

3745-81-72 Disinfection of water from surface water sources.

- (A) A public water system that uses a surface water source, in whole or in part, shall provide the disinfection treatment specified in paragraph (B) of this rule no later than eighteen months following designation by the director as a surface water source. Failure to meet any requirement of this rule, excluding paragraph (E) of this rule, is a treatment technique violation for which public notification is required under rule 3745-81-32 of the Administrative Code. Failure to meet any requirement of paragraph (E) of this rule is a monitoring violation for which public notification is required under rule 3745-81-32 of the Administrative Code. A public water system that uses a surface water source, in whole or in part, and does not already provide filtration treatment shall comply with any interim disinfection requirements established by the director before filtration is installed.
- (B) Each public water system that uses a surface water source, in whole or in part, shall provide disinfection treatment of the water as follows:
- (1) The disinfection treatment shall be considered sufficient if the total treatment processes of that public water system would consistently and reliably achieve at least 99.9 per cent (3 log) inactivation and/or removal of *Giardia lamblia* cysts and at least 99.99 per cent (4 log) inactivation and/or removal of viruses, as determined from table A, and tables B-1 to B-13 of this rule or tables under paragraph (N) of rule 3745-81-68 of the Administrative Code. The inactivation by disinfection is calculated from the actual CT divided by the required CT during the peak hourly flow of each day that the public water system is in operation.
 - (2) Table A of this rule lists: the minimum requirement for inactivation and/or removal of *Cryptosporidium*, *Giardia lamblia* and viruses; the extent to which a properly operated conventional filtration treatment, direct filtration, and slow sand filtration are considered sufficient to remove *Cryptosporidium*, *Giardia lamblia*, and viruses; and the minimum disinfection needed to complete the required minimum inactivation and/or removal of *Cryptosporidium*, *Giardia lamblia* and viruses. Table A specifies the additional minimum log inactivation of *Giardia lamblia* and viruses by disinfection if filtration is properly operated and the turbidity treatment technique requirements of rule 3745-81-73 of the Administrative Code are satisfied. The filtration and disinfection treatment shall include disinfection that consistently and reliably achieves at least the minimum log inactivation by disinfection of *Giardia lamblia* and viruses as specified in table A.
 - (3) The residual disinfectant concentration in the water entering the

distribution system shall not be less than 0.2 milligram per liter free chlorine or one milligram per liter combined chlorine for more than four consecutive hours.

- (4) The residual disinfectant concentration in the distribution system shall not be less than 0.2 milligram per liter free chlorine or one milligram per liter combined chlorine in more than five per cent of the samples each month for any two consecutive months that the public water system serves water to the public.

(C) Disinfection treatment sufficiency determination.

- (1) Paragraph (B)(1) of this rule requires minimum percentage of inactivation and/or removal of *Giardia lamblia* and viruses in water obtained at least partly from a surface water source. Because of the difficulties in measuring the concentrations of viable *Cryptosporidium*, *Giardia lamblia*, and viruses, maximum contaminant levels are not practical and treatment technique requirements are used to ensure control of these contaminants in drinking water. For disinfectants other than UV, tables B-1 to B-13 of this rule shall be used to determine the sufficiency of disinfection. This determination is made at the peak hourly flow rate of each day the water system is in operation. Systems using UV to comply with the inactivation requirements of this rule shall meet paragraph (N) of rule 3745-81-68 of the Administrative Code.
- (2) For disinfectants other than UV, the level of inactivation being provided by the system is determined by measuring actual CT values. The level of inactivation being provided by a system using UV is determined by the UV dosage. Only filtered water flow shall be used in the required CT calculations to meet the minimum log inactivation in table A of this rule, regardless of the disinfectant used. For systems using chlorine dioxide or ozone to comply with additional *Cryptosporidium* treatment requirements in paragraph (E) of rule 3745-81-67 of the Administrative Code, unfiltered water flow may be used in the required CT calculations if approved by the director.

Actual CT values are obtained by multiplying the residual disinfectant, C, by the disinfection contact time, T, giving the resultant, CT. The value of C in milligrams per liter is determined at a point before or at the first customer. The value of T in minutes is based on the time available for the disinfectant to work from the point at which it is added to the water until the point at which C is measured. Values of T are determined based on the approved effective volume factor of the clearwell or contact tank. It may be appropriate to determine the value

of C at more than one point of the water treatment flow, with the T associated with each C being estimated from the previous measurement point or the previous addition of disinfectant, whichever is closer. If more than one disinfectant concentration point is used, the products of each C and its associated T are added and the sum of these products is the actual CT value to compare with the appropriate value of the required minimum CT values for specified conditions and levels of inactivation in the following tables. Note that any disinfection after the last determination of C is not included in the actual CT value. Minimum required CT values for inactivation of *Giardia lamblia* and viruses by disinfection in relation to the disinfectant, the extent of inactivation, the disinfectant concentration, the pH, and the water temperature at the peak hourly flow rate for each day of operation are found in tables B-1 to B-13 of this rule. Applicable information for UV is found in paragraph (N) of rule 3745-81-68 of the Administrative Code.

- (3) In tables B-1 to B-13 of this rule, the required CT between the indicated pH or residual disinfectant concentration may be determined by linear interpolation. The required CT between the indicated temperatures of different tables may be determined by linear interpolation.

If no interpolation is used, then the required CT shall be determined at the lower temperature, and at the higher pH, and at the higher residual disinfectant concentration. If no interpolation is used, for *Giardia lamblia* inactivation at a pH greater than nine, the required CT shall be the same as the required CT at a pH equal to nine. If no interpolation is used, for virus inactivation at a pH greater than nine, the required CT shall be the same as the required CT at a pH equal to ten.

- (4) On each day when the actual CT value meets or exceeds the required minimum CT value in or linearly interpolated from tables B-1 to B-13 of this rule, then the water treatment plant is considered to be satisfying this rule's treatment technique requirements for disinfection of surface water sources. On each day when the actual CT value does not meet or exceed the required minimum CT value from tables B-1 to B-13 of this rule, then the water treatment plant is in violation of paragraph (B)(1) of this rule.
- (5) For each clearwell, or contact tank, the approved effective volume factor shall be determined by the director based upon its design characteristics including: the average flow path length to channel width ratio; baffling; and the proximity of the outlet to the inlet using figures

B-1 and B-2 of this rule. The approved effective volume factor shall be the preliminary effective volume factor obtained from figure B-1 of this rule multiplied by the reduction factor obtained from figure B-2 of this rule, rounded down to the nearest 0.05. A public water system may request that the director approve an effective volume factor that was determined by tracer studies, hydraulic analysis or modeling, or an equivalent demonstration. For a tracer study to be acceptable, the net advection of the tracer shall be within ten per cent of the change in the tracer chemical storage within the clearwell system. Net advection means the amount of tracer convected out of the clearwell system minus the amount of tracer convected into the clearwell system over the duration of the tracer study.

- (D) A public water system that serves a population of at least ten thousand persons and was required to develop a disinfection profile or benchmark under 40 CFR 141.172 or 40 CFR 141.170(d) as published July, 2002, or a community or nontransient noncommunity public water system that serves a population of less than ten thousand persons and was required to develop a disinfection profile or benchmark under 40 CFR 141.530 as published July, 2002, shall follow these requirements:
- (1) Prior to making a significant change in its disinfection practice, the public water system shall submit the disinfection profile to the director for review and consultation. Such changes may require approval if determined substantial by the director as specified by rule 3745-91-02 of the Administrative Code. Significant changes to disinfection practice include any of the following:
- (a) Changes to the point of disinfection;
 - (b) Changes to the disinfectant used in the treatment plant;
 - (c) Changes to the disinfection process; and
 - (d) Any other modification identified by the director, including those identified and proposed in a general plan required by paragraph (A)(7) of rule 3745-81-24 of the Administrative Code.

[Comment: The 40 CFR 141.172, 40 CFR 141.170(d), and 40 CFR 141.530 refer to the "Code of Federal Regulations" published on July 1, 2002. At the effective date of this rule, a copy may be obtained from the "Superintendent of Documents, PO Box 371954, Pittsburgh, PA 15250-7954," (866) 512-1800, or <http://bookstore.gpo.gov>. This

document is available for review at "Ohio EPA, Lazarus Government Center, 50 West Town Street, Columbus, OH, 43215-3425."]

- (2) The public water system shall calculate its disinfection benchmark using the following procedure:
 - (a) The disinfection benchmark is the lowest monthly average value (for public water systems with one year of profiling data) or average of lowest monthly average values (for public water systems with more than one year of profiling data) of the monthly logs of *Giardia lamblia* inactivation in each year of profiling data.
 - (b) For each year of profiling data collected and calculated, the public water system shall determine the lowest average monthly *Giardia lamblia* inactivation in each year of profiling data. The average *Giardia lamblia* inactivation shall be determined by dividing the sum of *Giardia lamblia* inactivation values by the number of values calculated for that month. For public water systems with a combined population of at least ten thousand persons, daily values shall be used. For public water systems with a combined population less than ten thousand persons, weekly values may be used. Values for each calendar month for each year of profiling data shall be used in the calculation.
- (3) A public water system that uses chloramines, chlorine dioxide, or ozone for primary disinfection shall also calculate the disinfection benchmark for viruses using a method acceptable to the director.
- (4) Prior to making a significant change, the public water system shall submit the following information for review by the director:
 - (a) A description of the proposed change;
 - (b) The disinfection profile for *Giardia lamblia* (and, if necessary, viruses) and disinfection benchmark; and
 - (c) An analysis of how the proposed change will affect the current levels of disinfection.
- (5) The public water system shall retain the disinfection profile data in graphic form, as a spreadsheet, or in some other format acceptable to

the director for review as part of a sanitary survey. The disinfection profile, disinfection benchmark, and all data and analysis used to complete the disinfection profile shall be retained by the public water system indefinitely.

- (E) Disinfection profiling and benchmarking requirements for any system making a significant change to their disinfection practice.
- (1) Following the completion of initial source water monitoring in accordance with paragraph (A) of rule 3745-81-65 of the Administrative Code, a system that plans to make a significant change to its disinfection practice, as defined in paragraph (E)(2) of this rule, shall develop disinfection profiles and calculate disinfection benchmarks for *Giardia lamblia* and viruses as described in paragraphs (E)(3) to (E)(7) of this rule. Prior to changing the disinfection practice, the system shall notify the director and shall include in this notice the following information:
 - (a) A completed disinfection profile and disinfection benchmark for *Giardia lamblia* and viruses as described in paragraphs (E)(3) to (E)(7) of this rule.
 - (b) A description of the proposed change in disinfection practice.
 - (c) An analysis of how the proposed change will affect the current level of disinfection.
 - (2) Significant changes to disinfection practices include any of the following:
 - (a) Changes to the point of disinfection;
 - (b) Changes to the disinfectant(s) used in the treatment plant;
 - (c) Changes to the disinfection process; or
 - (d) Any other modification identified by the director as a significant change to disinfection practice.
 - (3) Systems required to develop disinfection profiles in accordance with paragraphs (E)(1) and (E)(2) of this rule shall monitor at least weekly for a period of twelve consecutive months to determine the total log inactivation for *Giardia lamblia* and viruses. If systems monitor more frequently, the monitoring frequency shall be evenly spaced. Systems

that operate for fewer than twelve months per year shall monitor weekly during the period of operation. Systems shall determine log inactivation for *Giardia lamblia* and viruses through the entire plant, based on $CT_{99.9}$ values in tables B-1 to B-13 of this rule, as applicable. Systems shall determine log inactivation of viruses through the entire treatment plant based on a protocol accepted by the director.

- (4) Systems with a single point of disinfectant application prior to the entrance to the distribution system shall conduct the monitoring in this paragraph. Systems with more than one point of disinfectant application shall conduct the monitoring in this paragraph for each disinfection segment. Systems shall monitor the parameters necessary to determine the total inactivation ratio, using analytical methods in accordance with paragraph (C) of rule 3745-81-27 of the Administrative Code.
 - (a) For systems using a disinfectant other than UV, the temperature of the disinfected water shall be measured at each residual disinfectant concentration sampling point during peak hourly flow or at an alternative location accepted by the director.
 - (b) For systems using chlorine, the pH of the disinfected water shall be measured at each chlorine residual disinfectant concentration sampling point during peak hourly flow or at an alternative location accepted by the director.
 - (c) The disinfectant contact time(s), T , shall be determined during peak hourly flow.
 - (d) The residual disinfectant concentration(s), C , of the water before or at the first customer and prior to each additional point of disinfectant application shall be measured during peak hourly flow.
- (5) In lieu of conducting new monitoring under paragraph (E)(4) of this rule, systems may elect to meet the requirements of paragraph (E)(5)(a) or (E)(5)(b) of this rule.
 - (a) Systems that have at least one year of existing data that are substantially equivalent to data collected under the provisions of paragraph (E)(4) of this rule may use these data to develop disinfection profiles as specified in this rule if the system has neither made a significant change to its treatment practice nor changed sources since the data were collected. Systems may

develop disinfection profiles using up to three years of existing data.

- (b) Systems may use disinfection profile(s) developed in accordance with paragraph (D) of this rule in lieu of developing a new profile if the system has neither made a significant change to its treatment practice nor changed sources since the profile was developed. Systems that have not developed a virus profile under paragraph (D) of this rule shall develop a virus profile using the same monitoring data on which the *Giardia lamblia* profile is based.
- (6) Systems shall calculate the total inactivation ratio for *Giardia lamblia* as specified in paragraphs (E)(6)(a) to (E)(6)(c) of this rule.
- (a) Systems using only one point of disinfectant application may determine the total inactivation ratio for the disinfection segment based on either of the following:
 - (i) Determine one inactivation ratio ($CT_{calc}/CT_{99.9}$) before or at the first customer during peak hourly flow.
 - (ii) Determine successive $CT_{calc}/CT_{99.9}$ values, representing sequential inactivation ratios, between the point of disinfectant application and a point before or at the first customer during peak hourly flow. The system shall calculate the total inactivation ratio by determining ($CT_{calc}/CT_{99.9}$) for each sequence and then adding the ($CT_{calc}/CT_{99.9}$) values together to determine ($\sum(CT_{calc}/CT_{99.9})$).
 - (b) Systems using more than one point of disinfectant application before the first customer shall determine the CT value of each disinfection segment immediately prior to the next point of disinfectant application, or for the final segment, before or at the first customer, during peak hourly flow. The ($CT_{calc}/CT_{99.9}$) value of each segment and ($\sum(CT_{calc}/CT_{99.9})$) shall be calculated using the method in paragraph (E)(6)(a)(ii) of this rule.
 - (c) The system shall determine the total logs of inactivation by multiplying the value calculated in paragraph (E)(6)(a) or (E)(6)(b) of this rule by 3.0.

- (d) Systems shall calculate the log of inactivation for viruses using a protocol approved by the director.
- (7) Systems shall use the following procedures to calculate a disinfection benchmark:
- (a) For each year of profiling data collected and calculated under paragraphs (E)(3) to (E)(6) of this rule, systems shall determine the lowest average monthly level of both *Giardia lamblia* and virus inactivation. Systems shall determine the average *Giardia lamblia* and virus inactivation for each calendar month for each year of profiling data by dividing the sum of daily or weekly *Giardia lamblia* and virus log inactivation by the number of values calculated for that month.
 - (b) The disinfection benchmark is the lowest monthly average value (for systems with one year of profiling data) or the average of the lowest monthly average values (for systems with more than one year of profiling data) of *Giardia lamblia* and virus log inactivation in each year of profiling data.

| Table A Minimum Requirements For Inactivation Or Removal of Cryptosporidium, Giardia Lamblia, and Viruses | | | | | | | | |
|---|---|---------|---------|------------------------------------|---------|---------|--|---------|
| Type of Filtration | Required Minimum Log Removal/Inactivation | | | Expected Log Removal by Filtration | | | Minimum Log Inactivation by Disinfection | |
| | Cryptosporidium (Log Removal Only) | Giardia | Viruses | Cryptosporidium | Giardia | Viruses | Giardia | Viruses |
| Conventional | 2 | 3 | 4 | 2 | 2.5 | 2.0 | 0.5 | 2.0 |
| Direct | 2 | 3 | 4 | 2 | 2.0 | 1.0 | 1.0 | 3.0 |
| Slow Sand | 2 | 3 | 4 | 2 | 2.0 | 2.0 | 1.0 | 2.0 |

Comment: Log removal and log inactivation refer to the negative logarithm of the quotient of the concentration of an impurity after treatment divided by the concentration before treatment. For instance, a 99.9 per cent decrease in viruses has a post treatment concentration 0.001 times the pretreatment concentration and a 3 log removal designation. Common conversions include:

| Removal designation | Concentration decrease | Quotient after/before |
|---------------------|------------------------|-----------------------|
| 0.5 log | 70% | 0.3 |
| 1 log | 90% | 0.1 |
| 1.5 log | 97% | 0.03 |
| 2 log | 99% | 0.01 |
| 2.5 log | 99.7% | 0.003 |
| 3 log | 99.9% | 0.001 |
| 4 log | 99.99% | 0.0001 |

Table B-1
 Required CT For Inactivation
 Of Giardia Cysts By Free Chlorine
 At 0.5° Celsius Or Less

| Chlorine Concentration (mg/L) | pH≤6 | | | | | | pH=6.5 | | | | | | pH=7.0 | | | | | |
|-------------------------------------|-------------------|-----|-----|-----|-----|-----|-------------------|-----|-----|-----|-----|-----|-------------------|-----|-----|-----|-----|-----|
| | Log Inactivations | | | | | | Log Inactivations | | | | | | 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 | 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 | 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 | 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 | 30 | 60 | 91 | 121 | 151 | 181 | 36 | 72 | 109 | 145 | 181 | 217 | 44 | 87 | 131 | 174 | 218 | 261 |

| Chlorine Concentration (mg/L) | pH=7.5 | | | | | | pH=8.0 | | | | | | pH=8.5 | | | | | |
|-------------------------------------|-------------------|-----|-----|-----|-----|-----|-------------------|-----|-----|-----|-----|-----|-------------------|-----|-----|-----|-----|-----|
| | Log Inactivations | | | | | | Log Inactivations | | | | | | 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 | 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 | 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 | 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 | 53 | 105 | 158 | 211 | 263 | 316 | 64 | 127 | 191 | 255 | 318 | 382 | 77 | 153 | 230 | 307 | 383 | 460 |

| Chlorine Concentration (mg/L) | pH=9.0 or pH>9.0 | | | | | |
|-------------------------------------|-------------------|-----|-----|-----|-----|-----|
| | Log Inactivations | | | | | |
| | 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 | 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 | 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 | 92 | 184 | 276 | 368 | 460 | 552 |

[Comment: CT_{99.9} = CT for 3 log inactivation.]

Table B-2
 Required CT For Inactivation
 Of Giardia Cysts By Free Chlorine
 At 5° Celsius

| Chlorine Concentration (mg/L) | pH≤6 | | | | | | pH=6.5 | | | | | | pH=7.0 | | | | | |
|-------------------------------------|-------------------|-----|-----|-----|-----|-----|-------------------|-----|-----|-----|-----|-----|-------------------|-----|-----|-----|-----|-----|
| | Log Inactivations | | | | | | Log Inactivations | | | | | | 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 | 16 | 32 | 49 | 65 | 81 | 97 | 20 | 39 | 59 | 78 | 98 | 177 | 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 | 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 | 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 | 21 | 42 | 63 | 84 | 105 | 126 | 25 | 50 | 76 | 101 | 126 | 151 | 30 | 61 | 91 | 121 | 152 | 182 |

| Chlorine Concentration (mg/L) | pH=7.5 | | | | | | pH=8.0 | | | | | | pH=8.5 | | | | | |
|-------------------------------------|-------------------|-----|-----|-----|-----|-----|-------------------|-----|-----|-----|-----|-----|-------------------|-----|-----|-----|-----|-----|
| | Log Inactivations | | | | | | Log Inactivations | | | | | | 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 | 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 | 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 | 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 | 37 | 74 | 111 | 147 | 184 | 221 | 45 | 89 | 134 | 179 | 223 | 268 | 54 | 108 | 162 | 216 | 270 | 324 |

| Chlorine Concentration (mg/L) | pH=9.0 or pH>9.0 | | | | | |
|-------------------------------------|-------------------|-----|-----|-----|-----|-----|
| | Log Inactivations | | | | | |
| | 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 | 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 | 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 | 65 | 130 | 195 | 259 | 324 | 389 |

[Comment: CT_{99.9} = CT for 3 log inactivation.]

Table B-3
 Required CT For Inactivation
 Of Giardia Cysts By Free Chlorine
 At 10° Celsius

| Chlorine Concentration (mg/L) | pH≤6 | | | | | | pH=6.5 | | | | | | pH=7.0 | | | | | |
|-------------------------------|------|-----|-----|-----|-----|-----|--------|-----|-----|-----|-----|-----|--------|-----|-----|-----|-----|-----|
| | 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 |
| 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 | 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 | 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 | 16 | 32 | 48 | 63 | 79 | 95 | 19 | 38 | 57 | 75 | 94 | 113 | 23 | 46 | 69 | 91 | 114 | 137 |

| Chlorine Concentration (mg/L) | pH=7.5 | | | | | | pH=8.0 | | | | | | pH=8.5 | | | | | |
|-------------------------------|--------|-----|-----|-----|-----|-----|--------|-----|-----|-----|-----|-----|--------|-----|-----|-----|-----|-----|
| | 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 | 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 | 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 | 28 | 55 | 83 | 111 | 138 | 166 | 34 | 67 | 101 | 134 | 168 | 201 | 41 | 81 | 122 | 162 | 203 | 243 |

| Chlorine Concentration (mg/L) | pH=9.0 or pH>9.0 | | | | | |
|-------------------------------|------------------|-----|-----|-----|-----|-----|
| | 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 | 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 | 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 | 49 | 97 | 146 | 195 | 243 | 292 |

[Comment: CT_{99.9} = CT for 3 log inactivation.]

Table B-4
 Required CT For Inactivation
 Of Giardia Cysts By Free Chlorine
 At 15° Celsius

| Chlorine Concentration (mg/L) | pH≤6 | | | | | | pH=6.5 | | | | | | pH=7.0 | | | | | |
|-------------------------------------|-------------------|-----|-----|-----|-----|-----|-------------------|-----|-----|-----|-----|-----|-------------------|-----|-----|-----|-----|-----|
| | Log Inactivations | | | | | | Log Inactivations | | | | | | 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 | 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 | 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 | 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 | 11 | 21 | 32 | 42 | 53 | 63 | 13 | 25 | 38 | 51 | 63 | 76 | 15 | 30 | 46 | 61 | 76 | 91 |

| Chlorine Concentration (mg/L) | pH=7.5 | | | | | | pH=8.0 | | | | | | pH=8.5 | | | | | |
|-------------------------------------|-------------------|-----|-----|-----|-----|-----|-------------------|-----|-----|-----|-----|-----|-------------------|-----|-----|-----|-----|-----|
| | Log Inactivations | | | | | | Log Inactivations | | | | | | 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 | 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 | 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 | 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 | 19 | 37 | 56 | 74 | 93 | 111 | 22 | 45 | 67 | 89 | 112 | 134 | 27 | 54 | 81 | 108 | 135 | 162 |

| Chlorine Concentration (mg/L) | pH=9.0 or pH>9.0 | | | | | |
|-------------------------------------|-------------------|-----|-----|-----|-----|-----|
| | Log Inactivations | | | | | |
| | 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 | 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 | 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 | 33 | 65 | 98 | 130 | 163 | 195 |

[Comment: CT_{99.9} = CT for 3 log inactivation.]

Table B-5
 Required CT For Inactivation
 Of Giardia Cysts By Free Chlorine
 At 20° Celsius

| Chlorine Concentration (mg/L) | pH≤6 | | | | | | pH=6.5 | | | | | | pH=7.0 | | | | | |
|-------------------------------|-------------------|-----|-----|-----|-----|-----|-------------------|-----|-----|-----|-----|-----|-------------------|-----|-----|-----|-----|-----|
| | Log Inactivations | | | | | | Log Inactivations | | | | | | 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 | 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 | 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 | 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 | 8 | 16 | 24 | 31 | 39 | 47 | 10 | 19 | 29 | 38 | 48 | 57 | 11 | 23 | 34 | 45 | 57 | 68 |

| Chlorine Concentration (mg/L) | pH=7.5 | | | | | | pH=8.0 | | | | | | pH=8.5 | | | | | |
|-------------------------------|-------------------|-----|-----|-----|-----|-----|-------------------|-----|-----|-----|-----|-----|-------------------|-----|-----|-----|-----|-----|
| | Log Inactivations | | | | | | Log Inactivations | | | | | | 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 | 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 | 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 | 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 | 14 | 28 | 42 | 55 | 69 | 83 | 17 | 34 | 51 | 67 | 84 | 101 | 20 | 41 | 61 | 81 | 102 | 122 |

| Chlorine Concentration (mg/L) | pH=9.0 or pH>9.0 | | | | | |
|-------------------------------|-------------------|-----|-----|-----|-----|-----|
| | Log Inactivations | | | | | |
| | 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 | 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 | 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 | 24 | 49 | 73 | 97 | 122 | 146 |

[Comment: CT_{99.9} = CT for 3 log inactivation.]

Table B-6
 Required CT For Inactivation
 Of Giardia Cysts By Free Chlorine
 At 25° Celsius And Greater

| Chlorine Concentration (mg/L) | pH≤6 | | | | | | pH=6.5 | | | | | | pH=7.0 | | | | | |
|-------------------------------------|-------------------|-----|-----|-----|-----|-----|-------------------|-----|-----|-----|-----|-----|-------------------|-----|-----|-----|-----|-----|
| | Log Inactivations | | | | | | Log Inactivations | | | | | | 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 | 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 | 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 | 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 | 5 | 11 | 16 | 21 | 27 | 32 | 6 | 13 | 19 | 25 | 32 | 38 | 8 | 15 | 23 | 31 | 38 | 46 |

| Chlorine Concentration (mg/L) | pH=7.5 | | | | | | pH=8.0 | | | | | | pH=8.5 | | | | | |
|-------------------------------------|-------------------|-----|-----|-----|-----|-----|-------------------|-----|-----|-----|-----|-----|-------------------|-----|-----|-----|-----|-----|
| | Log Inactivations | | | | | | Log Inactivations | | | | | | 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 | 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 | 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 | 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 | 9 | 18 | 28 | 37 | 46 | 55 | 11 | 22 | 34 | 45 | 56 | 67 | 14 | 27 | 41 | 54 | 68 | 81 |

| Chlorine Concentration (mg/L) | pH=9.0 or pH>9.0 | | | | | |
|-------------------------------------|-------------------|-----|-----|-----|-----|-----|
| | 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 | 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 | 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 | 16 | 32 | 49 | 65 | 81 | 97 |

[Comment: CT_{99.9} = CT for 3 log inactivation.]

Table B-7
 Required CT For Inactivation
 of Viruses by Free Chlorine

| Temperature (Celsius) | Log Inactivation | | | | | |
|--------------------------|------------------------------|-------|---------|-------|---------|-------|
| | 2.0 Log | | 3.0 Log | | 4.0 Log | |
| | pH 6-9 | pH 10 | pH 6-9 | pH 10 | pH 6-9 | pH 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 |

Table B-8
CT Values for Inactivation of Giardia Cysts
by Chlorine Dioxide pH 6-9

| Log Inactivation | Temperature (Celsius) | | | | | |
|---------------------|-----------------------|-----|-----|-----|-----|-----|
| | ≤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 B-9
CT Values for Inactivation of Viruses
By Chlorine Dioxide pH 6-9

| Log Inactivation | Temperature (Celsius) | | | | | |
|---------------------|-----------------------|------|------|------|------|-----|
| | ≤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 |

Table B-10
CT Values for Inactivation of Giardia Cysts
By Ozone pH 6-9

| Log Inactivation | Temperature (Celsius) | | | | | |
|---------------------|-----------------------|------|------|------|------|------|
| | ≤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 B-11
CT Values for Inactivation of Viruses by Ozone

| Log Inactivation | Temperature (Celsius) | | | | | |
|---------------------|-----------------------|-----|-----|-----|------|------|
| | ≤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 |

Table B-12

| Required CT Values for Inactivation of Giardia Cysts by Chloramine, pH 6.0-9.0 | | | | | | | | | | | | | | | | | | | | | | | | | |
|--|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|-----|-----|-----|-----|
| Temperature (Celsius) | | | | | | | | | | | | | | | | | | | | | | | | | |
| Log Inactivation | ≤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 |
| 0.5 | 635 | 568 | 500 | 433 | 365 | 354 | 343 | 332 | 321 | 310 | 298 | 286 | 274 | 262 | 250 | 237 | 224 | 211 | 198 | 185 | 173 | 161 | 149 | 137 | 125 |
| 1 | 1270 | 1136 | 1003 | 869 | 735 | 711 | 687 | 663 | 639 | 615 | 592 | 569 | 546 | 523 | 500 | 474 | 448 | 422 | 396 | 370 | 346 | 322 | 298 | 274 | 250 |
| 1.5 | 1900 | 1700 | 1500 | 1300 | 1100 | 1066 | 1032 | 998 | 964 | 930 | 894 | 858 | 822 | 786 | 750 | 710 | 670 | 630 | 590 | 550 | 515 | 480 | 445 | 410 | 375 |
| 2 | 2535 | 2269 | 2003 | 1736 | 1470 | 1422 | 1374 | 1326 | 1278 | 1230 | 1184 | 1138 | 1092 | 1046 | 1000 | 947 | 894 | 841 | 788 | 735 | 688 | 641 | 594 | 547 | 500 |
| 2.5 | 3170 | 2835 | 2500 | 2165 | 1830 | 1772 | 1714 | 1656 | 1598 | 1540 | 1482 | 1424 | 1366 | 1308 | 1250 | 1183 | 1116 | 1049 | 982 | 915 | 857 | 799 | 741 | 683 | 625 |
| 3 | 3800 | 3400 | 3000 | 2600 | 2200 | 2130 | 2060 | 1990 | 1920 | 1850 | 1780 | 1710 | 1640 | 1570 | 1500 | 1420 | 1340 | 1260 | 1180 | 1100 | 1030 | 960 | 890 | 820 | 750 |

Table B-13

Required CT for Inactivation of Viruses by Chloramine¹

Temperature (Celsius)

| Log Inactivation | ≤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 |
|------------------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|
| 2 | 1243 | 1147 | 1050 | 954 | 857 | 814 | 771 | 729 | 686 | 643 | 600 | 557 | 514 | 471 | 428 | 407 | 385 | 364 | 342 | 321 | 300 | 278 | 257 | 235 | 214 |
| 3 | 2063 | 1903 | 1743 | 1583 | 1423 | 1352 | 1281 | 1209 | 1138 | 1067 | 996 | 925 | 854 | 783 | 712 | 676 | 641 | 605 | 570 | 534 | 498 | 463 | 427 | 392 | 356 |
| 4 | 2883 | 2659 | 2436 | 2212 | 1988 | 1889 | 1789 | 1690 | 1590 | 1491 | 1392 | 1292 | 1193 | 1093 | 994 | 944 | 895 | 845 | 796 | 746 | 696 | 646 | 597 | 547 | 497 |

¹These required CT may be assumed to achieve greater than 99.99 per cent inactivation of viruses only if chlorine is added and mixed in the water prior to the addition of ammonia. If this condition is not met, the public water system must demonstrate, based on onsite studies or other information, as approved by the director, that the public water system is achieving at least 99.99 per cent inactivation of viruses.

Figure B-1

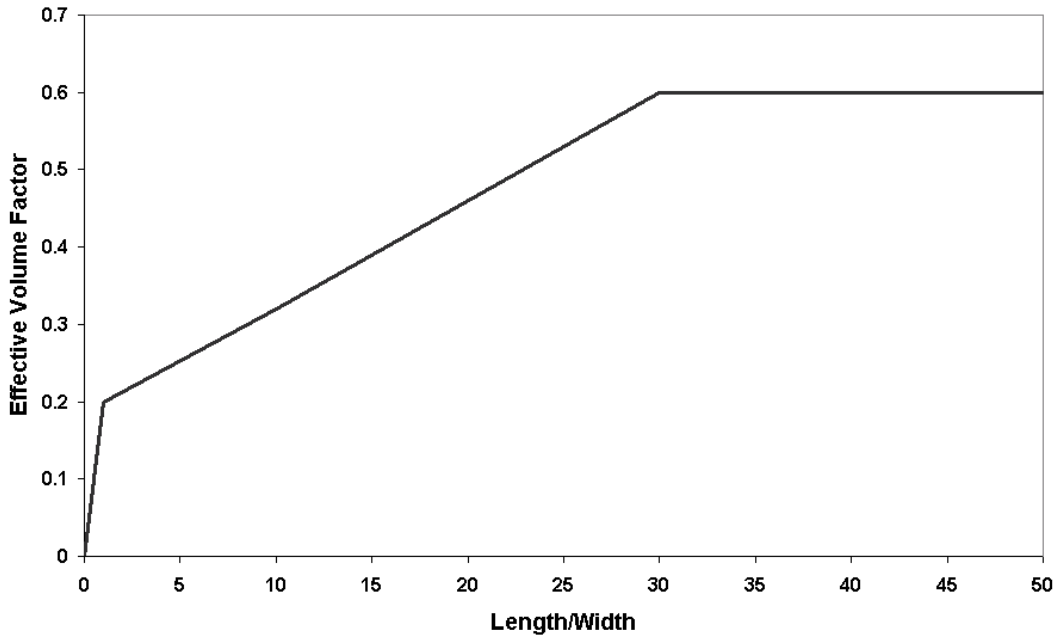
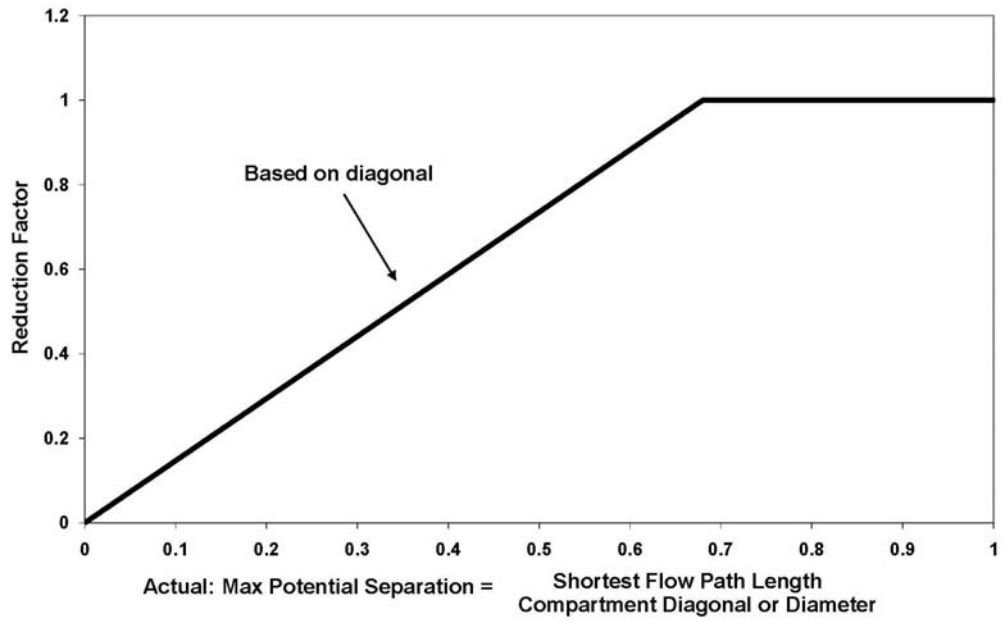


Figure B-2



Effective: 10/31/2010

R.C. 119.032 review dates: 08/16/2010 and 10/31/2015

Promulgated Under: 119.03

Statutory Authority: 6109.04

Rule Amplifies: 6109.03, 6109.04

Prior Effective Dates: 01/01/05, 01/08/10

Appendix

Disinfection Treatment Sufficiency Determination

This rule specifies the minimum log inactivation or removal of *Giardia lamblia*, *Cryptosporidium*, and viruses in water obtained from a surface water source, in whole or in part. A treatment technique is required in lieu of a maximum contaminant level for *Cryptosporidium*, *Giardia lamblia* viruses, heterotrophic plate count bacteria, *Legionella*, and turbidity.

The effectiveness of disinfection increases with increasing concentration of the disinfectant and with increasing time the disinfectant is in the water. A measure of the effectiveness of disinfection at the peak hourly flow rate, CT, is obtained by multiplying the lowest daily residual disinfectant concentration, C, by the lowest daily disinfectant contact time, T.

The value of C in milligrams per liter is determined at the entry to the distribution system and/or, if approved by the director, before the first customer. The value of T in minutes is based on the disinfectant contact time available for the disinfectant to work from the point where the disinfectant is added to the point where C is measured. Only filtered water flow shall be used in the required CT calculations to meet the minimum log inactivation in table A of this rule, regardless of the disinfectant used. For systems using chlorine dioxide or ozone to comply with additional *Cryptosporidium* treatment requirements in paragraph (E) of rule 3745-81-67 of the Administrative Code, unfiltered water flow may be used in the required CT calculations if approved by the director. Values of T shall be determined from:

- (a) Acceptable tracer studies; or
- (b) The lowest daily water volume divided by the peak flow; and
- (c) An approved effective volume factor as determined by the director.

For a typical day in many public water systems, the value of a single determination of C multiplied by its associated T will give an actual CT which is larger than the required CT. However, in other cases, it may be appropriate to determine the value of C at more than one point of the water treatment flow, with the T associated with each C being estimated from the previous measurement point or the previous addition of disinfectant, whichever is closer. If more than one disinfectant concentration point is used, the products of each C and its associated T are added and the sum of these products is the actual CT to compare with the appropriate

value of the required CT for specified conditions and log inactivation. Any disinfection after the last determination of C is not included in the actual CT value.

On each day if the actual CT is greater than or equal to the required CT, then the public water system is considered to be satisfying this rule's treatment technique requirements for disinfection. On each day if the actual CT is less than the required CT, then the water treatment plant is in violation of this rule.