the remaining volume in which no mixing occurs in the direction of flow. The mixed flow zone is characterized by complete mixing in the flow direction and is the complement to the plug flow zone.

As indicated in Table G-1, poor baffling conditions consist of an unbaffled inlet and outlet with no intra-basin baffling. Average baffling conditions consist of intra-basin baffling and either a baffled inlet or outlet. Superior baffling conditions consist of at least a baffled inlet and outlet, and possibly some intra-basin baffling to redistribute the flow throughout the basin's cross-section.

The three basic types of basin inlet baffling configuration are: a target-baffled pipe inlet, an overflow weir entrance, and a baffled submerged orifice or port inlet. Typical intra-basin baffling structures include:

- diffuser (perforated) walls;
- launders;
- cross, longitudinal, or maze baffling to cause horizontal or vertical serpentine flow; and
- longitudinal divider walls, which prevent mixing by increasing the length-to-width ratio of the basin(s).

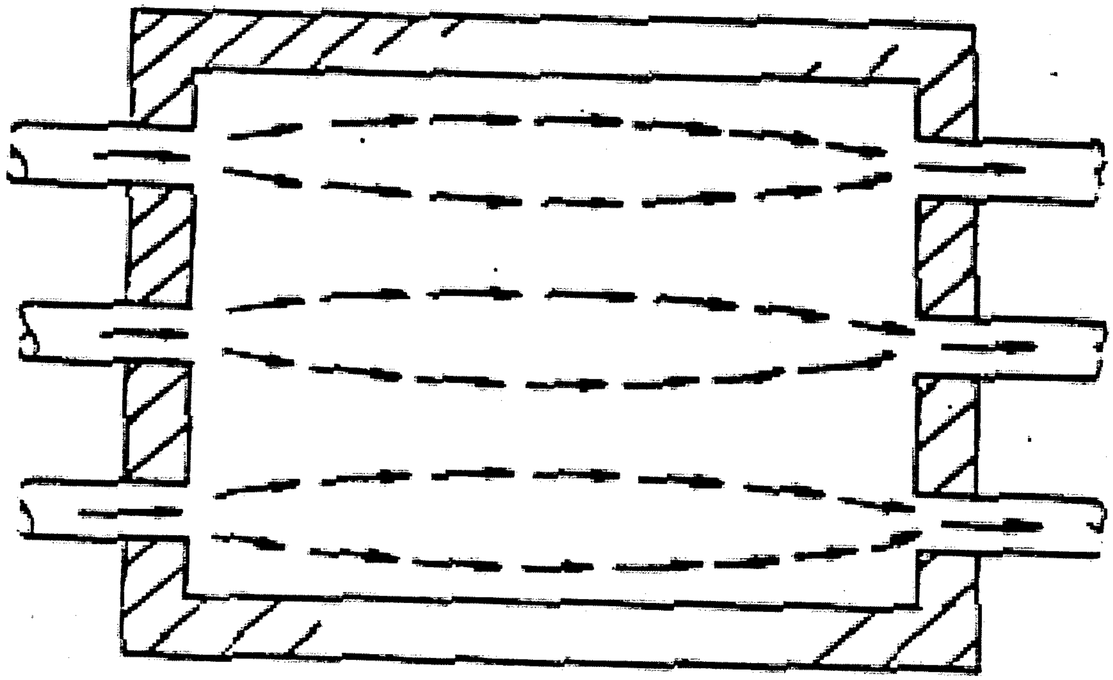
Commonly used baffled outlet structures include:

- free-discharging weirs, such as sharp-crested and v-notch, and submerged ports or weirs. Weirs that do not span the width of the contact basin, such as Cipolleti weirs, should not be considered baffling as their use may substantially increase weir overflow rates and the dead space zone of the basin.

TABLE G-1

BAFFLING CLASSIFICATIONS

Baffling Condition	T10/T	Baffling Description
Unbaffled (mixed flow)	0.1	None, agitated basin, very low length to width ratio, high inlet and outlet flow velocities
		Enclosed circular or rectangular tank with single inlet and outlet line
		Enclosed circular or rectangular tank with inlet on top and outlet on the bottom, either directly below or on the same side as the inlet line
Poor	0.3	Single or multiple unbaffled inlets and outlets, no intra-basin baffles
		Enclosed circular or rectangular tank with inlet on top and outlet on the bottom on the opposite wall
Average	0.5	Baffled inlet or outlet with some intra-basin baffles
Superior	0.7	Perforated inlet baffle, serpentine or perforated intra-basin baffles, outlet weir or perforated launders
Perfect (plug flow)	1.0	Very high length to width ratio (pipeline flow) perforated inlet, outlet, and intra-basin baffles



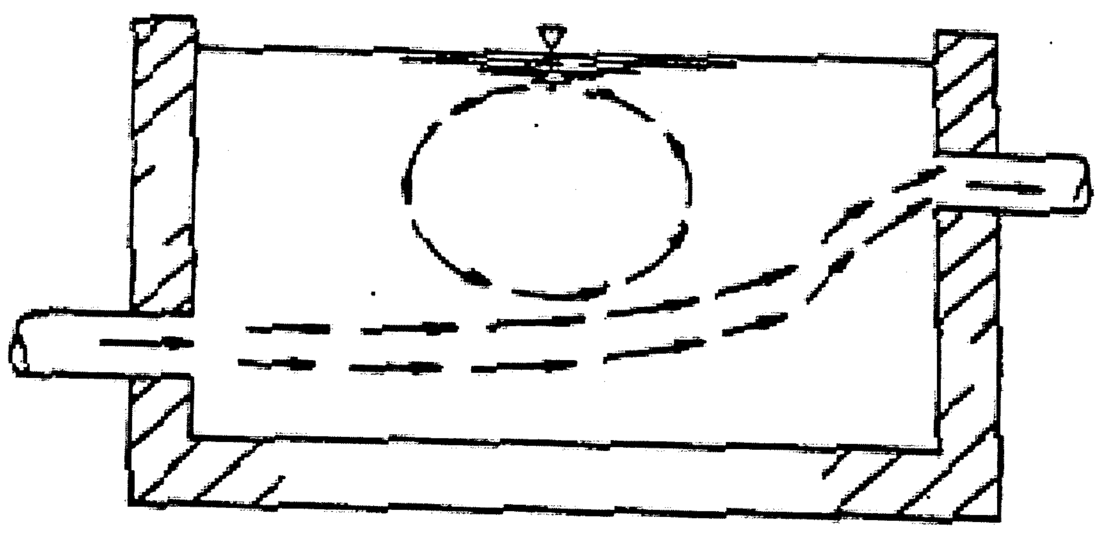
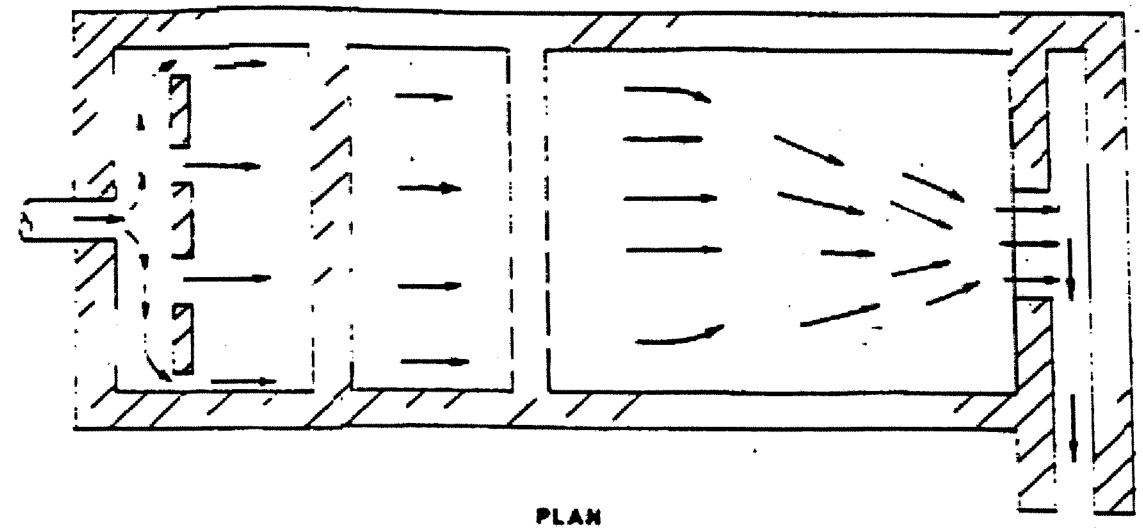
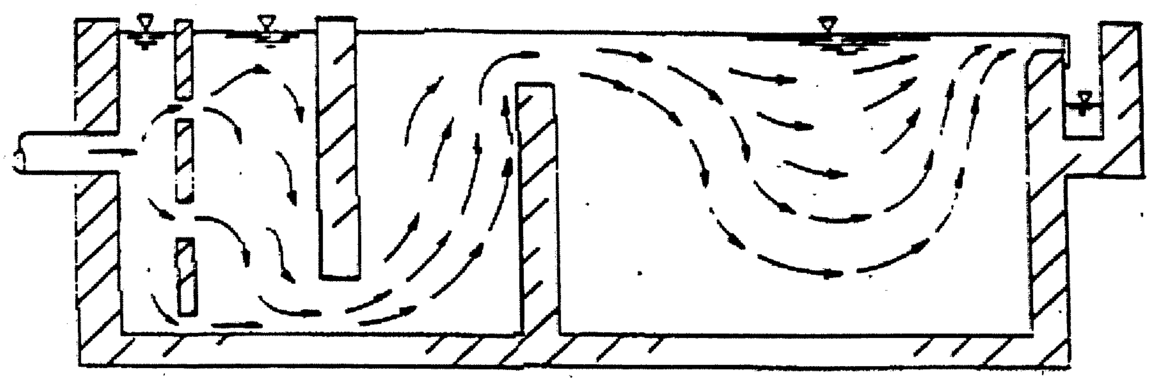


FIGURE G-1
POOR BAFFLING CONDITIONS
(RECTANGULAR CONTACT BASIN)



PLAN



SECTION

FIGURE G-2
AVERAGE BAFFLING CONDITIONS
(RECTANGULAR CONTACT BASIN)

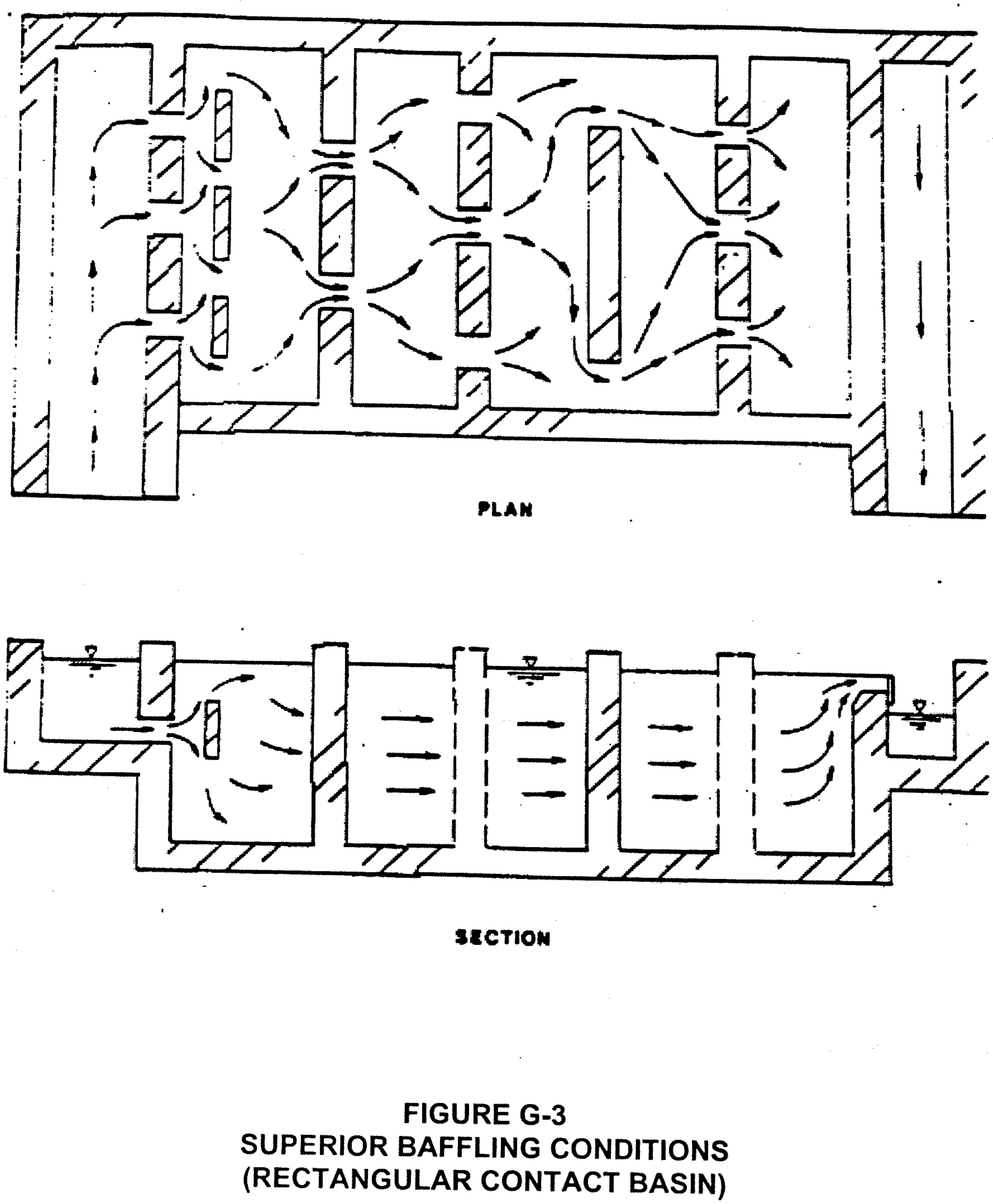
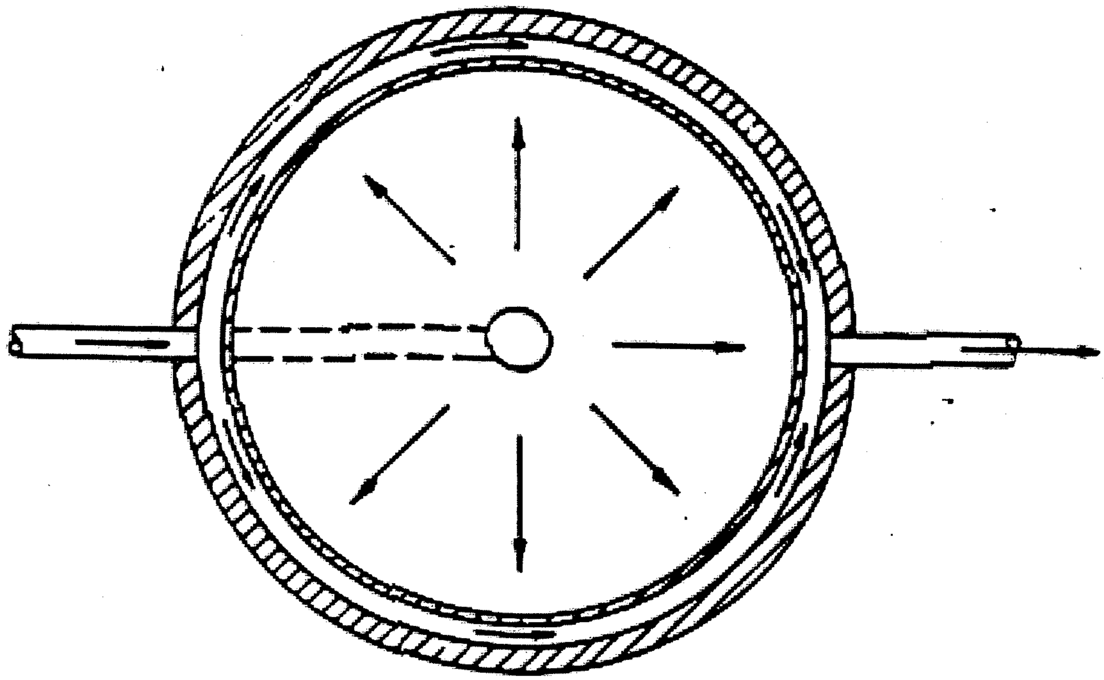
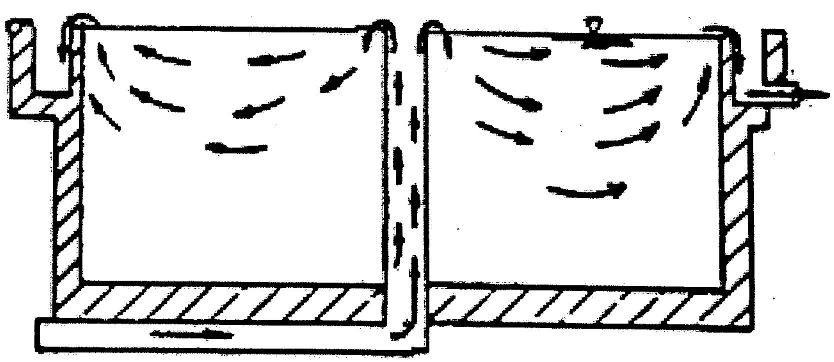


FIGURE G-3
SUPERIOR BAFFLING CONDITIONS
(RECTANGULAR CONTACT BASIN)

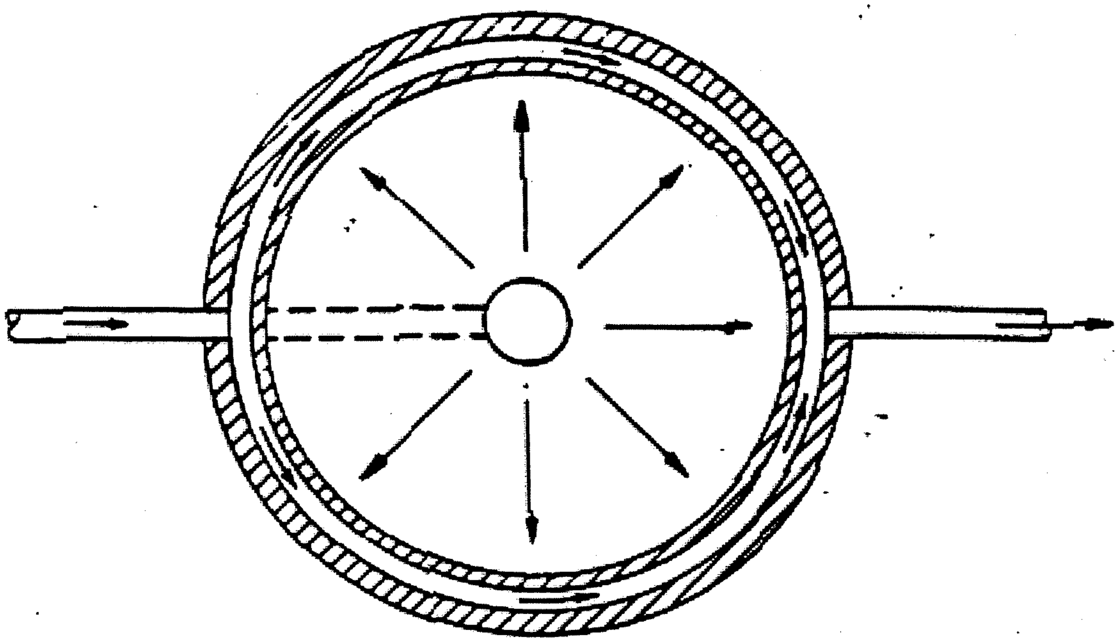


PLAN



SECTION

FIGURE G-4
POOR BAFFLING CONDITIONS
(CIRCULAR CONTACT BASIN)



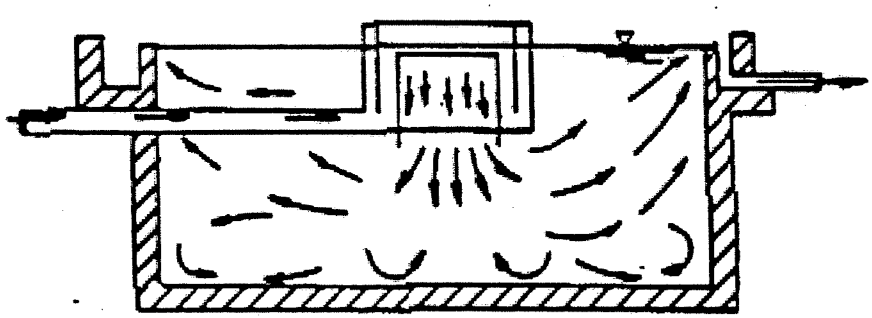
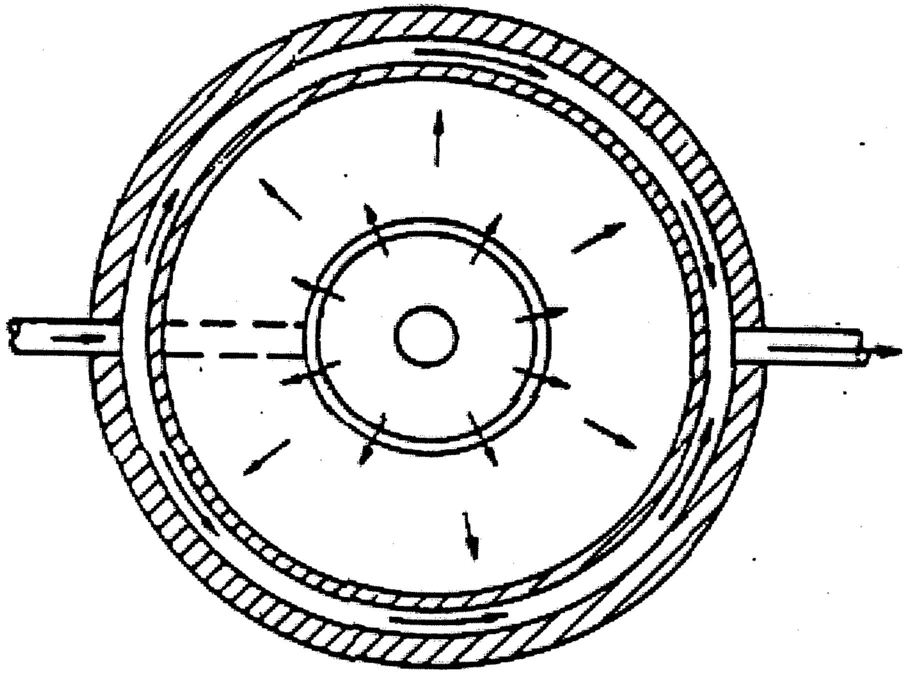
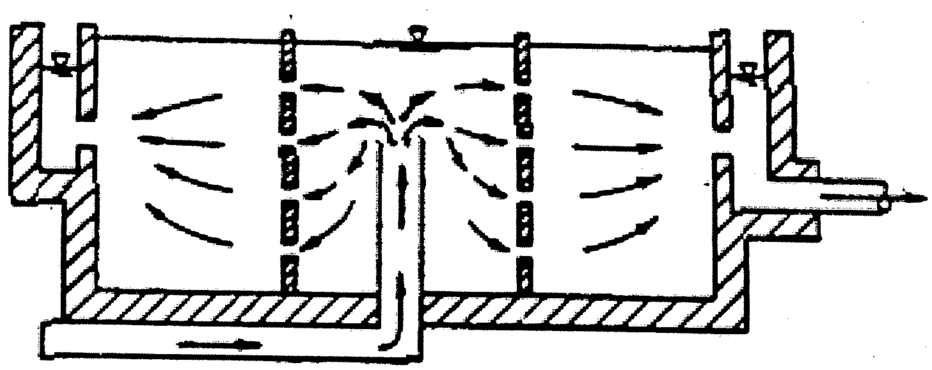


FIGURE G-5
AVERAGE BAFFLING CONDITIONS
(CIRCULAR CONTACT BASIN)



PLAN



SECTION

FIGURE G-6
SUPERIOR BAFFLING CONDITIONS
(CIRCULAR CONTACT BASIN)