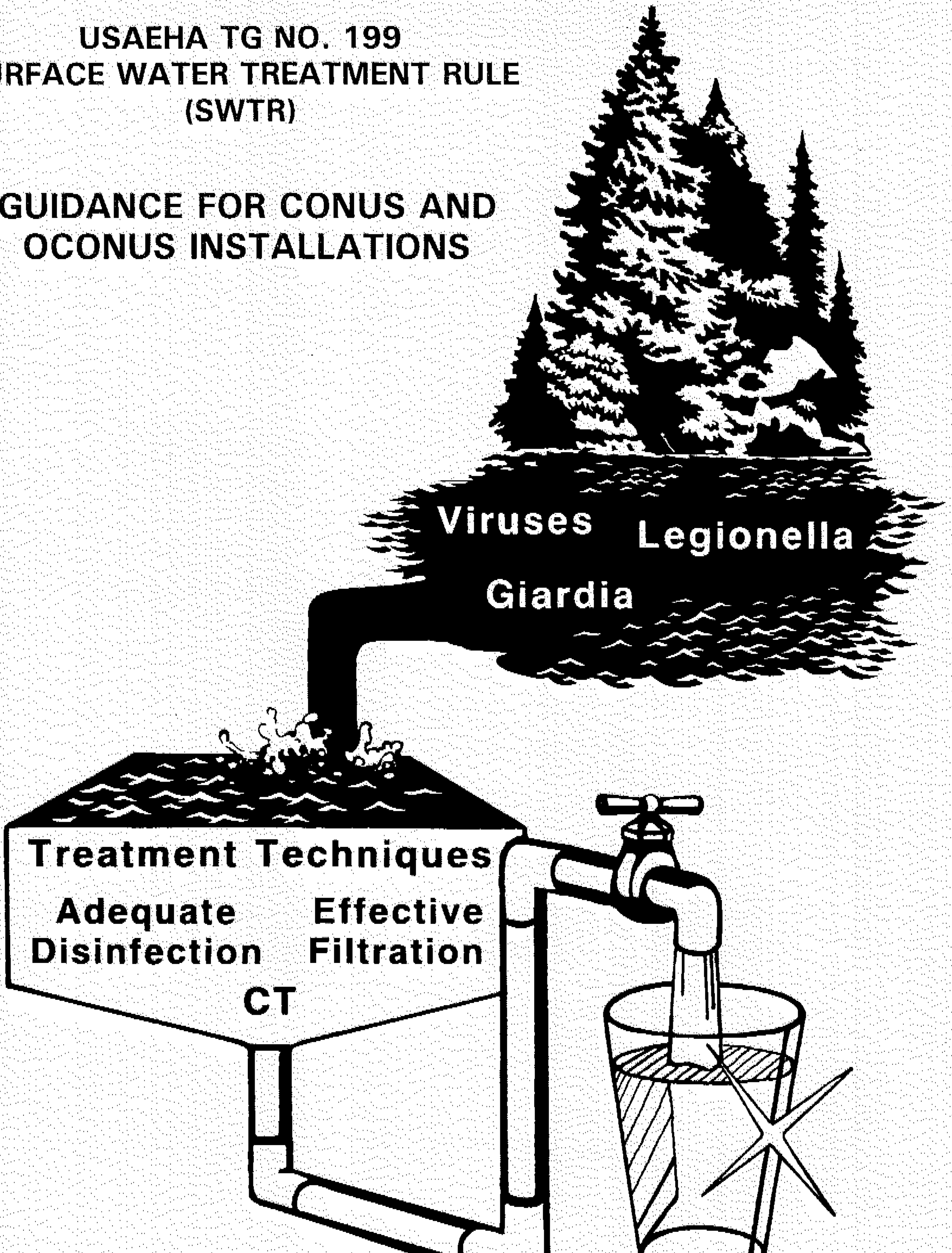
USAEHA

USAEHA TG NO. 199
SURFACE WATER TREATMENT RULE (SWTR)

GUIDANCE FOR CONUS AND OCONUS INSTALLATIONS



U.S. Army Environmental Hygiene Agency
Aberdeen Proving Ground, Maryland 21010-5422

Since 1942, USAEHA has provided worldwide preventive medicine support to the Army, Department of Defense and other Federal agencies. The USAEHA accomplishes this mission by providing information and consultative services to leaders and decision makers charged with the responsibility for the occupational and environmental health of military and civilian service members and associated communities worldwide. The USAEHA is unique nationally in its ability to matrix and tailor its staff, representing a wide array of scientific disciplines, for immediate response to occupational and environmental health crises and issues.

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CHAPTER 1 - INTRODUCTION.

1-1. PURPOSE. This Technical Guide (TG):

A. Contains a broad overview of the Surface Water Treatment Rule (SWTR) and describes some of the criteria which determine if an installation must achieve compliance with the SWTR.

B. Provides installation water purveyors CONUS and OCONUS, with more detailed information about the SWTR requirements, the unique characteristics regarding the rule, and steps for attaining compliance.

C. Applies to all Active Army, the Army National Guard, the U.S. Army Reserve, and activities under the control of the Department of the Army by ownership, lease, or similar instrument, that provide treatment of surface water or ground water under the influence of surface water for human consumption.

1-2. GENERAL.

A. Technical Assistance. Address technical questions, comments, or suggestions regarding this document to Commander, USAEHA, ATTN: HSHB-ME-W, APG, MD, DSN 584-3919 or commercial (410) 671-3919.

B. Glossary. See appendix B for a list of abbreviations and definitions.

1-3. RESPONSIBILITIES.

A. Installation Commander. The installation commander provides an adequate amount of potable water that complies with all Federal, State, and local regulations concerning safe drinking water. Compliance with the Safe Drinking Water Act Amendments of 1986 (reference 11) (SDWA), including the SWTR, also applies to OCONUS installations classified as suppliers of water, unless a deviation from the requirements is approved by the theater surgeon (references 1-3).

B. Installation Engineer. The Director of Public Works, Facilities Engineer, or Director of Engineering and Housing manages CONUS and OCONUS installation water supply systems to ensure compliance with all applicable Federal, State, local, and host nation regulations, whichever is most stringent, concerning the SWTR (references 1-3).

C. Installation Medical Authority. The installation medical authority coordinates with the installation engineer the surveillance monitoring requirements of potable water as required in the SWTR (references 1-3), and determines the health significance of potential drinking water contaminants.

1-4. HEALTH SIGNIFICANCE.

A. The SWTR was promulgated in June 1989 and is reflected in Title 40 Code of Federal Regulations, Part 141, Subpart H, Filtration and Disinfection (reference 12). The SWTR's principle purpose is to protect humans from acute health effects associated with several waterborne pathogens. There were approximately 500 reported outbreaks of waterborne diseases in the United States between 1971 and 1988. The reported cases were related to contaminated drinking water supplies which affected 110,000 people (reference 4). Beyond the reported waterborne disease outbreaks, health officials estimate there are hundreds more outbreaks which cause subclinical disease symptoms and go unreported (references 5 and 6).

B. Disease-causing organisms of concern in drinking water include viruses, bacteria, and protozoa, which cause gastrointestinal (GI) illness with symptoms of abdominal pain, diarrhea, and vomiting. The SWTR regulates *Giardia lamblia*, *Legionella*, viruses, heterotrophic plate count (HPC) bacteria, and turbidity.

C. *Giardia lamblia* is a protozoan which causes giardiasis, an illness having symptoms common to Acute Gastrointestinal Illness (AGI) and lasting for a few days or months. *Giardiasis* has emerged as a major waterborne disease over the last decade due to better diagnosis and reporting by physicians. Between 1971 and 1985, there were 92 reported outbreaks of *Giardiasis* affecting over 24,000 people (reference 7). It was the most frequently identified etiologic agent for the past 12 consecutive years. More recently, between 1989 and 1990, *Giardia lamblia* was implicated as the etiologic agent for seven of the twelve waterborne disease outbreaks for which an agent was identified (reference 8). *Giardia* generally exist as cysts that are approximately 10 micrometers (μm) long and 6 μm wide. Tests indicate that humans are readily infected with *Giardiasis* when exposed to greater than 10 cysts, although some humans can be infected by as few as 1 cyst (references 9 and 10). *Giardia* cysts are found primarily in surface water sources and *Giardiasis* outbreaks have generally been associated where disinfection of the drinking water from surface water sources is the only treatment provided. Groundwater sources, however, can have *Giardia* cysts present when under the direct influence of surface water (e.g., springs, infiltration galleries, and wells).

D. *Legionella pneumophila* is a bacterium found in surface waters and is known to cause Legionnaires Disease, a type of pneumonia. Other *Legionella* bacteria can cause symptoms similar to pneumonia and are of particular concern to persons with underlying illness. *Legionella* is commonly found in warm waters [approximately 49 degrees Celsius (°C) 120 degrees Fahrenheit (°F)] and the suspected route of entry for human exposure is through inhalation. As a result, aerosols from shower heads and faucets are considered likely sources for spreading the bacteria. Filtration is very effective at removing *Legionella* bacteria from surface water sources; however, small numbers of the bacteria can pass through even a well-operated water treatment plant (references 4 and 9).

E. Viruses are extremely small in diameter (10-25 nanometers) and also infect the GI tract. Viruses commonly transmitted in drinking water include: Hepatitis A (affecting the liver and possibly leading to jaundice); Rotaviruses (causing AGI primarily affecting children); and Adenoviruses, Enteroviruses, and Reoviruses (reference 9).

CHAPTER 2 - REQUIREMENTS AND COMPLIANCE TECHNIQUES.

2-1. WATER QUALITY STANDARDS.

A. The Maximum Contaminant Level Goal (MCLG) for *Giardia lamblia*, *Legionella*, and viruses is zero. The MCLG is a **non-enforceable health goal** developed by the U.S. Environmental Protection Agency (EPA) Administrator that defines the level of exposure at which "no known or anticipated adverse effects on the health of persons would occur and which allows an adequate margin of safety" (reference 11).

B. The Maximum Contaminant Level (MCL), however, is an **enforceable standard** that must be met by water suppliers [including water treatment systems at CONUS and OCONUS military installations (references 1-3 and 12). The EPA did not develop specific standards for the microbial contaminants identified in the SWTR but did establish the treatment techniques required for affected water treatment systems. The EPA believes that the treatment techniques identified in the SWTR will provide adequate removal of the microbial contaminants.

2-2. TREATMENT TECHNIQUES.

A. One of the principle differences between the SWTR and other drinking water regulations is the use of treatment techniques, rather than MCLs, to achieve compliance. The SWTR requires water treatment systems to achieve a minimum of 99.9 percent or a 3-log reduction of *Giardia* cysts and a minimum of 99.99 percent or a 4-log reduction of viruses (see Table 1). Removal and inactivation of these contaminants will

Table 1. Defining Log-Reduction

Percent reduction of a contaminant is often expressed as a log-reduction.

Percentage	Log-reduction
90	1-log
99	2-log
99.9	3-log
99.99	4-log
99.999	5-log

provide adequate removal/inactivation of *Legionella* and HPC bacteria. In general, treatment that achieves appropriate removal/inactivation of *Giardia* also achieves adequate removal/inactivation of viruses.

B. The two treatment processes commonly used to achieve compliance are filtration and disinfection. Filtration provides for removal of microbial contaminants and disinfection results in their inactivation. A combination of the two treatment processes is generally used to achieve the 3-log and 4-log removal/inactivation of *Giardia* and viruses, respectively.

2-3. REQUIRED OPERATOR CERTIFICATION.

A. Because treatment techniques are relied upon to achieve compliance with the SWTR, specific water treatment plant operator qualifications must be met. Most CONUS installations have certified operators at water treatment facilities, but many OCONUS installations may have inexperienced operators or operators with no formal training and/or certification in water treatment plant operations. Therefore, the Director of Engineering and Housing, Facilities Engineer, Director of Public Works, and the Installation Medical Authority should ensure that competent and qualified personnel operate water treatment facilities.

B. All CONUS installations should contact their states for available training programs, and OCONUS installations should contact the local host government for courses which provide operator certification in the host country. If the host country does not have certification or formal training programs, then the following organizations can be contacted for assistance in locating training or technical assistance:

(1) U.S. Army Pacific Environmental Health Engineering Agency (USAPACEHEA) for installations located in the Far East;

(2) U.S. Army Environmental Hygiene Agency (USAEHA) - Europe for installations located in Europe;

(3) USAEHA and its three Activities for CONUS and OCONUS installations.

(4) Additionally, the U.S. Army Environmental Center's 1991 Directory of Environmental Training Courses contains operator assistance training programs provided by the Sanitation Branch, Engineering Housing Support Center (ATTN: CEHSC-FU-S) [reference 13].

2-4. COMPLIANCE DATES. Table 2 contains the schedule for compliance with the SWTR. The SWTR affects surface water treatment systems that provide unfiltered water to consumers (SW-UF); surface water treatment systems that provide filtered water (SW-F); and ground-water treatment systems that are under the direct influence of surface water (GW-UDI).

Table 2. SWTR Compliance Dates

System Type	Requirement	Date
SW-UF	Begin monitoring/reporting	12/31/90
SW-UF	Meet all criteria to avoid filtering	12/31/90
SW-UF	Install filtration if required	6/29/93
SW-F	Performance and monitoring	6/29/93
GW-UDI	States determine if SWTR applies to community water systems	6/29/94
GW-UDI	States determine if SWTR applies to non-community water systems	6/29/99

CHAPTER 3 - SURFACE WATER TREATMENT RULE REQUIREMENTS.

3-1. SURFACE WATER - UNFILTERED SYSTEMS.

A. The compliance date for CONUS installations to begin filtering surface waters not meeting Federal or state exemption criteria was 29 June 1993. The Overseas Environmental Baseline Guidance Document (OEBGD) (reference 14) was published in October 1992 to enforce environmental regulations, including the SWTR. A number of OCONUS installations may not have had their raw water sources classified by Department of Defense (DOD) Component Executive Agents. Most DOD Executive Agents have not had enough time to classify water sources since publication of the OEBGD in October 1992. The Executive Agents establish the effective date for final governing standards (reference 14); Appendix D contains a list of DOD Component Executive Agents. The EPA has developed a set of criteria to avoid the filtration requirements of the SWTR that must be met by surface water systems providing disinfection only.

B. The SW-UF systems that have not been identified as a source of past waterborne disease outbreaks and meet the following performance and monitoring requirements can usually avoid filtration requirements (references 18 and 19):

(1) Bacteriological. Fecal coliform concentrations prior to disinfection must be less than 20/100 milliliters (mL) or total coliform concentrations must be less than 100/100 mL in at least 90 percent of the source water samples collected during a 6-month period (see Table 3).

Table 3. Source Water Bacteriological Sampling Frequency

Population Served	Samples/week
≤ 500	1
501 to 3,300	2
3,301 to 10,000	3
10,001 to 25,000	4
more than 25,000	5

(2) Turbidity. Turbidity cannot exceed 5 nephelometric turbidity units (NTU) for grab samples collected every 4 hours or for continuous monitoring. Water treatment systems can exceed the 5 NTU limit during unavoidable or unusual circumstances which are allowed by the State authority (CONUS) or the Executive Agent (OCONUS). No more than two such events can occur during a 12-month period or 5 times in any consecutive 10 years.

(3) Disinfectant Residual. The water treatment system must have a redundant disinfection capability or an automatic water feed shut off device to ensure that water entering a distribution system has a residual disinfectant concentration of at least 0.2 mg/L. Those SW-UF systems serving more than 3,300 persons must monitor residual disinfectant concentrations continuously. Systems that serve less than 3,300 persons must take grab samples at the frequency noted in Table 4. The disinfectant residual must also be monitored throughout the distribution system at least as frequently as total coliform samples [see paragraph 3-1B(1)]. The disinfectant residual cannot be undetectable in more than 5 percent of the samples each month for any 2 consecutive months. A HPC of ≤ 500/mL can be substituted as a detectable residual for some of the required distribution system residual measurements (reference 4).

Table 4. Residual Chlorine Monitoring

Population Served	Samples/day
≤ 500	1
501 to 1,000	2
1,001 to 2,500	3
2,501 to 3,300	4

(4) Total Trihalomethanes (TTHMs). The TTHMs cannot exceed 100 micrograms per liter (μg/L) on a running annual average for all water systems serving a population greater than 10,000 persons.

(5) Watershed Control. Establish and maintain a watershed control program that:

(a) Characterizes the watershed hydrology and land ownership;

(b) Identifies watershed characteristics and activities that may adversely affect the source water quality;

(c) Establishes a program to gain ownership or control of the land within the watershed that effectively controls activities that adversely affect water quality; and

(d) Reports annually any identified special concerns for the watershed and how they will be dealt with by the installation water utility (CONUS or OCONUS).

(6) Sanitary Surveys and Inspections. Conduct annual on-site inspections of the watershed control program and the SW-UF disinfection facilities. The SWTR requires that the State authorities (CONUS installations) or Executive Agents (OCONUS installations) approve the inspection party which should consist of competent sanitary and civil engineers, sanitarians, and technicians. The inspectors must have knowledge in design, operation and maintenance of water systems, and should have a thorough understanding of public health principles and waterborne diseases.

(7) Violations. If any SW-UF system fails to comply with the criteria listed above, the installation has 18 months to install filters and begin filtering the surface water source.

3-2. SURFACE WATER - FILTERED SYSTEMS.

A. The compliance date for CONUS installations to begin performance and monitoring requirements was 29 June 1993. The OEBGB did not specify different compliance dates for OCONUS installations; therefore, OCONUS installations also had a compliance date of 29 June 1993. Potable water supply systems at CONUS installations may be cited with a treatment technique notice of violation if the requirements under the SWTR were not met by the compliance date.

B. The SWTR specifies several treatment technologies that can be used to achieve compliance (reference 19). These include:

(1) Conventional treatment using coagulation, flocculation, sedimentation and filtration.

(2) Direct filtration using coagulation, flocculation and filtration.

(3) Slow sand filtration that uses physical and biological treatment.

(4) Diatomaceous earth filtration using a precoat cake of diatomaceous earth filter media.

(5) Reverse osmosis.

C. If conventional treatment or direct filtration is practiced, EPA requires that the SW-F system have filtered water turbidities less than or equal to 0.5 NTU in at least 95 percent of the samples collected each month; States with primacy can authorize a turbidity limit of 1.0 NTU. For slow sand or diatomaceous earth filtration, EPA requires filtered water turbidities of less than or equal to 1.0 NTU in at least 95 percent of the samples measured each month. Under no circumstances can filtered water turbidities exceed 5 NTU (reference 18).

D. The disinfection and turbidity monitoring requirements described for SW-UF systems also apply to SW-F systems.

E. Some treatment technologies recognized under the SWTR are more effective at removing *Giardia* and viruses than other treatment technologies. Consequently, the type of treatment technology used to treat surface water will influence the amount of disinfection needed to inactivate the remaining *Giardia* cysts and viruses. Table 5 contains the expected log-removal of contaminants for each treatment technique and the remaining log-inactivation necessary to achieve compliance. Regardless of the treatment technique used to remove/ inactivate contaminants, qualified operators must optimize filtration and disinfection unit operations to ensure that sufficient contaminant removal/inactivation occurs.

F. Effective operation of each treatment technique minimizes the risk of contaminants entering the potable water distribution system. Conventional and direct filtration processes require monitoring and control of chemical feed rates to ensure effective coagulation and flocculation. Filter backwash pumps must achieve sufficient scouring velocities to clean filter material, and cleaned filters must be brought back on-line with adequate time to condition the filter material before product water flows to the distribution system. Slow sand filtration requires less operator control, but maintenance of the "schmutzdecke" [the top layer (2 or 3 centimeters) of sand where microorganisms degrade harmful contaminants] is critical to achieve acceptable turbidity reduction. Diatomaceous earth filters require significant operator attention; diatomite dose rates must be closely monitored to ensure that the porosity of the filter cake is maintained and turbidity reductions meet treatment requirements. The CONUS and OCONUS installations should obtain technical assistance for water treatment plant performance evaluations and corrective action recommendations to achieve and/or maintain compliance with the SWTR.

Table 5. Log-Removal/Inactivation Requirements Based on Treatment Technique

Filtration	Expected Log Removal Giardia	Expected Log Removal Viruses	Additional Log Inactivation Required for Compliance Giardia	Additional Log Inactivation Required for Compliance Viruses
Conventional	2.5	2.0	0.5	2.0
Direct	2.0	1.0	1.0	3.0
Slow Sand	2.0	2.0	1.0	2.0
Diatomaceous Earth	2.0	1.0	1.0	3.0

3-3. GROUND-WATER TREATMENT SYSTEMS INFLUENCED BY SURFACE WATER.

A. Waterborne pathogens common to surface waters can also exist in ground waters when the latter are under the direct influence of surface waters. A number of groundwater sources are likely to be under the influence of surface water. These sources include:

(1) Shallow wells (less than 50 feet deep).

(2) Ranney wells (horizontal wells constructed at the bottom of a large vertical shaft).

(3) Springs and infiltration galleries.

(4) Any other source exposed to the atmosphere.

B. Figure 1 illustrates a decision flow chart that can be used to determine if a surface or ground-water source is subject to the requirements of the SWTR. State authorities (CONUS) and Executive Agents (OCONUS) have until 29 June 1994 and 29 June 1999 to determine if community and noncommunity ground-water systems, respectively, are directly influenced by surface water. The Installation Preventive Medicine and Public Works officials should use the source classification guidance contained in Figure 1 to determine the status of their water source(s). Technical support can be provided during related sanitary surveys, wellhead protection program reviews, and forthcoming assessments required for the groundwater disinfection rule (reference 18).

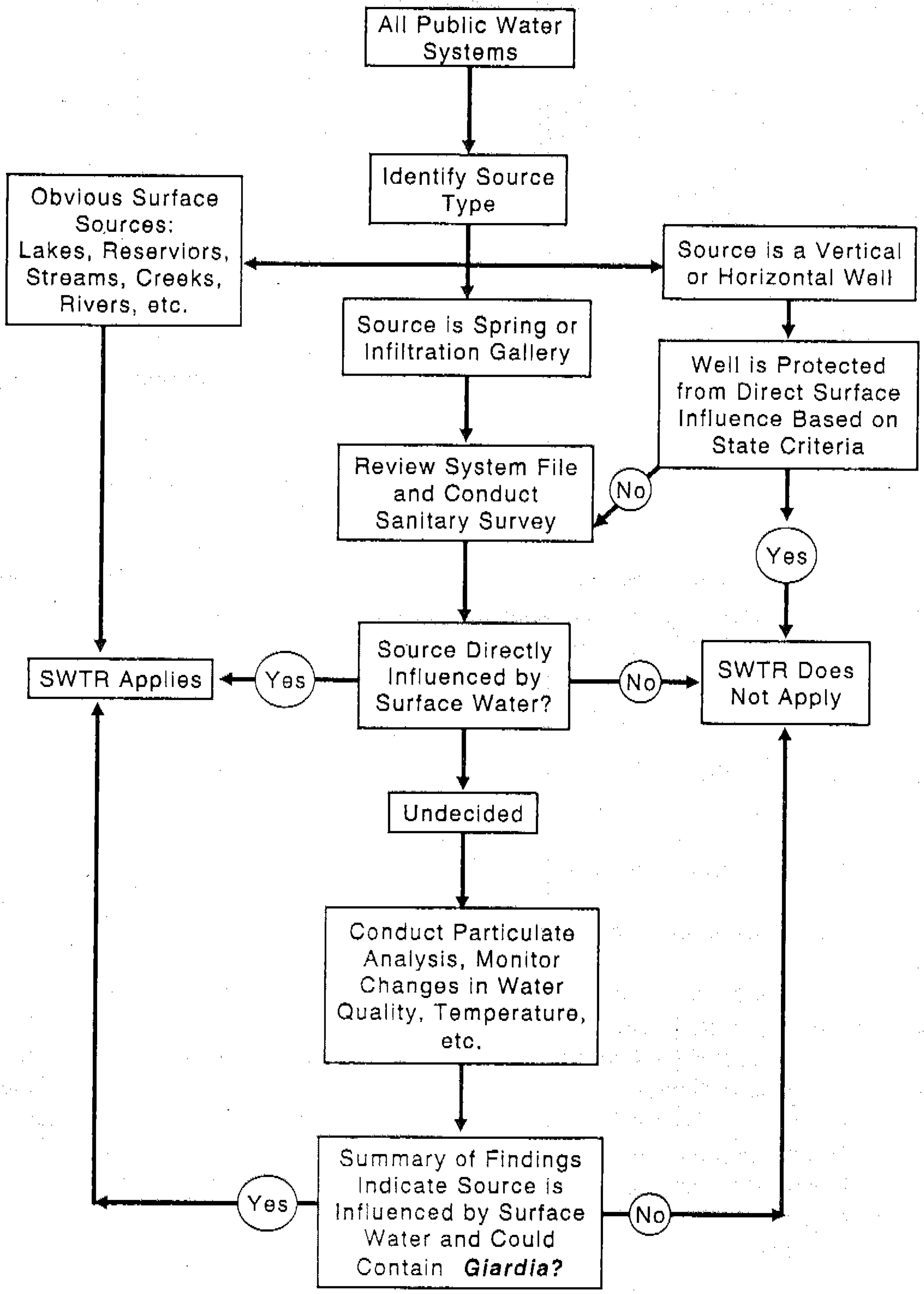

Figure 1. Decision Flow Chart for Source Classification (extracted from reference 19)

C. Installations that have GW-UDI must begin monitoring raw water quality (including fecal or total coliforms, turbidity, water temperature and pH, and disinfection determinations described in paragraph 3-4) within 6 months after the State authorities or Executive Agents determine their systems to be GW-UDI. State authorities and Executive Agents have an additional 18 months after monitoring begins to determine if the installation must initiate filtration based on their interpretation of the results obtained during water quality monitoring.

3-4. DISINFECTION REQUIREMENT DETERMINATION.

A. Log inactivation through disinfection of treated water is determined by calculation of the CT (concentration x time). The CT is the product of the residual disinfectant **concentration** (C) in mg/L, measured at the site of the first consumer served after disinfection, and the corresponding disinfecting (i.e., contact) **time** (T) in minutes. The following treatment cases typify the required inactivation needed to meet the SWTR requirements:

(1) Water treatment plants with no filtration that require CT values achieving 3-log and 4-log inactivation of *Giardia* and viruses, respectively.

(2) Water treatment plants providing filtration (e.g., conventional treatment using coagulation, flocculation, and sedimentation) that achieve log-removal and require CT values that achieve the remaining log-inactivation to total 3-log and 4-log reduction of *Giardia* and viruses, respectively.

B. A number of disinfectants are used to treat drinking water: chlorine, chlorine dioxide, chloramines, ozone, and several others. Each disinfectant's oxidizing capacity is different from the others and generally varies with water temperature and pH. As a result, EPA developed disinfectant-specific CT tables which can be used to determine the CT value necessary to ensure the required log-inactivation of *Giardia* and viruses. Appendix E contains CT tables for chlorine, chlorine dioxide, chloramines, and ozone to achieve 0.5- through 3.0-log inactivation of *Giardia* and 2.0- through 4.0-log inactivation of viruses.

C. Calculate the contact time through all basins and piping from the point the disinfectant is applied to the location of the first consumer tap to determine the disinfecting [or contact] time (T). The EPA and States with primacy require "worst case" conditions to be used for determining the contact time (T). The definition of "worst case" varies from state to state. Therefore, CONUS installations must contact their State officials listed in Appendix C for guidance on "worst case" conditions. The EPA requires that CT values be based on the peak hourly flow rate through the water treatment plant.

D. The theoretical contact time that water receives in a basin or pipe is a function of the water flow rate and is equal to:

$$T = \frac{V}{Q} = \frac{\textit{Volume of Basin}}{\textit{Flow Rate Through Basin}}$$

This equation holds true for pipelines which exhibit plug-flow; the water is unable to short-circuit and must follow the pipeline path.

E. The contact time water receives in a basin is significantly influenced by the design of the basin. In a well-baffled basin, the maximum achievable contact time is T=V/Q. In a poorly-baffled basin, water will short-circuit through the tank. As a result, the contact time is reduced to some fraction less than the theoretical total contact time (T). The T_{10} represents the time required for 10 percent of the treated water to pass through the clearwells. Table 6 contains the classifications of the baffles for basins and pipes. The T_{10}/T values in Table 6 should be used as a correction factor for the type of baffles in basins and pipes for determining the contact time (T) used in the CT determination. Appendix F contains examples of different basin types and corresponding baffle characteristics.

Table 6. Classifications of Baffles

Condition	T_{10}/T	Description
Unbaffled	0.1	None; agitated basin; very low length-to-width ratio; high inlet and outlet flow velocities
Poor	0.3	Single or multiple unbaffled inlets or outlets; no intrabasin baffles
Average	0.5	Baffled inlet or outlet, with some intrabasin baffles
Superior	0.7	Perforated inlet baffle; serpentine or perforated intrabasin baffles; either outlet weirs or perforated launders
Perfect (Plug Flow)	1.0	Very high length-to-width ratio (pipeline flow); perforated inlet, outlet, and intrabasin baffles

(Source: Reference 4)

F. Using multiple disinfectants or multiple application points in a water treatment process increases the complexity of the CT determination. In such instances, each water treatment process can be treated separately, using the concentration of the disinfectant at the end of the treatment process and the contact time (T) based on baffle conditions. Appendix G contains examples of CT calculations for single and multiple disinfectant and application points. Some states do not allow credit for inactivation achieved prior to filtration; therefore, contact State authorities listed in Appendix C for state implementation guidance. Executive Agents should consider recommendations from the Theater Medical Authority regarding credit for inactivation achieved prior to filtration for OCONUS installations. Some states require tracer studies using fluoride or other inert materials to empirically determine the actual T_{10} values through experimentation. The procedures and additional assistance on completing a fluoride tracer study are contained in the guidance documents identified in paragraph 4-1 of this TG.

3-5. FUTURE REGULATIONS AFFECTING SURFACE WATER TREATMENT RULE.

A. The EPA is reviewing the existing SWTR to determine the adequacy of recommended additional log-reductions for poorer quality source waters. An Enhanced SWTR (ESWTR) would make the recommended reductions mandatory. Options for affected installations include installing filters to enhance particle removal or increasing the CT to increase microbial particle inactivation. Since promulgating the SWTR in 1989, several waterborne disease outbreaks of *Cryptosporidium* have occurred in communities complying with the existing requirements of the SWTR. *Cryptosporidium* is a protozoan similar, but smaller than *Giardia*, which causes a self-limiting illness. *Cryptosporidium* is likely to be regulated by establishing an MCLG of zero and increasing *Giardia* removal from 3-log to 6-log based on source water quality.

B. The EPA is expected to promulgate the Disinfectants and Disinfectant By-Product (D-DBP) rule in 1994 as a follow-on regulation to the interim trihalomethanes regulation promulgated in 1979 (reference 12). The compliance date for the D-DBP rule is expected to be June 1998 for all water systems that practice disinfection. The D-DBP rule will prescribe Maximum Residual Disinfectant Levels (MRDLs) for disinfectants (chlorine, chlorine dioxide, chlorite, chloramine, and brominated disinfectants) and their by-products [TTHMs and five haloacetic acids (HAA5)]. The proposed MCLs for TTHMs and HAA5 will be set initially at 80 μg/L and 60 μg/L, respectively. The MCLs for TTHMs and HAA5 could be reduced to 40 μg/L and 30 μg/L, respectively, by the year 2002 for surface water systems serving more than 10,000 consumers (references 15 and 16).

C. In addition to inactivating many waterborne pathogens, disinfectants also react with natural organic material and form TTHMs and other disinfection by-products. For many water treatment facilities having difficulty meeting the required log-reduction of *Giardia* or viruses, a simple option is to increase the concentration of the disinfectant to achieve a corresponding increase in the CT. The increased CT provides greater log-inactivation of SWTR-regulated contaminants and compensates for lower contaminant removals achieved by less effective or poorly operated filtration processes.

D. If an installation water treatment plant manager determines that a high disinfectant dose is needed to meet the log inactivation requirements for the SWTR, the treated water may have increased concentrations of TTHMs and/or HAA5. In such cases, achieving compliance with the SWTR may cause noncompliance with the D-DBP rule and vice versa.

CHAPTER 4 - COMPLIANCE GUIDANCE.

4-1. GENERAL.

A. If your installation uses surface water (i.e., streams, rivers, lakes, or reservoirs) or is known to have a water source that is under the influence of surface water, please contact the Commander, USAEHA, ATTN: HSHB-ME-W, Aberdeen Proving Ground, MD 21010-5422, DSN 584-3816 or commercial (410) 671-3816 to receive two additional manuals complementing this document:

(1) ***Surface Water Treatment: The New Rules*** by Harry Von Huben, published by the American Water Works Association (reference 4).

(2) ***Guidance Manual for Compliance With the Filtration and Disinfection Requirements for Public Water Systems Using Surface Water Sources***, published by the EPA (reference 19).

B. Reference manuals are also available from the American Water Works Association, 6666 West Quincy Avenue, Denver, Colorado 80235, commercial (303) 794-7711. A series of operator training manuals are available from the California State University, School of Engineering, 6000 J Street, Sacramento, California 95819, commercial (916) 454-6142.

C. The SWTR is complex and has already affected a number of Army installations. Installations that determine compliance with the requirements of the SWTR based on the information provided in this document, should seek further technical support. Additionally, installations should consider future drinking water regulations; the impacts caused by base closure (e.g., changes to base populations); and installation and mobilization master planning documents (e.g., water requirements during mobilization or disaster relief). In some cases, compliance with the SWTR can be achieved by means other than costly process or equipment changes at the water treatment plant. These changes include switching from a surface raw water source to ground-water source; purchasing water from an adjacent potable water supply utility; or changing the location of the surface water intake to a location that is more acceptable to raw water quality requirements for SW-UF systems.

4-2. CONUS INSTALLATIONS.

A. In addition to the guidance listed in this document, CONUS installations can contact their State or Regional EPA offices for implementation guidance that is specific to their installation. States that have primacy for implementing the Safe Drinking Water Act Amendments of 1986 can place more stringent requirements on water suppliers. Consequently, installations should contact their State EPA water supply coordinators listed in Appendix C.

B. Surface water systems that can continue to avoid filtration should have already established monitoring and reporting requirements in concert with their State water authority. Installation water purveyors and preventive medicine officials should begin to review TTHM data as a means for screening treated water quality compliance with the forthcoming D-DBP Rule (see paragraph 3-5B).

C. Surface water systems that require filtration should have completed treatment process modifications or changed their water source, and should have established monitoring and reporting programs. If the ground-water system of the installation is influenced by surface water, contact State water authority for further guidance and monitor their efforts to classify the drinking water source. Additionally, installations should establish a watershed control program and complete on-site sanitary surveys to review water treatment practices and watershed control program implementation. The Environmental Pollution Prevention, Abatement and Control [RCS 1383] Process can be used to request services through the Major Army Command (MACOM) from the U.S. Army Environmental Center. USAEHA and its three Activities, USAPACEHEA, and the USAEHA - Europe can also provide direct programmed and unprogrammed technical assistance to installations.

4-3. OCONUS INSTALLATIONS.

A. Military OCONUS installations can receive technical support from USAPACEHEA at DSN 228-4831 (for installations in Japan and other Far East countries), or the USAEHA - Europe at DSN 486-8556 (for installations in Germany and other European countries). Executive Agents can also provide additional guidance on host nation water supply and treatment requirements that may be more stringent or on Status of Forces Agreements that may affect water treatment requirements.

B. The OEBGD provides the implementation guidance, procedures, and criteria for environmental compliance at DOD OCONUS installations (reference 14). The guidance in the document is to be used by Executive Agents in foreign countries to develop "final governing standards" to be used by all DOD installations. The Safe Drinking Water Act Amendments of 1986 are applicable to OCONUS installations, unless host nation standards are more stringent. The Theater Surgeon must review requests for deviations from enforceable drinking water standards (references 1 and 2).

C. The OEBGD contains a cursory view (Table 3-1, OEBGD, reference 14) of the SWTR requirements and should not be used alone as a tool for achieving compliance. Additional guidance contained in ***Surface Water Treatment: The New Rules***, and ***Guidance Manual for Compliance With the Filtration and Disinfection Requirements for Public Water Systems Using Surface Water Sources***, (reference 19) describes specific requirements and procedures for achieving and/or maintaining compliance.

D. If you suspect that the groundwater serving your installation is directly influenced by surface water, contact the Executive Agent listed in Appendix D who is responsible for classifying the water sources for your installation.

APPENDIX A

REFERENCES

1. AR 40-5, 15 October 1990, Preventive Medicine.

2. AR 420-46, 1 May 1992, Facilities Engineering, Water Supply and Wastewater.

3. TB MED 576, March 1982, Sanitary Control and Surveillance of Water Supplies at Fixed Installations.

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5. Committee Report, "Waterborne Disease in the United States and Canada," Journal American Water Works Association (JAWWA), 73:528-29, (October 1981).

6. Chute, C.G.; R.P. Smith; and J.A. Baron, "Risk Factors for Endemic Giardiasis," American Journal of Public Health, 77:585 (May 1987).

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APPENDIX B

ABBREVIATIONS/DEFINITIONS

1. AGI - Acute Gastrointestinal Illness
2. CONUS - Continental United States
3. CT - Concentration (mg/L) Time (min)
4. D-DBP - Disinfectants-Disinfection By-Products Rule
5. DOD - Department of Defense
6. EPA - United States Environmental Protection Agency
7. ESWTR - Enhanced Surface Water Treatement Rule
8. GI - Gastrointestinal
9. GW -UDI - Ground Water Under the Direct Influence of Surface Water
10. HAA5 - Five haloacetic acids proposed for regulation in the D-DBP
11. HPC - Heterotrophic Plate Count
12. MACOM - Major Army Command
13. MCL - Maximum Contaminant Level
14. MCLG - Maximum Contaminant Level Goal
15. MRDL - Maximum Residual Disinfectant Level
16. μg/L - micrograms per liter
17. μm - micrometers
18. mg/L - milligrams per liter
19. mL - milliliter
20. NTU - Nephelometric Turbidity Unit
21. OCONUS - Outside CONUS
22. OEBGD - Overseas Environmental Baseline Guidance Document
23. SDWA - Safe Drinking Water Act
24. SWTR - Surface Water Treatment Rule
25. SW - F - Surface Water that is Filtered
26. SW - UF - Surface Water that is Unfiltered
27. T - contact time
28. TTHMs - Total Trihalomethanes
29. T_{10} - Time required for 10 percent of volume to pass through a basin
30. USAEHA - U.S. Army Environmental Hygiene Agency
31. USAPACEHEA - U.S. Army Pacific Environmental Health Engineering Agency

APPENDIX C

STATE EPA POINTS OF CONTACT

ASDWA ADDRESS/TELEPHONE LIST

ASDWA Headquarters
1911 North Fort Myer Drive, Suite 1100
Arlington, VA 2209
(703) 524-2428
FAX (703) 524-2641

NAME/ADDRESS	TELEPHONE
Region I	
Mr. Gerald R. Iwan, Ph.D., Chief Connecticut Department of Health Services Water Supplies Section 150 Washington Street Hartford, Connecticut 06106	(203) 566-1251 Fax (203) 566-1710
Mr. David Terry, Director Division of Water Supply Department of Environmental Protection One Winter Street, 9th Floor Boston, Massachusetts 02108	(617) 292-5529 Fax(617)556-1049
Mr. Jeffrey W. Jenks, P.E. Manager Drinking Water Program Division of Health Engineering Maine Department of Human Services State House (STA 10) Augusta, Maine 04333	(207) 289-2070 Fax(207)289-4172
Mr. Rene Pelletier Administrator of Water Supply Engineering Bureau Department of Environmental Services Post Office Box 95, Hazen Drive Concord, New Hampshire 03302-0095	(603) 271-3139 Fax (603) 271-2867
♦ **Ms. June Swallow, Chief** Division of Drinking Water Quality Rhode Island Department of Health 75 Davis Street, Cannon Building Providence, Rhode Island 02908	(401) 277-6867 Fax (401) 277-6548
Mr. Jay Rutherford, Director Water Supply Program VT Department of Environmental Conservation 103 South Main Street Waterbury, Vermont 05671-0403	(802) 244-1562 Fax (802) 244-5141

♦ **Board Members**

NAME/ADDRESS	**TELEPHONE**
Region II	
♦ **Mr. Barker G. Hamill, Chief** Bureau of Safe Drinking Water Division of Water Resources New Jersey Department of Environmental Protection Post Office Box CN-029 Trenton, New Jersey 08625 **FOR FEDERAL EXPRESS:** 401 E. State Street Trenton, New Jersey 06825	(609) 292-5550 Fax(609)292-1654
Mr. Michael E. Burke, P.E., Director Bureau of Public Water Supply Protection New York Department of Health Room 406, University Place Albany, New York 12203-3399	(518) 458-6731 Fax(518)458-6434
Mr. Clery Morales, P.E., Director Water Supply Supervision Program Puerto Rico Department of Health Post Office Box 70184 San Juan, Puerto Rico 00936	(809) 763-4307 Fax(809)766-2240
Mr. Ira Hobson Planning & Natural Resources Government of Virgin Islands Nifky Center, Suite 231 St. Thomas, Virgin Islands 00802	(809) 774-3320 Fax (809) 774-5416
Region III	
Mr. Ed Hallock Program Director Office of Sanitary Engineering Delaware Division of Public Health Cooper Building Post Office Box 637 Dover, Delaware 19903	(302) 739-5410 Fax(302)739-3008
Mr. James R. Collier Chief, Water Hygiene Branch Department of Consumer & Regulatory Affairs Environmental Control Division Suite 203, 2100 Martin Luther King Avenue Washington, DC 20020	(202) 404-1120

NAME/ADDRESS	TELEPHONE
♦ **Mr. William F. Parrish, Jr.** Program Administrator Water Supply Program Maryland Department of the Environment Point Breeze Building 40, Room 8L 2500 Broening Highway Dundalk, Maryland 21224	(301) 631-3702 Fax (301) 631-4894
Mr. Frederick A. Marrocco, Chief Division of Water Supplies Department of Environmental Resources Post Office Box 2357 Harrisburg, Pennsylvania 17105-2357 **FOR FEDERAL EXPRESS:** 101 South 2nd Street, Room 518 Executive House Harrisburg, Pennsylvania 17101	(717) 787-9037 Fax (717) 772-3249
Mr. Allen R. Hammer, P.E., Director Division of Water Supply Engineering Virginia Department of Health Room 109-31 1500 East Main Street Richmond, Virginia 23219	(804) 786-1766 Fax(804)786-5567
Mr. Donald A. Kuntz, P.E., Director Environmental Engineering Division Office of Environmental Health Services State Department of Health Room 554 East 1900 Kanawha Blvd., East Charleston, West Virginia 25305	(304) 348-2981 Fax (304) 348-0045
Region IV	
♦ **Mr. Joe A. Power, Chief** Water Supply Branch Department of Environmental Management 1751 Congressman W.L. Dickinson Drive Montgomery, Alabama 36130	(205) 271-7773 Fax(205)271-7950
Mr. Van Hoofnagle, Administrator Drinking Water Section Department of Environmental Regulation Twin Towers Office Building 2600 Blair Stone Road Tallahassee, Florida 32399-2400	(904) 487-1762 Fax (904) 487-3618

NAME/ADDRESS	TELEPHONE
Mr. Fred Lehman Program Manager Drinking Water Program Georgia Environmental Protection Division Floyd Towers East, Room 1066 205 Butler Street, SE Atlanta, Georgia 30334	(404) 656-5660 Fax (404) 651-9425
Mr. John T. Smither, Manager Drinking Water Branch Division of Water 18 Reilly Road, Frankfort Office Park Frankfort, Kentucky 40601	(502) 564-3410 Ext. 543 Fax(502)564-4245
Mr. James C. McDonald, Director Division of Water Supply State Board of Health Post Office Box 1700 Jackson, Mississippi 39215-1700	(601) 960-7518 Fax (601) 960-7448
Mr. Wallace E. Venrick, Chief Public Water Supply Section Division of Environmental Health Department of Environment, Health & Natural Resources Post Office Box 27687 Raleigh, North Carolina 27611-7687	(919) 733-2321 Fax (919) 733-0488
♦ **Mr. Robert E. Malpass, Chief** Bureau of Drinking Water Protection Department of Health and Environmental Control 2600 Bull Street Columbia, South Carolina 29201	(803) 734-5310 Fax (803) 734-4661
Mr. W. David Draughon, Jr., Director Division of Water Supply Tennessee Department of Health and Environment 150 9th Avenue, North Terra Building, 2nd Floor Nashville, Tennessee 37247-3411	(615) 741-6636 Fax (615) 741-4608
Region V	
♦ **Mr. Roger D. Selburg, P.E., Manager** Division of Public Water Supplies Illinois Environmental Protection Agency 2200 Churchill Road P.O. Box 19276 Springfield, Illinois 62794-9276	(217) 785-8653 Fax (217) 524-4192

NAME/ADDRESS	TELEPHONE
Mr. Robert Hilton, Chief Drinking Water Branch Office of Water Management Indiana Department of Environmental Management 105 South Meridian P.O. Box 6015 Indianapolis, Indiana 46206	(317) 233-4222 Fax (317) 233-4165
Mr. James K. Cleland, Chief Division of Water Supply Michigan Department of Public Health P.O. Box 30195 Lansing, Michigan 48909 **FOR FEDERAL EXPRESS:** 3423 North Logan Street Lansing, Michigan 48909	(517) 335-8326 Fax(517)335-8298
Mr. Gary L. Englund, Chief Minnesota Department of Health Section of Water Supply and Well Management Division of Environmental Health 925 SE Delaware Street P.O. Box 59040 Minneapolis, Minnesota 55459-0040	(612) 627-5133 Fax(612)627-5135
Mr. John Sadzewicz, Chief Division of Drinking and Ground Waters Ohio Environmental Protection Agency 1800 WaterMark Drive Post Office Box 1049 Columbus, Ohio 43266-0149	(614) 644-2752 Fax (614) 644-2329
Mr. Robert Krill, Director Bureau of Water Supply Department of Natural Resources P.O. Box 7921 Madison, Wisconsin 53707 **FOR FEDERAL EXPRESS:** 101 S. Webster Street P.O. Box 7921 Madison, WI 53707	(608) 267-7651 Fax (608) 267-3579

NAME/ADDRESS	TELEPHONE
Region VI	
Mr. Harold Seifert, P.E. Division Director Division of Engineering Arkansas Department of Health 4815 West Markham Street - Mail Slot 37 Little Rock, Arkansas 72205-3867	(501) 661-2623 Fax(501)661-2468
♦ **Mr. T. Jay Ray, Administrator** Office of Public Health Louisiana Department of Health and Hospitals Post Office Box 60630 New Orleans, Louisiana 70160 **FOR FEDERAL EXPRESS:** 325 Loyola, Room 403 New Orleans, Louisiana 70112	(504) 568-5105 Fax (504) 568-7703
Mr. Robert M. Gallegos, Program Manager Drinking Water Section New Mexico Health & Environment Department 1190 St. Francis Drive Room South 2058 Santa Fe, New Mexico 87503 **FOR FEDERAL EXPRESS:** 1190 St. Francis Drive Harold Runnels State Office Building Room N2300 Santa Fe, New Mexico 87503	(505) 827-2778 Fax (505) 827-2836
Mr. Michael S. Harrell Water Quality Service Oklahoma State Department of Health Post Office Box 53551 Oklahoma City, Oklahoma 73152	(405) 271-7370 Fax (405) 271-7339
Mr. Dean Robbins, P.E., Director Water Utilities Division Texas Water Commission 1700 North Congress Avenue P.O. Box 13087 Austin, Texas 78731-3087	(512) 463-7941 Fax (512) 463-8317

NAME/ADDRESS	TELEPHONE
Region VII	
♦ **Mr. Darrell McAllister, Bureau Chief** Surface and Groundwater Protection Bureau Environmental Protection Division Iowa Department of Natural Resources Wallace State Office Building 900 East Grand Street Des Moines, Iowa 50319	(515) 281-8869 Fax (515) 281-8895
Mr. David F. Waldo, Chief Public Water Supply Section Bureau of Water Kansas Department of Health and the Environment Forbes Field Building 740 Topeka, Kansas 66620	(913) 296-5503 Fax (913) 296-6247
Mr. Jerry L. Lane, Director Public Drinking Water Program Division of Enviromental Quality Department of Natural Resources Post Office Box 176 Jefferson City, Missouri 65102	(314) 751-5331 Fax(314)751-3110
Mr. Jack Daniel, Director Division of Drinking Water and Environmental Sanitation Nebraska Department of Health 301 Centennial Mall South P.O. Box 95007, 3rd Floor Lincoln, Nebraska 68509	(402) 471-2541 -0510 Fax (402) 471-0383
Region VIII	
Mr. Jerry C. Biberstine, Manager Drinking Water Program Colorado Department of Health 4210 East 11th Avenue Denver, Colorado 80220	(303) 331-4546 Fax(303)322-9076
♦ **Mr. Dan L. Fraser, Chief** Water Quality Bureau Department of Health and Environmental Sciences Cogswell Building, Room A206 Helena, Montana 59620	(406) 444-2406 Fax(406)444-1374

NAME/ADDRESS	TELEPHONE
Mr. D. Wayne Kern Environmental Engineer Division of Water Supply and Pollution Control ND State Department of Health and Consolidated Laboratories 1200 Missouri Avenue P.O. Box 5520 Bismarck, North Dakota 58502-5520	(701) 221-5225 Fax (701) 221-5200
Mr. Darron C. Busch Office of Drinking Water Department of Water and Natural Resources Joe Foss Building 523 East Capital Avenue Pierre, South Dakota 57501	(605) 773-3754 Fax (605) 773-6035
♦ **Mr. Gayle J. Smith, P.E., Director** Division of Drinking Water Utah Department of Environmental Quality 288 North 1460 West Salt Lake City, Utah 84114-4830	(801) 538-6159 Fax(801)538-6016
FOR FEDERAL EXPRESS: 288 North 1460 West Salt Lake City, Utah 84116	
Mr. William L. Garland, Administrator DEQ - Water Quality Herschler Building 4th Floor West Cheyenne, Wyoming 82002	(307) 777-7781 Fax (307) 777-5973
Region IX	
Mr. Robert L. Munari, P.E. Manager, Compliance Unit Office of Water Quality AZ Department of Environmental Quality 3033 N. Central, Room 200 P.O Box 600 Phoenix, Arizona 85001-600	(602) 207-4617 Fax(602)207-2218
Mr. Peter A. Rogers, Chief Office of Drinking Water California Department of Health Services 714 P Street, Room 692 Sacramento, California 95814	(916) 323-1382 Fax (916) 323-9869

NAME/ADDRESS	TELEPHONE
Mr. Thomas E. Arizumi, Chief Environmental Management Division Hawaii Department of Health Post Office Box 3378 Honolulu, Hawaii 96801-9984	(808) 543-8304 Fax(808)548-7237
FOR FEDERAL EXPRESS: Five Waterfront Plaza, Suite 250 500 Ala Moana Boulevard Honolulu, Hawaii 96813	
♦ **Mr. Jeffrey A. Fontaine, Supervisor** Public Health Engineering Nevada Department of Human Resources Consumer Health Protection Services 505 East King Street, Room 103 Carson City, Nevada 89710	(702) 687-4750 Fax (702) 687-5197
Mr. Fred M. Castro Guam Environmental Protection Agency Government of Guam Harmon Plaza Complex Unit D-107 130 Rojas Street Harmon, Guam 96911	(671) 646-8863 -8864 -8865 Fax (671) 646-9402
Mr. F. Russell Mechem II, Chief Division of Environmental Quality Commonwealth of the Northern Mariana Islands Torres Hospital Post Office Box 1304 Saipan, CM 96950	
Mr. Marhence Madranchar, Executive Officer Palau Environmental Quality Protection Board Republic of Palau P.O. Box 100 Koror, Palau 96940	
Ms. Sheilia Wiegman Environmental Coordinator American Samoa Environmental Protection Agency Office of the Governor Pago Pago, American Samoa 96799	

NAME/ADDRESS	TELEPHONE
Region X	
Ms. Melanie Abell Alaska Drinking Water Program Wastewater and Water Treatment Section Department of Environmental Conservation 410 Willoughby Juneau, Alaska 99801	(907) 465-5316 Fax (907) 465-5274
Mr. Rick Mallory, Supervisor Drinking Water Program Division of Environmental Quality Idaho Department of Health and Welfare 1410 North Hilton Boise, Idaho 83706	(208) 334-5860 Fax (208) 334-0417
Mr. David Leland, Manager Drinking Water Program Health Division Department of Human Resources P.O. Box 14350 Portland, Oregon 97214	(503) 731-4010 Fax (503) 731-4077
♦ **Mr. B. David Clark, Director** Drinking Water Division Department of Health Airdustrial Park, Building 3 P.O. Box 47822 Olympia, Washington 98504-7822	(206) 753-1280 Fax(206)586-5529

APPENDIX D

HOST NATION ENVIRONMENTAL EXECUTIVE AGENTS

1. **U.S. Pacific Command**

Japan . . . . . . U.S. Forces Japan
Korea . . . . . . U.S. Forces Korea
Diego Garcia . . Department of the Navy

Environmental Coordinator:

Mr. Gordon Ishikawa
Director of Logistics and Security Assistance/J446
Headquarters, U.S. Pacific Command
Camp Smith, Hawaii 96861-59801
(808) 477-0879

Executive Agents (Point of Contact):

U.S. Forces Japan

Colonel John Hathaway, J42
DSN 225-4713
FAX 225-4079

U.S. Forces Korea

Dr. Jim Hartman, Chief, Environmental Programs Office
DSN 723-5049
FAX 723-6088

U.S. Naval Support Facility Diego Garcia

Ms. Erlinda Corpus, Environmental Engineer
DSN 370-4542
FAX 370-4509

2. U.S. European Command

Netherlands . . .	Department of the Army
Belgium	Department of the Army
Germany	Department of the Army
Italy	Department of the Navy
Spain	Department of the Navy
Greece	Department of the Navy
United Kingdom	Department of the Air Force
Portugal	Department of the Air Force
Turkey	Department of the Air Force

Environmental Coordinator:

Major Earnie Casiano
Logistics Directorate/J4-LIE
Headquarters, U.S. European Command
APO AE 09128-4209
9-011-49-711-680-5110

Executive Agents (Point of Contact):

Department of the Army:

Mr. Bill Nicholas, USAREUR
DSN 370-8125
FAX 370-8693

Department of the Navy:

Mr. Andrew Pissel
DSN 235-4653
FAX 235-4585

Department of the Air Force:

Mr. Jim Baker
DSN 480-6773
FAX 480-6481

3. **U.S. Atlantic Command**

Iceland	Department of the Navy
Bermuda	Department of the Navy
Caribbean	Department of the Navy
Puerto Rico ..	Department of the Navy
Greenland	Department of the Air Force (Air Force Space Command)
Azores	Department of the Air Force (Air Combat Command)
Ascension Isl. .	Department of the Air Force (Air Force Space Command)

Environmental Coordinator:

Mr. Bill Smith
Logistics Directorate/J4-E
Headquarters, U.S. Atlantic Command
Norfolk, Virginia 24511
(804) 445-5927

Executive Agents (Point of Contact):

Department of the Navy:

Mr. Gary Edwards
CIC, U.S. Atlantic Fleet
Code: N4423
1562 Mitscher Ave., Ste 250
Norfolk, VA 23551-2487
(804) 444-6790
DSN 564-6790

Department of the Air Force
(Air Combat Command):

Mr. Anthony Williams
HQ ACC/CEVCM
129 Andrews St., Ste 102
Langley AFB, VA 23665-2769
(804) 764-3553/4430
DSN 574-3553/4430

(Space Command):

Mr. David Praner
HQ AFSPACECOM/CEV
150 Vandenberg St.
Peterson AFB, CO 80914-4320
(719) 554-3867/5819
DSN 692-5819/FAX 692-2562

4. **U.S. Southern Command**

All countries . . Department of the Army

Environmental Coordinator/Executive Agent:

LTC Bob Smiley
Logistics Directorate/SCEN
Headquarters, U.S. Southern Command
APO AA Florida 34003-0190
9-011-507-85-5665

5. **U.S. Central Command**

Bahrain . . . . . Department of the Army
Egypt . . . . . . Department of the Army

Environmental Coordinator:

LCDR Chris Roth
Directorate for Logistics and Security Assistance/7-PE
Headquarters, U.S. Central Command
MacDill AFB, Florida 33608-1001
(813) 830-6607

Executive Agents (Point of Contact):

Department of the Army:

Mr. Jim Fletcher, Environmental Engineer
ARCENT (Third U.S. Army)
DSN 572-4365
Commercial (404) 752-4365

APPENDIX E

CT TABLES
[EXCERPTS FROM EPA GUIDANCE MANUAL (reference 19)]

CT VALUES FOR INACTIVATION
OF GIARDIA CYSTS BY FREE CHLORINE
AT 0.5 C OR LOWER (1)

CHLORINE CONCENTRATION (mg/L)	pH<=6 Log Inactivations						pH=6.5 Log Inactivations						pH=7.0 Log Inactivations						pH=7.5 Log Inactivations					
	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	0.5	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	40	79	119	158	198	237
0.6	24	47	71	94	118	141	28	56	84	112	140	168	33	67	100	133	167	200	40	80	120	159	199	239
0.8	24	48	73	97	121	145	29	57	86	115	143	172	34	68	103	137	171	205	41	82	123	164	205	246
1	25	49	74	99	123	148	29	59	88	117	147	176	35	70	105	140	175	210	42	84	127	169	211	253
1.2	25	51	76	101	127	152	30	60	90	120	150	180	36	72	108	143	179	215	43	86	130	173	216	259
1.4	26	52	78	103	129	155	31	61	92	123	153	184	37	74	111	147	184	221	44	89	133	177	222	266
1.6	26	52	79	105	131	157	32	63	95	126	158	189	38	75	113	151	188	226	46	91	137	182	228	273
1.8	27	54	81	108	135	162	32	64	97	129	161	193	39	77	116	154	193	231	47	93	140	186	233	279
2	28	55	83	110	138	165	33	66	99	131	164	197	39	79	118	157	197	236	48	95	143	191	238	286
2.2	28	56	85	113	141	169	34	67	101	134	168	201	40	81	121	161	202	242	50	99	149	198	248	297
2.4	29	57	86	115	143	172	34	68	103	137	171	205	41	82	124	165	206	247	50	99	149	199	248	298
2.6	29	58	88	117	146	175	35	70	105	139	174	209	42	84	126	168	210	252	51	101	152	203	253	304
2.8	30	59	89	119	148	178	36	71	107	142	178	213	43	86	129	171	214	257	52	103	155	207	258	310
3	30	60	91	121	151	181	36	72	109	145	181	217	44	87	131	174	218	261	53	105	158	211	263	316

CHLORINE CONCENTRATION (mg/L)	pH=8.0 Log Inactivations						pH=8.5 Log Inactivations						pH<=9.0 Log Inactivations					
	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	46	92	139	185	231	277	55	110	165	219	274	329	65	130	195	260	325	390
0.6	48	95	143	191	238	286	57	114	171	228	285	342	68	136	204	271	339	407
0.8	49	98	148	197	246	295	59	118	177	236	295	354	70	141	211	281	352	422
1	51	101	152	203	253	304	61	122	183	243	304	365	73	146	219	291	364	437
1.2	52	104	157	209	261	313	63	125	188	251	313	376	75	150	226	301	376	451
1.4	54	107	161	214	268	321	65	129	194	258	323	387	77	155	232	309	387	464
1.6	55	110	165	219	274	329	66	132	199	265	331	397	80	159	239	318	398	477
1.8	56	113	169	225	282	338	68	136	204	271	339	407	82	163	245	326	408	489
2	58	115	173	231	288	346	70	139	209	278	348	417	83	167	250	333	417	500
2.2	59	118	177	235	294	353	71	142	213	284	355	426	85	170	256	341	426	511
2.4	60	120	181	241	301	361	73	145	218	290	363	435	87	174	261	348	435	522
2.6	61	123	184	245	307	368	74	148	222	296	370	444	89	178	267	355	444	533
2.8	63	125	188	250	313	375	75	151	226	301	377	452	91	181	272	362	453	543
3	64	127	191	255	318	382	77	153	230	307	383	460	92	184	276	368	460	552

Notes:

(1) $CT_{99.9}$ = CT for 3-log inactivation

CT VALUES FOR INACTIVATION
OF GIARDIA CYSTS BY FREE CHLORINE
AT 5 C (1)

CHLORINE CONCENTRATION (mg/L)	pH<=6 Log Inactivations						pH=6.5 Log Inactivations						pH=7.0 Log Inactivations						pH=7.5 Log Inactivations					
	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	0.5	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	28	55	83	111	138	166
0.6	17	33	50	67	83	100	20	40	60	80	100	120	24	48	72	95	119	143	29	57	86	114	143	171
0.8	17	34	52	69	86	103	20	41	61	81	102	122	24	49	73	97	122	146	29	58	88	117	146	175
1	18	35	53	70	88	105	21	42	63	83	104	125	25	50	75	99	124	149	30	60	90	119	149	179
1.2	18	36	54	71	89	107	21	42	64	85	106	127	25	51	76	101	127	152	31	61	92	122	153	183
1.4	18	36	55	73	91	109	22	43	65	87	108	130	26	52	78	103	129	155	31	62	94	125	156	187
1.6	19	37	56	74	93	111	22	44	66	88	110	132	26	53	79	105	132	158	32	64	96	128	160	192
1.8	19	38	57	76	95	114	23	45	68	90	113	135	27	54	81	108	135	162	33	65	98	131	163	196
2	19	39	58	77	97	116	23	46	69	92	115	138	28	55	83	110	138	165	33	67	100	133	167	200
2.2	20	39	59	79	98	118	23	47	70	93	117	140	28	56	85	113	141	169	34	68	102	136	170	204
2.4	20	40	60	80	100	120	24	48	72	95	119	143	29	57	86	115	143	172	35	70	105	139	174	209
2 6	20	41	61	81	102	122	24	49	73	97	122	146	29	58	88	117	146	175	36	71	107	142	178	213
2 8	21	41	62	83	103	124	25	49	74	99	123	148	30	59	89	119	148	178	36	72	109	145	181	217
3	21	42	63	84	105	126	25	50	76	101	126	151	30	61	91	121	152	182	37	74	111	147	184	221

CHLORINE CONCENTRATION (mg/L)	pH=8.0 Log Inactivations						pH=8.5 Log Inactivations						pH<=9.0 Log Inactivations					
	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	33	66	99	132	165	198	39	79	118	157	197	236	47	93	140	186	233	279
0.6	34	68	102	136	170	204	41	81	122	163	203	244	49	97	146	194	243	291
0.8	35	70	105	140	175	210	42	84	126	168	210	252	50	100	151	201	251	301
1	36	72	108	144	180	216	43	87	130	173	217	260	52	104	156	208	260	312
1.2	37	74	111	147	184	221	45	89	134	178	223	267	53	107	160	213	267	320
1.4	38	76	114	151	189	227	46	91	137	183	228	274	55	110	165	219	274	329
1.6	39	77	116	155	193	232	47	94	141	187	234	281	56	112	169	225	281	337
1.8	40	79	119	159	198	238	48	96	144	191	239	287	58	115	173	230	288	345
2	41	81	122	162	203	243	49	98	147	196	245	294	59	118	177	235	294	353
2.2	41	83	124	165	207	248	50	100	150	200	250	300	60	120	181	241	301	361
2.4	42	84	127	169	211	253	51	102	153	204	255	306	61	123	184	245	307	368
2.6	43	86	129	172	215	258	52	104	156	208	260	312	63	125	188	250	313	375
2.8	44	88	132	175	219	263	53	106	159	212	265	318	64	127	191	255	318	382
3	45	89	134	179	223	268	54	108	162	216	270	324	65	130	195	259	324	389

Notes:

(1) $CT_{99.9}$ = CT for 3-log inactivation

CT VALUES FOR INACTIVATION OF GIARDIA CYSTS BY FREE CHLORINE AT 10 C (1)

CHLORINE CONCENTRATION (mg/L)	pH<=6 Log Inactivations						pH=6.5 Log Inactivations						pH=7.0 Log Inactivations						pH=7.5 Log Inactivations					
	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	0.5	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	21	42	63	83	104	125
0.6	13	25	38	50	63	75	15	30	45	60	75	90	18	36	54	71	89	107	21	43	64	85	107	128
0.8	13	26	39	52	65	78	15	31	46	61	77	92	18	37	55	73	92	110	22	44	66	87	109	131
1	13	26	40	53	66	79	16	31	47	63	78	94	19	37	56	75	93	112	22	45	67	89	112	134
1.2	13	27	40	53	67	80	16	32	48	63	79	95	19	38	57	76	95	114	23	46	69	91	114	137
1.4	14	27	41	55	68	82	16	33	49	65	82	98	19	39	58	77	97	116	23	47	70	93	117	140
1.6	14	28	42	55	69	83	17	33	50	66	83	99	20	40	60	79	99	119	24	48	72	96	120	144
1.8	14	29	43	57	72	86	17	34	51	67	84	101	20	41	61	81	102	122	25	49	74	98	123	147
2	15	29	44	58	73	87	17	35	52	69	87	104	21	41	62	83	103	124	25	50	75	100	125	150
2.2	15	30	45	59	74	89	18	35	53	70	88	105	21	42	64	85	106	127	26	51	77	102	128	153
2.4	15	30	45	60	75	90	18	36	54	71	89	107	22	43	65	86	108	129	26	52	79	105	131	157
2.6	15	31	46	61	77	92	18	37	55	73	92	110	22	44	66	87	109	131	27	53	80	107	133	160
2.8	16	31	47	62	78	93	19	37	56	74	93	111	22	45	67	89	112	134	27	54	82	109	136	163
3	16	32	48	63	79	95	19	38	57	75	94	113	23	46	69	91	114	137	28	55	83	111	138	166

CHLORINE CONCENTRATION (mg/L)	pH=8.0 Log Inactivations						pH=8.5 Log Inactivations						pH<=9.0 Log Inactivations					
	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	25	50	75	99	124	149	30	59	89	118	148	177	35	70	105	139	174	209
0.6	26	51	77	102	128	153	31	61	92	122	153	183	36	73	109	145	182	218
0.8	26	53	79	105	132	158	32	63	95	126	158	189	38	75	113	151	188	226
1	27	54	81	108	135	162	33	65	98	130	163	195	39	78	117	156	195	234
1.2	28	55	83	111	138	166	33	67	100	133	167	200	40	80	120	160	200	240
1.4	28	57	85	113	142	170	34	69	103	137	172	206	41	82	124	165	206	247
1.6	29	58	87	116	145	174	35	70	106	141	176	211	42	84	127	169	211	253
1.8	30	60	90	119	149	179	36	72	108	143	179	215	43	86	130	173	216	259
2	30	61	91	121	152	182	37	74	111	147	184	221	44	88	133	177	221	265
2.2	31	62	93	124	155	186	38	75	113	150	188	225	45	90	136	181	226	271
2.4	32	63	95	127	158	190	38	77	115	153	192	230	46	92	138	184	230	276
2.6	32	65	97	129	162	194	39	78	117	156	195	234	47	94	141	187	234	281
2.8	33	66	99	131	164	197	40	80	120	159	199	239	48	96	144	191	239	287
3	34	67	101	134	168	201	41	81	122	162	203	243	49	97	146	195	243	292

Notes:

(1) $CT_{99.9}$ = CT for 3-log inactivation

CT VALUES FOR INACTIVATION OF GIARDIA CYSTS BY FREE CHLORINE AT 15 C (1)

CHLORINE CONCENTRATION (mg/L)	pH<=6 Log Inactivations 0.5	1.0	1.5	2.0	2.5	3.0	pH=6.5 Log Inactivations 0.5	1.0	1.5	2.0	2.5	3.0	pH=7.0 Log Inactivations 0.5	1.0	1.5	2.0	2.5	3.0	pH=7.5 Log Inactivations 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	14	28	42	55	69	83
0.6	8	17	25	33	42	50	10	20	30	40	50	60	12	24	36	48	60	72	14	29	43	57	72	86
0.8	9	17	26	35	43	52	10	20	31	41	51	61	12	24	37	49	61	73	15	29	44	59	73	88
1	9	18	27	35	44	53	11	21	32	42	53	63	13	25	38	50	63	75	15	30	45	60	75	90
1.2	9	18	27	36	45	54	11	21	32	43	53	64	13	25	38	51	63	76	15	31	46	61	77	92
1.4	9	18	28	37	46	55	11	22	33	43	54	65	13	26	39	52	65	78	16	31	47	63	78	94
1.6	9	19	28	37	47	56	11	22	33	44	55	66	13	26	40	53	66	79	16	32	48	64	80	96
1.8	10	19	29	38	48	57	11	23	34	45	57	68	14	27	41	54	68	81	16	33	49	65	82	98
2	10	19	29	39	48	58	12	23	35	46	58	69	14	28	42	55	69	83	17	33	50	67	83	100
2.2	10	20	30	39	49	59	12	23	35	47	58	70	14	28	43	57	71	85	17	34	51	68	85	102
2.4	10	20	30	40	50	60	12	24	36	48	60	72	14	29	43	57	72	86	18	35	53	70	88	105
2.6	10	20	31	41	51	61	12	24	37	49	61	73	15	29	44	59	73	88	18	36	54	71	89	107
2.8	10	21	31	41	52	62	12	25	37	49	62	74	15	30	45	59	74	89	18	36	55	73	91	109
3	11	21	32	42	53	63	13	25	38	51	63	76	15	30	46	61	76	91	19	37	56	74	93	111

CHLORINE CONCENTRATION (mg/L)	pH=8.0 Log Inactivations 0.5	1.0	1.5	2.0	2.5	3.0	pH=8.5 Log Inactivations 0.5	1.0	1.5	2.0	2.5	3.0	pH<=9.0 Log Inactivations 0.5	1.0	1.5	2.0	2.5	3.0
<=0.4	17	33	50	66	83	99	20	39	59	79	98	118	23	47	70	93	117	140
0.6	17	34	51	68	85	102	20	41	61	81	102	122	24	49	73	97	122	146
0.8	18	35	53	70	88	105	21	42	63	84	105	126	25	50	76	101	126	151
1	18	36	54	72	90	108	22	43	65	87	108	130	26	52	78	104	130	156
1.2	19	37	56	74	93	111	22	45	67	89	112	134	27	53	80	107	133	160
1.4	19	38	57	76	95	114	23	46	69	91	114	117	28	55	83	110	138	165
1.6	19	39	58	77	97	116	24	47	71	94	118	141	28	56	85	113	141	169
1.8	20	40	60	79	99	119	24	48	72	96	120	144	29	58	87	115	144	173
2	20	41	61	81	102	122	25	49	74	98	123	147	30	59	89	118	148	177
2.2	21	41	62	83	103	124	25	50	75	100	125	150	30	60	91	121	151	181
2.4	21	42	64	85	106	127	26	51	77	102	128	153	31	61	92	123	153	184
2.6	22	43	65	86	108	129	26	52	78	104	130	156	31	63	94	125	157	188
2.8	22	44	66	88	110	132	27	53	80	106	133	159	32	64	96	127	159	191
3	22	45	67	89	112	134	27	54	81	108	135	162	33	65	98	130	163	195

Notes

(1) $CT_{99.9}$ = CT for 3 log inactivation

CT VALUES FOR INACTIVATION OF GIARDIA CYSTS BY FREE CHLORINE AT 20 C (1)

CHLORINE CONCENTRATION	pH<=6 Log Inactivations						pH=6.5 Log Inactivations						pH=7.0 Log Inactivations						pH=7.5 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	0.5	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	10	21	31	41	52	62
0.6	6	13	19	25	32	38	8	15	23	30	38	45	9	18	27	36	45	54	11	21	32	43	53	64
0.8	7	13	20	26	33	39	8	15	23	31	38	46	9	18	28	37	46	55	11	22	33	44	55	66
1	7	13	20	26	33	39	8	16	24	31	39	47	9	19	28	37	47	56	11	22	34	45	56	67
1.2	7	13	20	27	33	40	8	16	24	32	40	48	10	19	29	38	48	57	12	23	35	46	58	69
1.4	7	14	21	27	34	41	8	16	25	33	41	49	10	19	29	39	48	58	12	23	35	47	58	70
1.6	7	14	21	28	35	42	8	17	25	33	42	50	10	20	30	39	49	59	12	24	36	48	60	72
1.8	7	14	22	29	36	43	9	17	26	34	43	51	10	20	31	41	51	61	12	25	37	49	62	74
2	7	15	22	29	37	44	9	17	26	35	43	52	10	21	31	41	52	62	13	25	38	50	63	75
2.2	7	15	22	29	37	44	9	18	27	35	44	53	11	21	32	42	53	63	13	26	39	51	64	77
2.4	8	15	23	30	38	45	9	18	27	36	45	54	11	22	33	43	54	65	13	26	39	52	65	78
2.6	8	15	23	31	38	46	9	18	28	37	46	55	11	22	33	44	55	66	13	27	40	53	67	80
2.8	8	16	24	31	39	47	9	19	28	37	47	56	11	22	34	45	56	67	14	27	41	54	68	81
3	8	16	24	31	39	47	10	19	29	38	48	57	11	23	34	45	57	68	14	28	42	55	69	83

CHLORINE CONCENTRATION	pH=8.0 Log Inactivations						pH=8.5 Log Inactivations						pH<=9.0 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	25	37	49	62	74	15	30	45	59	74	89	18	35	53	70	88	105
0.6	13	26	39	51	64	77	15	31	46	61	77	92	18	36	55	73	91	109
0.8	13	26	40	53	66	79	16	32	48	63	79	95	19	38	57	75	94	113
1	14	27	41	54	68	81	16	33	49	65	82	98	20	39	59	78	98	117
1.2	14	28	42	55	69	83	17	33	50	67	83	100	20	40	60	80	100	120
1.4	14	28	43	57	71	85	17	34	52	69	86	103	21	41	62	82	103	123
1.6	15	29	44	58	73	87	18	35	53	70	88	105	21	42	63	84	105	126
1.8	15	30	45	59	74	89	18	36	54	72	90	108	22	43	65	86	108	129
2	15	30	46	61	76	91	18	37	55	73	92	110	22	44	66	88	110	132
2.2	16	31	47	62	78	93	19	38	57	75	94	113	23	45	68	90	113	135
2.4	16	32	48	63	79	95	19	38	58	77	96	115	23	46	69	92	115	138
2.6	16	32	49	65	81	97	20	39	59	78	98	117	24	47	71	94	118	141
2.8	17	33	50	66	83	99	20	40	60	79	99	119	24	48	72	95	119	143
3	17	34	51	67	84	101	20	41	61	81	102	122	24	49	73	97	122	146

Notes:

(1) $CT_{99.9}$ = CT for 3 log inactivation

CT VALUES FOR INACTIVATION OF GIARDIA CYSTS BY FREE CHLORINE AT 25 C (1)

CHLORINE CONCENTRATION (mg/L)	pH<=6 Log Inactivations						pH=6.5 Log Inactivations						pH=7.0 Log Inactivations						pH=7.5 Log Inactivations					
	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	0.5	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	7	14	21	28	35	42
0.6	4	8	13	17	21	25	5	10	15	20	25	30	6	12	18	24	30	36	7	14	22	29	36	43
0.8	4	9	13	17	22	26	5	10	16	21	26	31	6	12	19	25	31	37	7	15	22	29	37	44
1	4	9	13	17	22	26	5	10	16	21	26	31	6	12	19	25	31	37	8	15	23	30	38	45
1.2	5	9	14	18	23	27	5	11	16	21	27	32	6	13	19	25	32	38	8	15	23	31	38	46
1.4	5	9	14	18	23	27	6	11	17	22	28	33	7	13	20	26	33	39	8	16	24	31	39	47
1.6	5	9	14	19	23	28	6	11	17	22	28	33	7	13	20	27	33	40	8	16	24	32	40	48
1.8	5	10	15	19	24	29	6	11	17	23	28	34	7	14	21	27	34	41	8	16	25	33	41	49
2	5	10	15	19	24	29	6	12	18	23	29	35	7	14	21	27	34	41	8	17	25	33	42	50
2.2	5	10	15	20	25	30	6	12	18	23	29	35	7	14	21	28	35	42	9	17	26	34	43	51
2.4	5	10	15	20	25	30	6	12	18	24	30	36	7	14	22	29	36	43	9	17	26	35	43	52
2.6	5	10	16	21	26	31	6	12	19	25	31	37	7	15	22	29	37	44	9	18	27	35	44	53
2.8	5	10	16	21	26	31	6	12	19	25	31	37	8	15	23	30	38	45	9	18	27	36	45	54
3	5	11	16	21	27	32	6	13	19	25	32	38	8	15	23	31	38	46	9	18	28	37	46	55

CHLORINE CONCENTRATION (mg/L)	pH=8.0 Log Inactivations						pH=8.5 Log Inactivations						pH<=9.0 Log Inactivations					
	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	17	25	33	42	50	10	20	30	39	49	59	12	23	35	47	58	70
0.6	9	17	26	34	43	51	10	20	31	41	51	61	12	2;	37	49	61	73
0.8	9	18	27	35	44	53	11	21	32	42	53	63	13	25	38	50	63	75
1	9	18	27	36	45	54	11	22	33	43	54	65	13	26	39	52	65	78
1.2	9	18	28	37	46	55	11	22	34	45	56	67	13	27	40	53	67	80
1.4	10	19	29	38	48	57	12	23	35	46	58	69	14	27	41	55	68	82
1.6	10	19	29	39	48	58	12	23	35	47	58	70	14	28	42	56	70	84
1.8	10	20	30	40	50	60	12	24	36	48	60	72	14	29	43	57	72	86
2	10	20	31	41	51	61	12	25	37	49	62	74	15	29	44	59	73	88
2.2	10	21	31	41	52	62	13	25	38	50	63	75	15	30	45	60	75	90
2.4	11	21	32	42	53	63	13	26	39	51	64	77	15	31	46	61	77	92
2.6	11	22	33	43	54	65	13	26	39	52	65	78	16	31	47	63	78	94
2.8	11	22	33	44	55	66	13	27	40	53	67	80	16	32	48	64	80	96
3	11	22	34	45	56	67	14	27	41	54	68	81	16	32	49	65	81	97

Notes:

(1) $CT_{99.9}$ = CT for 3-log inactivation

CT VALUES FOR INACTIVATION OF VIRUSES BY FREE CHLORINE

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

CT VALUES FOR INACTIVATION OF GIARDIA CYSTS BY CHLORINE DIOXIDE

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

CT VALUES FOR
INACTIVATION OF VIRUSES
BY CHLORINE DIOXIDE pH 6-9

Removal	Temperature (C)					
	<=1	5	10	15	20	25
2-log	8.4	5.6	4.2	2.8	2.1	1.4
3-log	25.6	17.1	12.8	8.6	6.4	4.3
4-log	50.1	33.4	25.1	16.7	12.5	8.4

CT VALUES FOR
INACTIVATION OF GIARDIA CYSTS
BY OZONE

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

CT VALUES FOR
INACTIVATION OF VIRUSES BY OZONE

Inactivation	Temperature (C)					
	<=1	5	10	15	20	25
2-log	0.9	0.6	0.5	0.3	0.25	0.15
3-log	1.4	0.9	0.8	0.5	0.4	0.25
4-log	1.8	1.2	1.0	0.6	0.5	0.3

CT VALUES FOR
INACTIVATION OF GIARDIA CYSTS
BY CHLORAMINE pH 6-9

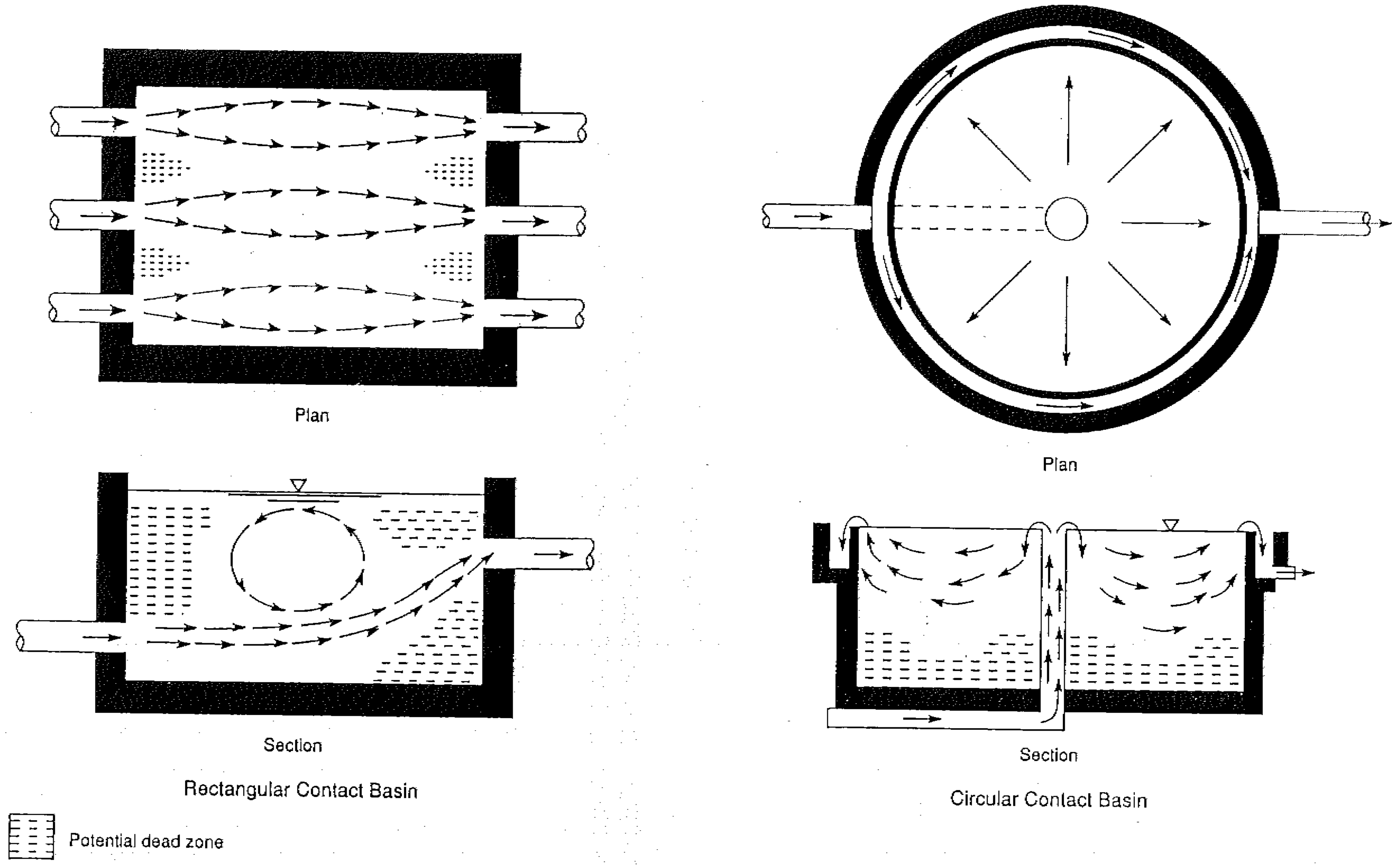
	Temperature (C)					
Inactivation	<=1	5	10	15	20	25
0.5-log	635	365	310	250	185	125
1-log	1,270	735	615	500	370	250
1.5-log	1,900	1,100	930	750	550	375
2-log	2,535	1,470	1,230	1,000	735	500
2.5-log	3,170	1,830	1,540	1,250	915	625
3-log	3,800	2,200	1,850	1,500	1,100	750

CT VALUES FOR
INACTIVATION OF VIRUSES BY CHLORAMINE

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

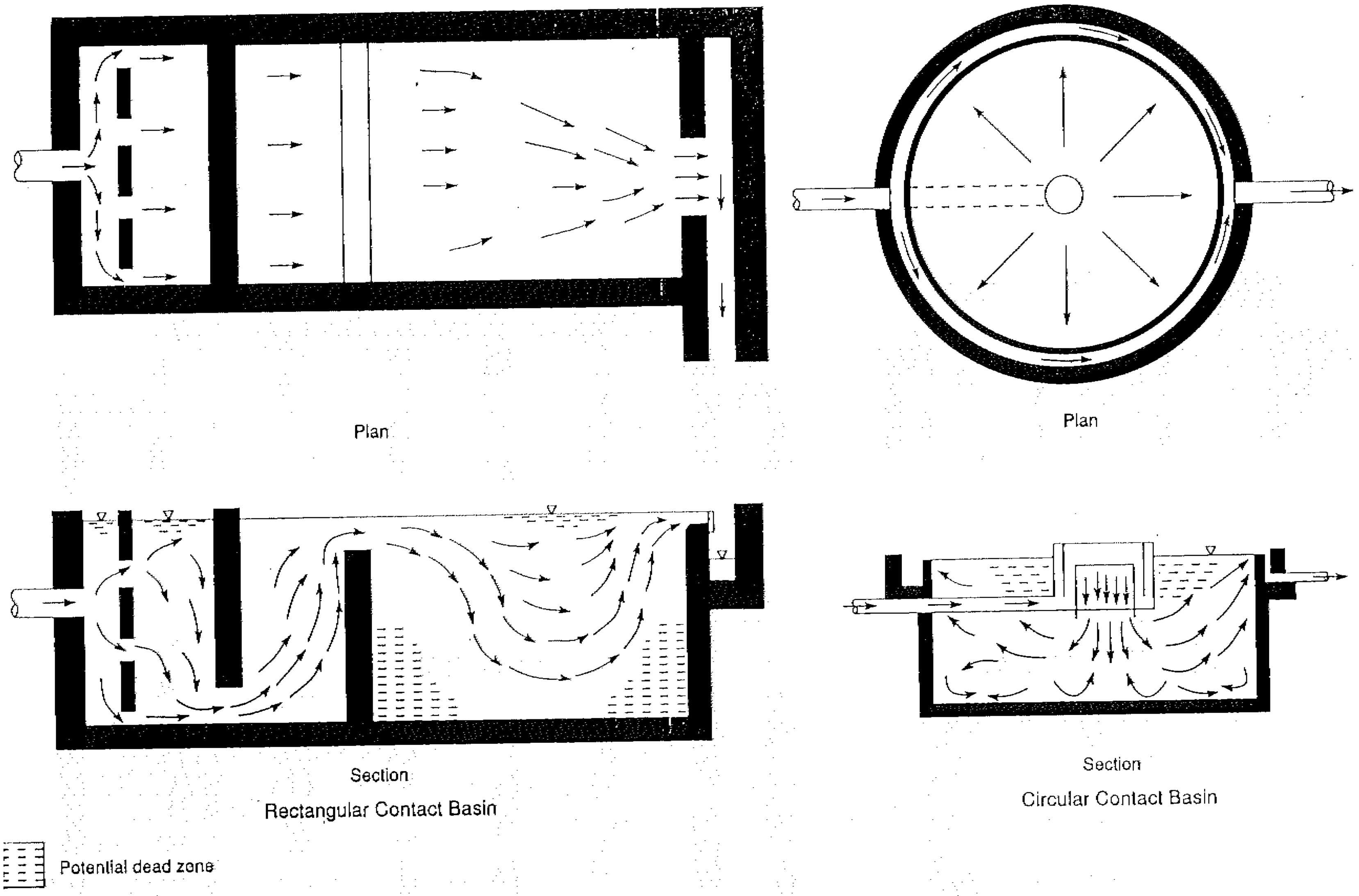
APPENDIX F

BAFFLE CHARACTERISTICS OF VARIOUS BASINS
[EXCERPTS FROM *Surface Water Treatment: The New Rules* (reference 4)]



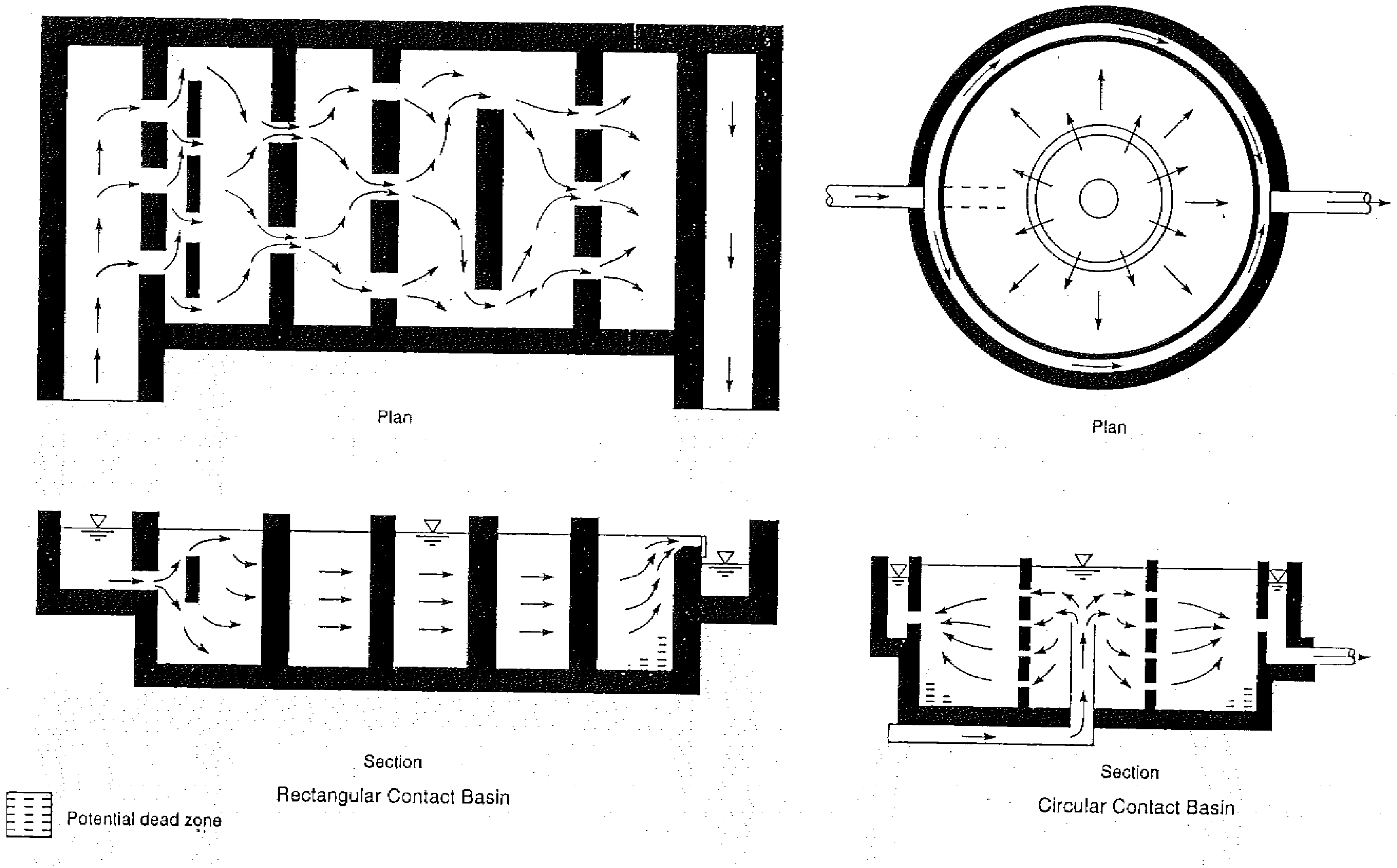
Source: Guidance Manual.

Figure F-2. Examples of poor baffling conditions in basins.



Source: Guidance Manual.

Figure F-3. Examples of average baffling conditions in basins.



Source: Guidance Manual.

Figure F-4. Examples of superior baffling conditions in basins.

APPENDIX G

EXAMPLES OF CT CALCULATIONS

Example 1. Single Point of Disinfection.

Given:

Water treatment plant uses conventional treatment (i.e., coagulation, flocculation, sedimentation, and filtration). The size of the clearwell used for disinfecting the treated water is 30,000 gallons.

Daily peak hourly flow rate = 500 gallons per minute (gpm)
Average Water temperature = 10°C
Average Water pH = 7.2
Disinfectant is chlorine and the free available chlorine residual at the first customer tap is 1.0 mg/L.

Assumptions:

First consumer is the water plant operator located at the water treatment plant.

Water temperature under worst case conditions = 5°C --this value can be obtained by reviewing operational records from the previous 12 months.

Water pH under worst case conditions = 8.0.

Conventional treatment plant is well-operated and can achieve 2.5-log removal of *Giardia* and 2.0-log removal of viruses. Clearwell tank has a baffled inlet and some intrabasin baffles (see Table 6 and Figure F-3).

Required: Disinfection must achieve 0.5-log and 2.0-log inactivation of *Giardia* and viruses, respectively.

Analysis:

From the Table on page E-3, the CT for 0.5 log *Giardia* inactivation under worst case conditions (water temperature = 5°C, pH = 8.0, free chlorine residual = 1.0 mg/L) is 36. From the Table on page E-8, the CT for 2.0-log inactivation of viruses under worst case conditions is 4. **Therefore, the minimum required CT is 36.**

CT achieved in the clearwell using the "average" baffling $T_{10}/T = 0.5$ (from Table 6); the theoretical contact time (T) is:

$$T = \frac{30{,}000 \text{ gallons}}{500 \text{ gpm}} = 60 \text{ minutes}$$

The T_{10} for the clearwells is:

$T_{10} = (T_{10}/T)(T) = 0.5(60 \text{ minutes}) = 30 \text{ minutes}$

Worst Case CT = (1.0 mg/L)(30 minutes) = 30 <u>[NON-COMPLIANCE WITH SWTR]</u>

The required CT is 36. This is greater than the assumed worst case conditions (CT = 30). Two options for improving inactivation are to increase the free chlorine dose rate or improve the baffling in the clearwell from average to superior.

If the clearwell baffling were improved:

$T_{10} = (T_{10}/T)(T) = 0.7(60 \text{ minutes}) = 42 \text{ minutes}$

Revised Worst Case CT = (1.0 mg/L)(42 min) = 42 <u>[COMPLIES WITH SWTR]</u>

If the concentration of free chlorine were increased to 1.2 mg/L and the baffling remained classified as "average":

Revised Worst Case CT = (1.2 mg/L)(30 min) = 36 <u>[COMPLIES WITH SWTR]</u>

Other Considerations:

Military installations must also consider the requirements for increased water demands during contingency operations or mobilization. There are three alternative approaches to determining the "worst case" CT at military installations. Alternative 3, below, provides the best method of determining the actual CT value under worst case (conservative) conditions.

1. Calculate the CT based on the treated water requirements during mobilization.

2. Calculate the CT based on the maximum design capacity of the water treatment plant.

3. Calculate the CT based on empirical tracer studies under operating conditions that permit: 1) constant plant flow; 2) clearwell storage volume representing no more than 30 percent of maximum capacity; and 3) finished water outflow equal to or exceeding plant inflow.

When the option to increase the free chlorine concentration to achieve compliance with the SWTR is pursued, water purveyors and preventive medicine personnel should be aware of potential increases to the TTHM and/or HAA5. The MCL for TTHM is 100 μg/L, and future drinking water regulations will lower that MCL further. Consequently, increasing disinfectant concentrations may have undesirable affects on treated water quality.

Example 2. Multiple Points of Disinfection with Multiple Disinfectants.

Given:

Water treatment plant uses conventional treatment (i.e., coagulation, flocculation, sedimentation, and filtration). The size of the clearwell used for disinfecting the drinking water is 200,000 gallons.

Design flow rate = 10 million gallons per day (mgd)
Average Water temperature = 10°C
Average Water pH = 7.2
Two disinfectant locations:

Pre-disinfection with chlorine dioxide. Concentration before filtration is 0.2 mg/L.
Post-disinfection with chlorine. Free chlorine residual at first customer is 1.0 mg/L.

5 flocculation basins with capacity of 92,000 gallons each.
5 sedimentation basins with capacity of 89,000 gallons each.

Fluoride tracer study under worst case conditions (see previous example) indicates that the contact time in clearwells is T_{10} = 22 minutes. A fluoride tracer study was not conducted to determine the contact time in either the flocculation or sedimentation basins.

Assumptions:

First consumer is the water plant operator located at the water treatment plant

Water temperature under worst case conditions = 0.5°C --this value can be obtained by reviewing operational records from the previous 12 months.

Water pH under worst case conditions = 8.5

Conventional treatment plant is well-operated and can achieve 2.5-log removal of *Giardia* and 2.0-log removal of viruses.

The flocculation basins and sedimentation basins are directly connected and do not have effective intrabasin baffling. Consequently, they are both considered "poorly" baffled.

Required: Disinfection must achieve 0.5-log and 2.0-log inactivation of *Giardia* and viruses, respectively.

Analysis:

The first step is to divide the treatment process into two separate sections: Section 1 is treatment provided prior to filtration; Section 2 is treatment provided after filtration. The second step is to determine the inactivation achieved from the end of the treatment scheme (Section 2). If the inactivation is insufficient, then the EPA Guidance Manual (reference 19) recommends that the inactivation achieved in Section 1 be determined and added to the inactivation in Section 2.

Section 2 Analysis:

From the Table on page E-2, the CT for *Giardia* under worst case conditions (water temperature = 0.5°C, pH = 8.5, free chlorine residual = 1.0 mg/L) is 61. From the Table on page E-8, the CT for viruses under worst case conditions is 6. **Therefore, the minimum required CT in Section 2 is 61.**

CT achieved in the clearwell using the contact time T_{10} determined during the tracer study is:

Worst Case CT for Section 2 = (1.0 mg/L)(22 minutes) = 22 [NONCOMPLIANCE WITH SWTR]. The required CT is 61. This is greater than the worst case conditions (CT = 22). The next step is to determine the "inactivation ratio" achieved in the clearwells. The inactivation ratio = $CT_{calc}/CT_{0.5\text{-}log}$. For Section 2:

$$\text{the inactivation ratio} = \frac{22}{61} = 0.36$$

The inactivation ratio must be equal to or greater than 1.0 to achieve a 0.5 log-inactivation of *Giardia*. Since the inactivation ratio is less than 1.0, the inactivation ratio for Section 1 must be calculated and added to the inactivation ratio for Section 2.

Section 1 Analysis:

From the Table on page E-9, the CT for *Giardia* under worst case conditions (water temperature = 0.5°C, chlorine dioxide residual = 0.2 mg/L) is approximately 10. From the table on page E-10, the CT for viruses under worst case conditions is 8.4. **Therefore, the minimum required CT in Section 1 is 10.**

Conditions: The firm capacity for the basins is the theoretical contact time available when one of the sedimentation/flocculation basins is out of service. The sedimentation/ flocculation basins have a "poor" baffling [T_{10}/T = 0.3 (from Table 6)] classification.

$$T = \frac{(4 \text{ basins})(92{,}000 + 89{,}000 \text{ gallons})}{(10 \text{ mgd})} \times (1{,}440 \text{ min/day}) = 104 \text{ minutes}$$

The T_{10} for the sedimentation/flocculation basins is:

$T_{10} = (T_{10}/T)(T) = 0.3(104 \text{ minutes}) = 31.2 \text{ minutes}$

Worst Case CT for Section 1 = (0.2 mg/L)(31.2 minutes) = 6.25

The inactivation ratio = $CT_{calc}/CT_{0.5\text{-}log}$. For Section 1:

$$\text{the inactivation ratio} = \frac{6.25}{10} = 0.625$$

The final step is to sum the inactivation ratios for Section 1 and 2. The sum must be greater than 1.0 to achieve a 0.5-log inactivation of *Giardia.*

the total inactivation ratio is = 0.36 + 0.625 = 0.985

0.985 < 1.0, therefore the CT does not provide 0.5-log inactivation
[NONCOMPLIANCE WITH SWTR]

In this case, a tracer study of the flocculation/sedimentation basins may provide better information on the actual contact time, rather than using the T_{10}/T ratio of 0.3 for "poor" baffling in those basins. In addition, the options for improving the inactivation identified in Example 1 are also possible solutions to meeting the requirements of the SWTR.

Additionally, some States with primacy have eliminated the credit for inactivation achieved through pre-disinfection. Consult the State water authority for further information regarding the use of pre-disinfection inactivation ratios when determining compliance with the SWTR.

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