567—43.11(455B) Enhanced treatment for *Cryptosporidium*.

43.11(1) *Applicability.* The requirements of this rule are national primary drinking water regulations and establish or extend treatment technique requirements in lieu of maximum contaminant levels for *Cryptosporidium*. These requirements are in addition to the filtration and disinfection requirements of 567—43.5(455B), 567—43.9(455B) and 567—43.10(455B) and apply to all Iowa public water systems supplied by surface water or influenced groundwater sources.

a. Wholesale systems. Wholesale systems must comply with the requirements based on the population of the largest system in the combined distribution system.

b. Filtered systems. The requirements of this rule for filtered systems apply to systems that are required to provide filtration treatment pursuant to 567—43.5(455B), whether or not the system is currently operating a filtration system.

43.11(2) *General requirements.* Systems subject to this rule must comply with the following requirements:

a. Source water monitoring. Systems must conduct two rounds of source water monitoring for each plant that treats a surface water or influenced groundwater source. This monitoring may include sampling for *Cryptosporidium*, *E. coli*, and turbidity, as described in 43.11(3), to determine what level, if any, of additional *Cryptosporidium* treatment the systems must provide.

b. Disinfection profiles and benchmarks. Systems that plan to make a significant change to their disinfection practice must develop disinfection profiles and calculate disinfection benchmarks, as described in 43.11(4).

c. Cryptosporidium treatment bin determination. Systems must determine their *Cryptosporidium* treatment bin classification and provide additional treatment for *Cryptosporidium*, if required, according to the prescribed schedule.

d. Additional treatment for Cryptosporidium. Systems required to provide additional treatment for *Cryptosporidium* must implement microbial toolbox options that are designed and operated as described in 43.11(8) through 43.11(13).

e. Record keeping and reporting. Systems must comply with the applicable record-keeping and reporting requirements described in 43.11(14) and 43.11(15).

f. Significant deficiencies. Systems must address significant deficiencies identified during sanitary surveys as described in 43.1(7).

43.11(3) *Source water monitoring.*

a. Schedule. Systems must conduct the source water monitoring no later than the month and year listed in Table 1. A system may avoid the source water monitoring if the system provides a total of at least 5.5-log treatment for *Cryptosporidium*, equivalent to meeting the treatment requirements of Bin 4 in 43.11(6). The system must install and operate technologies to provide this level of treatment by the applicable treatment compliance date specified in 43.11(7).

Table 1: Source Water Monitoring Schedule

System	First round of monitoring	Second round of monitoring
Serves at least 100,000 people	October 2006	April 2015
Serves 50,000-99,999 people	April 2007	October 2015
Serves 10,000-49,999 people	April 2008	October 2016
Serves fewer than 10,000 people and only conducts *E. coli* monitoring	October 2008	October 2017
Serves fewer than 10,000 people and conducts *Cryptosporidium* monitoring	April 2010	April 2019

b. Monitoring requirements. The minimum monitoring requirements are listed below. Systems may sample more frequently, provided the sampling frequency is evenly spaced throughout the monitoring period.

(1) Systems serving at least 10,000 people. Systems serving at least 10,000 people must sample their source water for *Cryptosporidium*, *E. coli*, and turbidity at least monthly for 24 months.

(2) Systems serving fewer than 10,000 people. Systems serving fewer than 10,000 people are allowed to first conduct *E. coli* monitoring to determine if further monitoring for *Cryptosporidium* is required.

1. Systems must sample their source water for *E. coli* at least once every two weeks for 12 months. If the annual mean *E. coli* concentration is at or below 100 *E. coli* per 100 mL, the system can avoid further *Cryptosporidium* monitoring in that sampling round.

2. A system may avoid *E. coli* monitoring if the system notifies the department no later than three months prior to the *E. coli* monitoring start date that the system will conduct *Cryptosporidium* monitoring.

3. Systems that fail to conduct the required *E. coli* monitoring or that cannot meet the *E. coli* annual mean limit are required to conduct *Cryptosporidium* monitoring. The system must sample its source water for *Cryptosporidium* either at least twice per month for 12 months or at least monthly for 24 months.

4. A system that begins monitoring for *E. coli* and determines during the sampling period that the system mathematically cannot meet the applicable *E. coli* annual mean limit may discontinue the *E. coli* sampling. The system is then required to start *Cryptosporidium* monitoring according to the schedule in Table 1.

(3) Plants operating only part of the year. Systems with surface water or influenced groundwater treatment plants that operate for only part of the year must conduct source water monitoring in accordance with this rule, but with the following modifications.

1. Systems must sample their source water only during the months that the plant operates unless the department specifies another monitoring period based on plant operating practices.

2. Systems with plants that operate less than six months per year and that monitor for must collect at least six samples per year for two years. The samples must be evenly spaced throughout the period the plant operates.

(4) New sources. A system that begins using a new surface water or influenced groundwater source after the dates in Table 1 must monitor according to a schedule approved by the department and meet the requirements of this subrule. The system must also meet the requirements of the bin classification and *Cryptosporidium* treatment for the new source on a schedule approved by the department. The system must conduct the second round of source water monitoring no later than six years following the initial bin classification or determination of the mean *Cryptosporidium* level, as applicable.

(5) Monitoring violation determination. Failure to collect any source water sample required under this subrule in accordance with the sampling plan, location, analytical method, approved laboratory, or reporting requirements of 43.11(3)*"c"* through 43.11(3)*"e"* is a monitoring violation.

(6) Grandfathered monitoring data. Systems were allowed to use source water monitoring *Cryptosporidium* data collected prior to the applicable start date in Table 1 to meet the requirements of the first round of monitoring, a process referred to as grandfathering data. This grandfathered data substituted for an equivalent number of months at the end of the monitoring period and had to meet the requirements of 40 CFR 141.707 as adopted on January 5, 2006, which the department hereby adopts by reference. Department approval of the grandfathered data application is required.

c. Sampling plan. Systems must submit a sampling plan that specifies the sampling locations in relation to the sources and treatment processes and the calendar dates when the system will collect each required sample. The specific treatment process locations that must be included in the plan are pretreatment, points of chemical treatment, and filter backwash recycle.

(1) The sampling plan must be submitted no later than three months prior to the applicable monitoring date in Table 1. If the department does not respond to a system regarding the submitted sampling plan prior to the start of the monitoring period, the system must sample according to the submitted sampling plan.

(2) The plan must be submitted in a form acceptable to the department.

(3) The system must monitor within two days of the date specified in the plan, unless one of the following conditions occurs.

1. If an extreme condition or situation exists that may pose danger to the sample collector, or that cannot be avoided, and causes the system to be unable to sample in the scheduled five-day period, the system must sample as close to the scheduled date as is feasible unless the department approves an alternative sampling date. The system must submit an explanation for the delayed sampling date to the department within one week of the missed sampling period. A replacement sample must be collected.

2. If a system is unable to report a valid analytical result for a scheduled sampling date due to equipment failure, loss of or damage to the sample, failure to comply with the analytical method or quality control requirements, or failure of the laboratory to analyze the sample, the system must notify the department of the cause of the delay and collect a replacement sample.

3. A replacement sample must be collected within 21 days of the scheduled sampling period or on the resampling date approved by the department.

(4) Missed sampling dates. Systems that fail to meet the dates in their sampling plan for any source water sample must revise their sampling plan to add dates for collecting all missed samples. The revised schedule must be submitted to the department for approval prior to the collection of the missed samples.

d. Sampling locations. Systems must collect samples for each treatment plant that treats a surface water or influenced groundwater source. If multiple plants draw water from the same influent (same pipe or intake), the department may approve one set of monitoring results to be used to satisfy the requirements for those plants.

(1) Chemical treatment location. Systems must collect source water samples prior to chemical treatment. If the system cannot feasibly collect a sample prior to chemical treatment, the department may grant approval for the system to collect the sample after chemical treatment. This approval would only be granted if the department determines in writing that collecting the samples prior to chemical treatment is not feasible for the system and that the chemical treatment is unlikely to have a significant adverse effect on the analysis of the sample.

(2) Filter backwash recycle return location. Systems that recycle filter backwash water must collect the source water samples prior to the point of filter backwash water addition.

(3) Bank filtration credit sampling location.

1. Systems that receive *Cryptosporidium* treatment credit for bank filtration under 43.9(3)*"b"* or 43.10(4)*"c"* must collect source water samples in the surface water source prior to bank filtration.

2. Systems that use bank filtration as pretreatment to a filtration plant must collect source water samples from the well, which is after bank filtration has occurred. Use of bank filtration during monitoring must be consistent with routine operational practice. Systems collecting samples after a bank filtration process may not receive treatment credit for the bank filtration under 43.11(10)*"c."*

(4) Multiple sources. Systems with plants that use multiple water sources, including multiple surface water sources and blended surface water and groundwater sources, must collect samples as follows:

1. The use of multiple sources during monitoring must be consistent with routine operational practice.

2. If a sampling tap is available where the sources are combined prior to treatment, the system must collect samples from that tap.

3. If a sampling tap where the sources are combined prior to treatment is not available, the system must collect samples at each source near the intake on the same day and must use either of the following options for sample analysis.

- Physically composite the source samples into a single sample for analysis. Systems may composite the sample from each source into one sample prior to analysis. The volume of the sample from each source must be weighted according to the proportion of the source in the total plant flow at the time the sample is collected.
- Analyze the samples separately and mathematically composite the results. Systems may analyze samples from each source separately and calculate a weighted average of the analytical results for each sampling date. The weighted average must be calculated by multiplying the analytical result

for each source by the fraction that source contributed to the total plant flow at the time the sample was collected and then summing the weighted analytical results.

e. Analytical methodology, laboratory certification, and data reporting requirements. Systems must have samples analyzed pursuant to the specifications listed in this paragraph. The system must report, in a format acceptable to the department, the analytical results from the source water monitoring no later than ten days after the end of the first month following the month when the sample is collected.

(1) *Cryptosporidium.* Systems must have *Cryptosporidium* samples analyzed by a laboratory that is approved under EPA's Laboratory Quality Assurance Evaluation Program for Analysis of *Cryptosporidium* in Water.

1. These are the approved analytical methods for *Cryptosporidium*:

- "Method 1623: *Cryptosporidium* and *Giardia* in Water by Filtration/IMS/FA," 2005, US EPA, EPA-815-R-05-002. Available at www.nemi.gov;
- "Method 1622: *Cryptosporidium* in Water by Filtration/IMS/FA," 2005, US EPA, EPA-815-R-05-001. Available at www.nemi.gov; and
- "Method 1623.1: *Cryptosporidium* and *Giardia* in Water by Filtration/Immunomagnetic Separation/Immunofluorescence Assay Microscopy," 2012, EPA-816-R-12-001. Available at www.nepis.epa.gov.

2. Using one of the approved methods, the laboratory must analyze at least a 10 L sample or a packed pellet volume of at least 2 mL. Systems unable to process a 10 L sample must analyze as much sample volume as can be filtered by two filters specified in the method, up to a packed pellet volume of at least 2 mL.

3. A matrix spike (MS) sample must be spiked and filtered by the laboratory according to the approved method. If the volume of the MS sample is greater than 10 L, the system may filter all but 10 L of the MS sample in the field and ship the filtered sample and the remaining 10 L of source water to the laboratory. In this case, the laboratory must spike the remaining 10 L of water and filter it through the filter used to collect the balance of the sample in the field.

4. Flow cytometer-counted spiking suspensions must be used for the matrix spike samples and the ongoing precision and recovery samples.

5. The following data elements must be reported for each *Cryptosporidium* analysis:

- PWSID.
- Facility ID.
- Sample collection date.
- Sample type (i.e., field or matrix spike).
- Sample volume filtered (L), to the nearest 0.25 L.
- Whether 100 percent of the filtered volume was examined by the laboratory.
- Number of oocysts counted.
- For matrix spike samples: sample volume spiked and estimated number of oocysts spiked.
- For samples in which less than 10 L is filtered or less than 100 percent of the sample volume is examined: the number of filters used and the packed pellet volume.
- For samples in which less than 100 percent of sample volume is examined: the volume of resuspended concentrate and the volume of this resuspension processed through immunomagnetic separation.

(2) *E. coli.* Systems must have the *E. coli* samples analyzed by a laboratory certified by EPA, the National Environmental Laboratory Accreditation Conference, or the department for total coliform or fecal coliform analysis in drinking water samples using the same approved *E. coli* method for the analysis of source water.

1. The approved analytical methods for the enumeration of *E. coli* in source water are shown in Table 2.

Table 2: *E. coli* Analytical Methods

Method	EPA	Standard Methods	Other
Most probable number with multiple tube or multiple well[1, 2]		9223 B[11]	991.15[4] Colilert[3, 5] Colilert-18[3, 5, 6]
Membrane filtration, single step[1, 7, 8]	1603[9]		m-ColiBlue24[10]
Membrane filtration, two step		9222D/9222G[12]	

[1]Tests must be conducted to provide organism enumeration (i.e., density). Select the appropriate configuration of tubes/filtrations and dilutions/volumes to account for the quality, consistency, and anticipated organism density in the water sample.

[2]Samples shall be enumerated by the multiple-tube or multiple-well procedure. Using multiple-tube procedures, employ an appropriate tube and dilution configuration of the sample as needed and report the Most Probable Number (MPN). Samples tested with Colilert® may be enumerated with the multiple-well procedures, Quanti-Tray®, Quanti-Tray® 2000, and the MPN calculated from the table provided by the manufacturer.

[3]These tests are collectively known as defined enzyme substrate tests, where, for example, a substrate is used to detect the enzyme beta-glucouronidase produced by *E. coli*.

[4]Association of Official Analytical Chemists, International. "Official Methods of Analysis of AOAC International, 16th Ed., Volume 1, Chapter 17, 1995. AOAC, 481 N. Frederick Ave., Suite 500, Gaithersburg, MD 20877-2417.

[5]Descriptions of the Colilert®, Colilert-18®, Quanti-Tray®, and Quanti-Tray® 2000 may be obtained from IDEXX Laboratories, Inc., 1 IDEXX Drive, Westbrook, ME 04092.

[6]Colilert-18® is an optimized formulation of the Colilert® for the determination of total coliforms and *E. coli* that provides results within 18 hours of incubation at 35 degrees C rather than the 24 hours required for the Colilert® test.

[7]The filter must be a 0.45 micron membrane filter or a membrane filter with another pore size certified by the manufacturer to fully retain organisms to be cultivated and to be free of extractables which could interfere with organism growth.

[8]When the membrane filter method has been used previously to test waters with high turbidity or large numbers of noncoliform bacteria, a parallel test should be conducted with a multiple-tube technique to demonstrate applicability and comparability of results.

[9]"Method 1603: *Escherichia coli (E. coli)* in Water by Membrane Filtration Using Modified Membrane-Thermotolerant *Escherichia coli* Agar (modified mTEC), USEPA, July 2006." US EPA, Office of Water, Washington, DC, EPA 821-R-06-011. Available at www.nepis.epa.gov.

[10]A description of the m-ColiBlue24® test, Total Coliforms and *E. coli*, is available from Hach Company, 100 Dayton Ave., Ames, IA 50010.

[11]Standard Methods for the Analysis of Water and Wastewater, 18th (1992), 19th (1995), and 20th (1998) editions, American Public Health Association. Available from APHA, 800 I Street, NW, Washington, DC 20001-3710.

[12]Standard Methods for the Examination of Water and Wastewater, 20th edition (1998). Available from APHA, 800 I Street, NW, Washington, DC 20001-3710.

2. The holding time (the time period from sample collection to initiation of analysis) shall not exceed 30 hours. The department may approve on a case-by-case basis an extension of the holding time to 48 hours, if the 30-hour holding time is not feasible. If the extension is allowed, the laboratory must use the Colilert® reagent version of the Standard Methods 9223B to conduct the analysis.

3. The samples must be maintained between 0 and 10 degrees C during storage and transit to the laboratory.

4. The following data elements must be reported for each *E. coli* analysis:

- PWSID.
- Facility ID.
- Sample collection date.
- Analytical method number.
- Method type.
- Source type (flowing stream or river; lake or reservoir; or influenced groundwater).
- Number of *E. coli* per 100 mL.
- Turbidity in NTU.

(3) Turbidity. The approved analytical methods for turbidity are listed in 43.5(4)*"a"*(1). Measurements of turbidity must be made by a party approved by the department, and reported on the laboratory data sheet with the corresponding *E. coli* sample.

43.11(4) *Disinfection profiling and benchmarking.*

a. General requirements. Following completion of the first round of source water monitoring, a system that plans to make a significant change to its disinfection practice must develop disinfection profiles and calculate disinfection benchmarks for *Giardia lamblia* and viruses.

(1) Notification to the department. The system must notify the department prior to changing its disinfection practice and must include in the notice the completed disinfection profile and disinfection benchmark for *Giardia lamblia* and viruses, a description of the proposed change in disinfection practice, and an analysis of how the proposed change will affect the current level of disinfection.

(2) Definition of "significant change." A significant change to the disinfection practice is defined as follows:

1. Any change to the point of disinfection;
2. Any change to the disinfectant(s) used in the treatment plant;
3. Any change to the disinfection process; or
4. Any other modification identified by the department as a significant change to disinfection practice.

b. Developing the disinfection profile. In order to develop a disinfection profile, a system must monitor at least weekly for a period of 12 consecutive months to determine the total log inactivation for *Giardia lamblia* and viruses. If a system monitors more frequently, the monitoring frequency must be evenly spaced. A system that operates for fewer than 12 months per year must monitor weekly during the period of operation. A system must determine log inactivation for *Giardia lamblia* through the entire plant, based on $CT_{99.9}$ values in Appendix A, Tables 1 through 6, as applicable. Systems must determine log inactivation for viruses through the entire treatment plant based on a protocol approved by the department.

(1) Monitoring requirements. Systems with a single point of disinfectant application prior to the entrance to the distribution system must conduct the monitoring listed in this subparagraph. Systems with multiple points of disinfectant application must conduct the same monitoring for each disinfection segment. Systems must monitor the parameters necessary to determine the total inactivation ratio. The analytical methods for the parameters are listed in 43.5(4)*"a."* All measurements must be taken during peak hourly flow.

1. For systems using a disinfectant other than UV, the temperature of the disinfected water must be measured in degrees Celsius at each residual disinfectant concentration sampling point or at an alternative location approved by the department.
2. For systems using chlorine, the pH of the disinfected water must be measured at each chlorine residual disinfectant concentration sampling point or at an alternative location approved by the department.
3. The disinfectant contact time must be determined in minutes.
4. The residual disinfectant concentrations of the water must be determined in mg/L before or at the first customer and prior to each additional point of disinfectant application.
5. A system may use existing data to meet the monitoring requirements if the data are substantially equivalent to the required data, the system has not made any significant change to its treatment practice, and the system has the same source water as it had when the data were collected. Systems may develop disinfection profiles using up to three years of existing data.
6. A system may use disinfection profiles developed under 43.9(2) or 43.10(2) if the system has not made a significant change to its treatment practice and has the same source water as it had when the profile was developed. The virus profile must be developed using the same data on which the *Giardia lamblia* profile is based.

(2) Calculation of the total inactivation ratio for *Giardia lamblia*.

1. Systems using only one point of disinfectant application may determine the total inactivation ratio ($CT_{calc}/CT_{99.9}$) for the disinfection segment using either of the following methods.

- Determine one inactivation ratio before or at the first customer during peak hourly flow.
- Determine successive sequential inactivation ratios between the point of disinfectant application and a point before or at the first customer during peak hourly flow. Calculate the total inactivation ratio by determining the inactivation ratio for each sequence ($CT_{calc}/CT_{99.9}$) and adding the values together.

2. Systems using more than one point of disinfectant application before the first customer must 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. Calculate the ($CT_{calc}/CT_{99.9}$) value of each segment and add the values together to determine the total inactivation ratio.

3. Systems must then determine the total logs of inactivation by multiplying the total inactivation ratio by 3.0.

(3) Calculation of the total inactivation ratio for viruses. The system must calculate the log of inactivation for viruses using a protocol approved by the department.

c. Calculation of the disinfection benchmark.

(1) For each year of profiling data collected and calculated under this subrule, systems must determine the lowest mean monthly level of both *Giardia lamblia* and virus inactivation. Systems must determine the mean *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.

(2) For a system with one year of profiling data, the disinfection benchmark is the lowest monthly mean value. For a system with more than one year of profiling data, the disinfection benchmark is the mean of the lowest monthly mean values of *Giardia lamblia* and virus log inactivation in each year of profiling data.

43.11(5) *Bin classification.* Upon completion of the first round of source water monitoring, systems must calculate an initial *Cryptosporidium* bin concentration for each plant for which monitoring was required. Calculation of the bin concentration must use the *Cryptosporidium* results reported under 43.11(3)*"a."*

a. Calculation of mean Cryptosporidium or bin concentration value.

(1) Systems that collect at least 48 samples. For systems that collect a total of at least 48 samples, the bin concentration is equal to the arithmetic mean of all sample concentrations.

(2) Systems that collect 24 to 47 samples. For systems that collect at least 24 samples but not more than 47 samples, the bin concentration is equal to the highest arithmetic mean of all sample concentrations in any 12 consecutive months during which *Cryptosporidium* samples were collected.

(3) Systems serving fewer than 10,000 people and monitoring for only one year. For systems that serve fewer than 10,000 people and monitor *Cryptosporidium* for only one year (i.e., 24 samples in 12 months), the bin concentration is equal to the arithmetic mean of all sample concentrations.

(4) Systems with plants operating on a part-time basis. For systems with plants operating only part of the year that monitor fewer than 12 months per year, the bin concentration is equal to the highest arithmetic mean of all sample concentrations during any year of *Cryptosporidium* monitoring.

(5) If the monthly *Cryptosporidium* sampling frequency varies, systems must first calculate a monthly average for each month of monitoring. Systems must then use these monthly average concentrations, rather than individual sample concentrations, in the applicable calculation for bin classification.

b. Determination of bin classification.

(1) First monitoring round. A system must determine the bin classification from Table 3, using its calculated bin concentration from 43.11(5)*"a."*

Table 3: Bin Classification Table

System Type	*Cryptosporidium* Concentration, in oocysts/L	Bin Classification
Systems required to monitor for *Cryptosporidium* under 43.11(3)*"b"*(1) or 43.11(3)*"b"*(2)"3"	Fewer than 0.075 oocysts/L	Bin 1
	Between 0.075 and fewer than 1.0 oocysts/L	Bin 2
	Between 1.0 and fewer than 3.0 oocysts/L	Bin 3
	3.0 oocysts/L or greater	Bin 4
Systems serving fewer than 10,000 and not required to monitor for *Cryptosporidium*, pursuant to 43.11(3)*"b"*(2)"1"	Not applicable	Bin 1

(2) Second monitoring round. Following completion of the second round of source water monitoring, a system must recalculate its bin concentration and determine its new bin classification, using the same protocols outlined in 43.11(5)*"a"* and *"b."*

c. Reporting bin classification to the department. Within six months of the end of the sampling period, the system must report its bin classification to the department for approval. The report must also include a summary of the source water monitoring data and the calculation procedure used to determine the bin classification.

d. Treatment technique violation. Failure to comply with 43.11(5)*"b"* and *"c"* is a violation of the treatment technique requirement.

43.11(6) *Additional Cryptosporidium treatment requirements.* A system must provide the level of additional treatment for *Cryptosporidium* specified in Table 4 based on its bin classification determined in 43.11(5) and according to the schedule in 43.11(7).

a. Determination of additional Cryptosporidium treatment requirements. Using Table 4, a system must determine any additional treatment requirements based upon its bin classification. The Bin 1 classification does not require any additional treatment. Bins 2 through 4 require additional *Cryptosporidium* treatment.

Table 4: Additional *Cryptosporidium* Treatment Requirements

Bin Classification	Treatment Used by the System for Compliance with 43.5, 43.9, and 43.10			
	Conventional filtration (including softening)	Direct filtration	Slow sand or diatomaceous earth filtration	Alternative filtration technologies
Bin 1	No additional treatment	No additional treatment	No additional treatment	No additional treatment
Bin 2	1-log treatment	1.5-log treatment	1-log treatment	At least 4.0-log[1]
Bin 3	2-log treatment	2.5-log treatment	2-log treatment	At least 5.0-log[1]
Bin 4	2.5-log treatment	3-log treatment	2.5-log treatment	At least 5.5-log[1]

[1]The total *Cryptosporidium* removal and inactivation must be at least this value, as determined by the department.

b. Treatment requirements for Bins 2 through 4. A system that is classified as Bin 2, 3, or 4 must use one or more of the treatment and management options listed in 43.11(8) to comply with the required additional *Cryptosporidium* treatment. Systems classified as Bins 3 and 4 must achieve at least 1-log of the additional *Cryptosporidium* treatment required by using either one or a combination of the following: bag filters, bank filtration, cartridge filters, chlorine dioxide, membranes, ozone, or UV, as listed in 43.11(9) through 43.11(13).

c. Treatment technique violation. Failure by a system in any month to achieve treatment credit by meeting criteria in 43.11(9) through 43.11(13) that is at least equal to the level of treatment required in 43.11(6)*"a"* is a violation of the treatment technique requirement.

d. Significant changes to the watershed. If, after the system's completion of source water monitoring (either round), the department determines during a sanitary survey or an equivalent source water assessment that significant changes occurred in the system's watershed that could lead to

increased contamination of the source water by *Cryptosporidium*, the system must take actions specified by the department to address the contamination. These actions may include additional source water monitoring and implementing microbial toolbox options listed in 43.11(8).

43.11(7) *Schedule for compliance with Cryptosporidium treatment requirements.* Following the initial bin classification under 43.11(5), systems must provide the level of treatment for *Cryptosporidium* required in 43.11(6), according to the schedule in Table 5. If the bin classification of a system changes following the second round of source water monitoring, the system must provide the level of treatment for *Cryptosporidium* required in 43.11(6), on a schedule approved by the department.

Table 5: *Cryptosporidium* Treatment Compliance Dates

Schedule	Population Served by System	Compliance Date for *Cryptosporidium* treatment requirements[1]
1	At least 100,000 people	April 1, 2012
2	From 50,000 to 99,999 people	October 1, 2012
3	From 10,000 to 49,999 people	October 1, 2013
4	Fewer than 10,000 people	October 1, 2014

[1]The department may allow up to an additional two years for compliance with the treatment requirement if the system must make capital improvements.

43.11(8) *Microbial toolbox options for meeting Cryptosporidium treatment requirements.* Systems receive the treatment credits listed in Table 6 by meeting the conditions for microbial toolbox options described in 43.11(9) through 43.11(13). Systems apply these treatment credits to meet the treatment requirements in 43.11(6). Table 6 summarizes options in the microbial toolbox.

Table 6: Microbial Toolbox Summary Table: Options, Treatment Credits, and Criteria

Toolbox Option	Specific Criteria Rule	*Cryptosporidium* treatment credit with design and implementation criteria
Source Protection and Management Toolbox Options		
Watershed control program	43.11(9)	0.5-log credit for department-approved program comprising required elements, annual program status report to department, and regular watershed survey.
Alternative source/intake management	43.11(9)*"b"*	No prescribed credit. Systems may conduct simultaneous monitoring for treatment bin classification at alternative intake locations or under alternative intake management strategies.
Prefiltration Toolbox Options		
Presedimentation basin with coagulation	43.11(10)*"a"*	0.5-log credit during any month that presedimentation basins achieve a monthly mean reduction of 0.5-log or greater in turbidity or alternative department-approved performance criteria. To be eligible, basins must be operated continuously with coagulant addition and all plant flow must pass through the basins.
Two-stage lime softening	43.11(10)*"b"*	0.5-log credit for two-stage softening where chemical addition and hardness precipitation occur in both stages. All plant flow must pass through both stages. Single-stage softening is credited as equivalent to conventional treatment.

Toolbox Option	Specific Criteria Rule	*Cryptosporidium* treatment credit with design and implementation criteria
Bank filtration	43.11(10)*"c"*	0.5-log credit for 25-foot setback; 1.0-log credit for 50-foot setback; aquifer must be unconsolidated sand containing at least 10 percent fines; average turbidity in wells must be less than 1 NTU. A system using a well followed by filtration when conducting source water monitoring must sample the well to determine bin classification and is not eligible for additional credit.
Treatment Performance Toolbox Options		
Combined filter performance	43.11(11)*"a"*	0.5-log credit for combined filter effluent turbidity less than or equal to 0.15 NTU in at least 95 percent of measurements each month.
Individual filter performance	43.11(11)*"b"*	0.5-log credit (in addition to the 0.5-log combined filter performance credit) if individual filter effluent turbidity is less than or equal to 0.15 NTU in at least 95 percent of samples each month in each filter and is never greater than 0.3 NTU in two consecutive measurements in any filter.
Demonstration of performance	43.11(11)*"c"*	Credit awarded to unit process or treatment train based on a demonstration to the department with a department-approved protocol.
Additional Filtration Toolbox Options		
Bag or cartridge filters (individual filters)	43.11(12)*"a"*	Up to 2-log credit based on the removal efficiency demonstrated during challenge testing with a 1.0-log factor of safety.
Bag or cartridge filters (in series)	43.11(12)*"a"*	Up to 2.5-log credit based on the removal efficiency demonstrated during challenge testing with a 0.5-log factor of safety.
Membrane filtration	43.11(12)*"b"*	Log credit equivalent to removal efficiency demonstrated in challenge test for device if supported by direct integrity testing.
Second-stage filtration	43.11(12)*"c"*	0.5-log credit for second separate granular media filtration stage if treatment train includes coagulation prior to first filter.
Slow sand filtration	43.11(12)*"d"*	2.5-log credit as a secondary filtration step; 3.0-log credit as a primary filtration process. No prior chlorination for either option.
Inactivation Toolbox Options		
Chlorine dioxide	43.11(13)	Log credit based on measured CT in relation to CT table.
Ozone	43.11(13)	Log credit based on measured CT in relation to CT table.
Ultraviolet light (UV)	43.11(13)	Log credit based on validated UV dose in relation to UV dose table; reactor validation testing required to establish UV dose and associated operating conditions.

43.11(9) *Source toolbox components.*

a. Watershed control program. Systems receive 0.5-log *Cryptosporidium* treatment credit for implementing a watershed control program that meets the requirements of this paragraph.

(1) Notification. Systems that intend to apply for the watershed control program credit must notify the department of this intent no later than two years prior to the treatment compliance date in 43.11(7) applicable to the system.

(2) Proposed watershed control plan. Systems must submit to the department a proposed watershed control plan no later than one year before the applicable treatment compliance date in 43.11(7). The department must approve the watershed control plan for the system to receive watershed control program treatment credit. The watershed control plan must include the following elements:

1. Identification of an "area of influence" outside of which the likelihood of *Cryptosporidium* or fecal contamination affecting the treatment plant intake is not significant. This is the area to be evaluated in future watershed surveys under 43.11(9)*"a"*(5)"2."

2. Identification of both potential and actual sources of *Cryptosporidium* contamination and an assessment of the relative impact of these sources on the system's source water quality.

3. An analysis of the effectiveness and feasibility of control measures that could reduce *Cryptosporidium* loading from sources of contamination to the system's source water.

4. A statement of goals and specific actions the system will undertake to reduce source water *Cryptosporidium* levels. The plan must explain how the actions are expected to contribute to specific goals, identify watershed partners and their roles, identify resource requirements and commitments, and include a schedule for plan implementation with deadlines for completing specific actions identified in the plan.

(3) Existing watershed control programs. Systems with watershed control programs that were in place on January 5, 2006, are eligible to seek this credit. The systems' watershed control plans must meet the criteria in 43.11(9)*"a"*(2) and must specify ongoing and future actions that will reduce source water *Cryptosporidium* levels.

(4) Department response to submitted plan. If the department does not respond to a system regarding approval of a watershed control plan submitted under this subrule and the system meets the other requirements of this subrule, the watershed control program will be considered approved and 0.5-log *Cryptosporidium* treatment credit will be awarded unless and until the department subsequently withdraws such approval.

(5) System requirements to maintain 0.5-log credit. Systems must complete the following actions to maintain the 0.5-log credit.

1. Submit an annual watershed control program status report to the department. The annual watershed control program status report must describe the system's implementation of the approved plan and assess the adequacy of the plan to meet its goals. The plan must explain how the system is addressing any shortcomings in plan implementation, including those previously identified by the department or as a result of the watershed survey conducted under 43.11(9)*"a"*(5)"2." It must also describe any significant changes that have occurred in the watershed since the last watershed sanitary survey. If a system determines during implementation that making a significant change to its approved watershed control program is necessary, the system must notify the department prior to making any such changes. If any change is likely to reduce the level of source water protection, the system must also list in its notification the actions the system will take to mitigate this effect.

2. Undergo a watershed sanitary survey every three years for community water systems and every five years for noncommunity water systems and submit the survey report to the department. The survey must be conducted according to department guidelines and by persons acceptable to the department.

- The watershed sanitary survey must meet the following criteria: encompass the region identified in the department-approved watershed control plan as the area of influence; assess the implementation of actions to reduce source water *Cryptosporidium* levels; and identify any significant new sources of *Cryptosporidium.*
- If the department determines that significant changes may have occurred in the watershed since the previous watershed sanitary survey, systems must undergo another watershed sanitary survey by the date specified by the department, which may be earlier than the regular schedule of a three- or five-year frequency.

3. The system must make the watershed control plan, annual status reports, and watershed sanitary survey reports available to the public upon request. These documents must be in a plain language style and include criteria by which to evaluate the success of the program in achieving plan goals. The department may approve systems to withhold portions of an annual status report, watershed control plan, and watershed sanitary survey from the public, based on water supply security considerations.

(6) Withdrawal of watershed control program treatment credit. If the department determines that a system is not carrying out the approved watershed control plan, the department may withdraw the watershed control program treatment credit.

b. Alternative source. A system may conduct source water monitoring that reflects a different intake location (either in the same source or for an alternate source) or a different procedure for the timing or level of withdrawal from the source (alternative source monitoring). If the department approves, a system may determine its bin classification under 43.11(5) based on alternative source monitoring results.

(1) Systems conducting alternative source monitoring must also monitor their current plan intake concurrently, as described in 43.11(3).

(2) Alternative source monitoring must meet the requirements for source monitoring to determine bin classification, as described in 43.11(3). Systems must report to the department the alternative source monitoring results and provide supporting information documenting the operating conditions under which the samples were collected.

(3) If a system determines its bin classification under 43.11(5) using alternative source monitoring results that reflect a different intake location or a different procedure for managing the timing or level of withdrawal from the source, the system must relocate the intake or permanently adopt the withdrawal procedure, as applicable, no later than the applicable treatment compliance date in 43.11(7).

43.11(10) *Prefiltration treatment toolbox components.*

a. Presedimentation. Systems receive 0.5-log *Cryptosporidium* treatment credit for a presedimentation basin during any month the process meets the criteria in this paragraph.

(1) The presedimentation basin must be in continuous operation and must treat the entire plant flow taken from a surface water or influenced groundwater source.

(2) The system must continuously add a coagulant to the presedimentation basin.

(3) The presedimentation basin must achieve either of the following performance criteria:

1. Demonstrates at least 0.5-log mean reduction of influent turbidity. This reduction must be determined using daily turbidity measurements in the presedimentation process influent and effluent and must be calculated as follows: LOG_{10}(monthly mean of daily influent turbidity) – LOG_{10}(monthly mean of daily effluent turbidity).

2. Complies with department-approved performance criteria that demonstrate at least 0.5-log mean removal of micron-sized particulate material through the presedimentation process.

b. Two-stage lime softening. Systems receive an additional 0.5-log *Cryptosporidium* treatment credit for a two-stage lime softening plant if chemical addition and hardness precipitation occur in two separate and sequential softening stages prior to filtration. Both softening stages must treat the entire plant flow taken from a surface water or influenced groundwater source.

c. Bank filtration. Systems receive *Cryptosporidium* treatment credit for bank filtration that serves as pretreatment to a filtration plant by meeting the criteria in this paragraph. Systems using bank filtration when they begin source water monitoring under 43.11(3)*"a"* must collect samples as described in 43.11(3)*"d"*(3) and are not eligible for this credit.

(1) Treatment credit. Wells with a groundwater flow path of at least 25 feet receive 0.5-log treatment credit; wells with a groundwater flow path of at least 50 feet receive 1.0-log treatment credit. The groundwater flow path must be determined as specified in 43.11(10)*"c"*(4).

(2) Granular aquifers only. Only wells in granular aquifers are eligible for treatment credit. Granular aquifers are those comprised of sand, clay, silt, rock fragments, pebbles or larger particles, and minor cement. A system must characterize the aquifer at the well site to determine aquifer properties. Systems must extract a core from the aquifer and demonstrate that in at least 90 percent of the core length, grains less than 1.0 mm in diameter constitute at least 10 percent of the core material.

(3) Horizontal and vertical wells only. Only horizontal and vertical wells are eligible for treatment credit.

(4) Measurement of groundwater flow path. For vertical wells, the groundwater flow path is the measured distance from the edge of the surface water body under high flow conditions (determined by the 100-year floodplain elevation boundary or by the floodway, as defined in Federal Emergency Management Agency flood hazard maps) to the well screen. For horizontal wells, the groundwater flow path is the measured distance from the bed of the river under normal flow conditions to the closest horizontal well lateral screen.

(5) Turbidity monitoring at the wellhead. Systems must monitor each wellhead for turbidity at least once every four hours while the bank filtration process is in operation. If monthly average turbidity levels, based on daily maximum values in the well, exceed 1 NTU, the system must report this result to the department and conduct an assessment within 30 days to determine the cause of the high turbidity levels in the well. If the department determines that microbial removal has been compromised, the department may revoke treatment credit until the system implements corrective actions approved by the department to remediate the problem.

(6) Springs and infiltration galleries. This treatment credit is not eligible for springs and infiltration galleries. Springs and infiltration galleries are eligible for credit through demonstration of performance study under 43.11(11)*"c."*

(7) Bank filtration demonstration of performance. The department may approve *Cryptosporidium* treatment credit for bank filtration based on a demonstration of performance study that meets the criteria in this subparagraph. This treatment credit may be greater than 1.0-log and may be awarded to bank filtration that does not meet the criteria in 43.11(10)*"c"*(1) to (5).

1. The study must follow a protocol approved by the department and must involve the collection of data on the removal of *Cryptosporidium* or a surrogate for *Cryptosporidium* and related hydrogeologic and water quality parameters during the full range of operating conditions.

2. The study must include sampling both from the production well(s) and from monitoring wells that are screened and located along the shortest flow path between the surface water source and the production well(s).

43.11(11) *Treatment performance toolbox components.* This option pertains to physical treatment processes.

a. Combined filter performance. Systems using conventional filtration treatment or direct filtration treatment receive an additional 0.5-log *Cryptosporidium* treatment credit during any month the system meets the criteria in this paragraph. Combined filter effluent (CFE) turbidity must be less than or equal to 0.15 NTU in at least 95 percent of the measurements. Turbidity must be measured as described in 43.5(4) and, if applicable, 43.10(4).

b. Individual filter performance. Systems using conventional filtration treatment or direct filtration treatment receive 0.5-log *Cryptosporidium* treatment credit during any month the system meets the criteria in this paragraph, which can be in addition to the CFE 0.5-log credit from 43.11(11)*"a."* Compliance with these criteria must be based on individual filter turbidity monitoring as described in 43.9(4) or 43.10(5), as appropriate.

(1) The filtered water turbidity for each individual filter must be less than or equal to 0.15 NTU in at least 95 percent of the measurements recorded each month.

(2) No individual filter may have a measured turbidity greater than 0.3 NTU in two consecutive measurements taken 15 minutes apart.

(3) Any system that has received treatment credit for individual filter performance and fails to meet the requirements of 43.11(11)*"b"*(2) and (3) during any month shall not receive a treatment technique violation under 43.11(6) if the department determines the following:

1. The failure was due to unusual and short-term circumstances that could not reasonably be prevented through optimizing the treatment plant design, operation, and maintenance.

2. The system has experienced no more than two such failures in any calendar year.

c. Demonstration of performance. The department may approve *Cryptosporidium* treatment credit for drinking water treatment processes based on a demonstration of performance study that meets

the criteria in this paragraph. This treatment credit may be greater than or less than the prescribed treatment credits in 43.11(6) or 43.11(10) through 43.11(13) and may be awarded to treatment processes that do not meet the criteria for the prescribed credits.

(1) Systems cannot receive the prescribed treatment credit for any toolbox option in 43.11(10) through 43.11(13) if that toolbox option is included in a demonstration of performance study for which treatment credit is awarded under this paragraph.

(2) The demonstration of performance study must follow a department-approved protocol and must demonstrate the level of *Cryptosporidium* reduction the treatment process will achieve under the full range of expected operating conditions for the system.

(3) Approval by the department must be in writing and may include monitoring and treatment performance criteria that the system must demonstrate and report on an ongoing basis to remain eligible for the treatment credit. The department may designate such criteria where necessary to verify that the conditions under which the demonstration of performance credit was approved are maintained during routine operation.

43.11(12) *Additional filtration toolbox components.*

a. Bag and cartridge filters. By meeting the criteria in this paragraph, systems receive *Cryptosporidium* treatment credit of up to 2.0-log for the use of individual bag or cartridge filters and up to 2.5-log for the use of bag or cartridge filters operated in series. To be eligible for this credit, systems must report the results of challenge testing that meets the requirements of 43.11(12)*"a"*(2) through 43.11(12)*"a"*(9) to the department. The filters must treat the entire plant flow taken from a surface water or influenced groundwater source.

(1) The *Cryptosporidium* treatment credit awarded for use of bag or cartridge filters must be based on the removal efficiency demonstrated during challenge testing that is conducted in accordance with the criteria in 43.11(12)*"a"*(2) through 43.11(12)*"a"*(9). A safety factor equal to 1-log for individual bag or cartridge filters and 0.5-log for bag or cartridge filters in series must be applied to challenge testing results to determine removal credit. Systems may use results from challenge testing conducted prior to January 5, 2006, if the prior testing was consistent with the criteria specified in this paragraph.

(2) Challenge testing must be performed on full-scale bag or cartridge filters, and the associated filter housing or pressure vessel, that are identical in material and construction to the filters and housings the system will use for removal of *Cryptosporidium*. Bag or cartridge filters must be challenge tested in the same configuration that the system will use, either as individual filters or as a series configuration of filters.

(3) Challenge testing must be conducted using *Cryptosporidium* or a surrogate that is removed no more efficiently than *Cryptosporidium*. The microorganism or surrogate used during challenge testing is referred to as the challenge particulate. The concentration of the challenge particulate must be determined using a method capable of discretely quantifying the specific microorganisms or surrogate used in the test; gross measurements such as turbidity shall not be used.

(4) The maximum feed water concentration that can be used during a challenge test must be based on the detection limit of the challenge particulate in the filtrate (i.e., filtrate detection limit) and must be calculated using this equation:

Maximum Feed Water Concentration = 10,000 × Filtrate Detection Limit

(5) Challenge testing must be conducted at the maximum design flow rate for the filter as specified by the manufacturer.

(6) Each filter evaluated must be tested for a duration sufficient to reach 100 percent of the terminal pressure drop, which thereby establishes the maximum pressure drop under which the filter may be used to comply with the requirements of this paragraph.

(7) Removal efficiency of a filter must be determined from the results of the challenge test and expressed in terms of log removal values using the following equation:

$LRV = LOG_{10}(C_f) - LOG_{10}(C_p)$

Where:

LRV = log removal value demonstrated during challenge test;

C_f = the feed concentration measured during the challenge test; and

C_p = the filtrate concentration measured during the challenge test.

Equivalent units must be used for the feed and filtrate concentrations. If the challenge particulate is not detected in the filtrate, the term C_p must be set equal to the detection limit.

(8) Each filter tested must be challenged with the challenge particulate during three periods over the filtration cycle: within two hours of start-up of a new filter; when the pressure drop is between 45 and 55 percent of the terminal pressure drop; and at the end of the cycle after the pressure drop has reached 100 percent of the terminal pressure drop. An LRV must be calculated for each of these challenge periods for each filter tested. The LRV for the filter (LRV_{filter}) must be assigned the value of the minimum LRV observed during the three challenge periods for that filter.

(9) If fewer than 20 filters are tested, the overall removal efficiency for the filter product line must be set equal to the lowest LRV_{filter} among the filters tested. If 20 or more filters are tested, the overall removal efficiency for the filter product line must be set equal to the tenth percentile of the set of LRV_{filter} values for the various filters tested. The percentile is defined by [i/(n+1)] where "i" is the rank of "n" individual data points ordered lowest to highest. If necessary, the tenth percentile may be calculated using linear interpolation.

(10) If a previously tested filter is modified in a manner that could change the removal efficiency of the filter product line, challenge testing to demonstrate the removal efficiency of the modified filter must be conducted and submitted to the department.

b. Membrane filtration.

(1) Systems receive *Cryptosporidium* treatment credit for using membrane filtration that meets the criteria of this paragraph. Systems using membrane cartridge filters that meet the definition of membrane filtration in 567—40.2(455B) are eligible for this credit. The level of treatment credit a system receives is equal to the lower of the values determined under the following two paragraphs:

1. The removal efficiency demonstrated during challenge testing conducted under the criteria in 43.11(12)*"b"*(2).

2. The maximum removal efficiency that can be verified through direct integrity testing used with the membrane filtration process under the conditions in 43.11(12)*"b"*(3).

(2) Challenge testing. The membrane used by the system must undergo challenge testing to evaluate removal efficiency, and the system must report the results of challenge testing to the department. Challenge testing must be conducted according to the criteria listed in this subparagraph. Systems may use data from challenge testing conducted prior to January 5, 2006, if the prior testing was consistent with the criteria listed in this subparagraph.

1. Challenge testing must be conducted on either a full-scale membrane module, identical in material and construction to the membrane modules used in the system's treatment facility, or a smaller-scale membrane module, identical in material and similar in construction to the full-scale module. A module is defined as the smallest component of a membrane unit in which a specific membrane surface area is housed in a device with a filtrate outlet structure.

2. Challenge testing must be conducted using *Cryptosporidium* oocysts or a surrogate that is removed no more efficiently than *Cryptosporidium* oocysts. The organisms or surrogate used during challenge testing is referred to as the challenge particulate. The concentration of the challenge particulate, in both the feed and filtrate water, must be determined using a method capable of discretely quantifying the specific challenge particulate used in the test; gross measurements such as turbidity shall not be used.

3. The maximum feed water concentration that can be used during a challenge test is based on the detection limit of the challenge particulate in the filtrate and must be determined according to the following equation:

Maximum Feed Water Concentration = 3,160,000 × Filtrate Detection Limit

4. Challenge testing must be conducted under representative hydraulic conditions at the maximum design flux and maximum design process recovery specified by the manufacturer for the membrane module. Flux is defined as the throughput of a pressure-driven membrane process expressed as flow per unit of membrane area. Recovery is defined as the volumetric percent of feed water that is converted

to filtrate over the course of an operating cycle uninterrupted by events such as chemical cleaning or a solids removal process (i.e., backwashing).

5. Removal efficiency of a membrane module must be calculated from the challenge test results and expressed as a log removal value according to the following equation:

$LRV = LOG_{10}(C_f) - LOG_{10}(C_p)$

Where:

LRV = log removal value demonstrated during challenge test;

C_f = the feed concentration measured during the challenge test; and

C_p = the filtrate concentration measured during the challenge test.

Equivalent units must be used for the feed and filtrate concentrations. If the challenge particulate is not detected in the filtrate, the term C_p must be set equal to the detection limit for the purpose of calculating the LRV. An LRV must be calculated for each membrane module evaluated during the challenge test.

6. The removal efficiency of a membrane filtration process demonstrated during challenge testing must be expressed as a log removal value ($LRV_{C\text{-}Test}$). If fewer than 20 modules are tested, then $LRV_{C\text{-}Test}$ is equal to the lowest of the representative LRVs among the modules tested. If 20 or more modules are tested, then $LRV_{C\text{-}Test}$ is equal to the tenth percentile of the representative LRVs among the modules tested. The percentile is defined by [i/(n+1)] where "i" is the rank of "n" individual data points ordered lowest to highest. If necessary, the tenth percentile may be calculated using linear interpolation.

7. The challenge test must establish a quality control release value (QCRV) for a nondestructive performance test that demonstrates the *Cryptosporidium* removal capability of the membrane filtration module. In order to verify *Cryptosporidium* removal capability, this performance test must be applied to each production membrane module that was not directly challenge tested but was used by the system. Production modules that do not meet the established QCRV are not eligible for the treatment credit demonstrated during the challenge test.

8. If a previously tested membrane is modified in a manner that could change the removal efficiency of the membrane or the applicability of the nondestructive performance test and associated QCRV, additional challenge testing to demonstrate the removal efficiency of the modified membrane must be conducted and submitted to the department, along with determination of a new QCRV.

(3) Direct integrity testing. Systems must conduct direct integrity testing in a manner that demonstrates a removal efficiency equal to or greater than the removal credit awarded for the membrane filtration process and meets the requirements described in this subparagraph. A direct integrity test is defined as a physical test applied to a membrane unit in order to identify and isolate integrity breaches (i.e., one or more leaks that could result in contamination of the filtrate).

1. The direct integrity test must be independently applied to each membrane unit in service. A membrane unit is defined as a group of membrane modules that share common valving that allows the unit to be isolated from the rest of the system for the purpose of integrity testing or other maintenance.

2. The direct integrity method must have a resolution of 3 micrometers or less, where resolution is defined as the size of the smallest integrity breach that contributes to a response from the direct integrity test.

3. The direct integrity test must have a sensitivity sufficient to verify the log treatment credit awarded by the department for the membrane filtration process, where sensitivity is defined as the maximum log removal value that can be reliably verified by a direct integrity test. Sensitivity must be determined using the approach in either of the following paragraphs as applicable to the type of direct integrity test the system uses.

- For direct integrity tests using applied pressure or vacuum, the direct integrity test sensitivity must be calculated according to the following equation:

$LRV_{DIT} = LOG_{10}\,[Q_p/(VCF \times Q_{breach})]$

Where:

LRV_{DIT} = the sensitivity of the direct integrity test;

Q_p = total design filtrate flow from the membrane unit;

Q_{breach} = flow of water from an integrity breach associated with the smallest integrity test response that can be reliably measured; and

VCF = volumetric concentration factor, which is the ratio of the suspended solids concentration on the high-pressure side of the membrane relative to that in the feed water.

- For direct integrity tests using a particulate or molecular marker, the direct integrity test sensitivity must be calculated according to the following equation:

$LRV_{DIT} = LOG_{10} (C_f) – LOG_{10} (C_p)$

Where:

LRV_{DIT} = the sensitivity of the direct integrity test;

C_f = the typical feed concentration of the marker used in the test; and

C_p = the filtrate concentration of the marker from an integral membrane unit.

4. Systems must establish a control limit within the sensitivity limits of the direct integrity test that is indicative of an integral membrane unit capable of meeting the removal credit awarded by the department.

5. If the result of a direct integrity test exceeds the control limit established under 43.11(12)*"b"*(3)"4," the system must remove the membrane unit from service. Systems must conduct a direct integrity test to verify any repairs and may return the membrane unit to service only if the direct integrity test is within the established control limit.

6. Systems must conduct direct integrity testing on each membrane unit at a frequency of not less than once each day that the membrane unit is in operation. The department may approve less frequent testing, based on demonstrated process reliability, the use of multiple barriers effective for *Cryptosporidium*, or reliable process safeguards.

(4) Indirect integrity monitoring. Systems must conduct continuous indirect integrity monitoring on each membrane unit according to the following criteria. Indirect integrity monitoring is defined as monitoring some aspect of filtrate water quality that is indicative of the removal of particulate matter. A system that implements continuous direct integrity testing of membrane units in accordance with the criteria in 43.11(12)*"b"*(3) is not subject to the requirements for continuous indirect integrity monitoring. Systems must submit a monthly report to the department summarizing all continuous indirect integrity monitoring results triggering direct integrity testing and the corrective action that was taken in each case.

1. Unless the department approves an alternative parameter, continuous indirect integrity monitoring must include continuous filtrate turbidity monitoring.

2. Continuous monitoring must be conducted at a frequency of no less than once every 15 minutes.

3. Continuous monitoring must be separately conducted on each membrane unit.

4. If indirect integrity monitoring includes turbidity and if the filtrate turbidity readings are above 0.15 NTU for a period greater than 15 minutes (i.e., two consecutive 15-minute readings above 0.15 NTU), direct integrity testing must immediately be performed on the associated membrane unit as specified in 43.11(12)*"b"*(3)"1" through 43.11(12)*"b"*(3)"5."

5. If indirect integrity monitoring includes a department-approved alternative parameter and if the alternative parameter exceeds a department-approved control limit for a period greater than 15 minutes, direct integrity testing must immediately be performed on the associated membrane units as specified in 43.11(12)*"b"*(3)"1" through 43.11(12)*"b"*(3)"5."

c. Second-stage filtration. Systems receive 0.5-log *Cryptosporidium* treatment credit for using a separate second stage of filtration that consists of sand, dual media, GAC, or other fine-grain media following granular media filtration if the department approves. To be eligible for this credit, the first stage of filtration must be preceded by a coagulation step and both filtration stages must treat the entire plant flow taken from a surface water or influenced groundwater source. A cap, such as GAC, on a single stage of filtration is not eligible for this credit. The department must approve the treatment credit based on an assessment of the design characteristics of the filtration process.

d. Slow sand filtration (as secondary filter). Systems are eligible to receive 2.5-log *Cryptosporidium* treatment credit for using a slow sand filtration process that follows a separate stage

of filtration if both filtration stages treat entire plant flow taken from a surface water or influenced groundwater source and no disinfectant residual is present in the influent water to the slow sand filtration process. The department must base its approval of the treatment credit on an assessment of the design characteristics of the filtration process. This does not apply to treatment credit awarded for slow sand filtration used as a primary filtration process.

43.11(13) *Inactivation toolbox components.*

a. Calculation of CT values.

(1) CT is the product of the disinfectant contact time (T, in minutes) and disinfectant concentration (C, in milligrams per liter). Systems with treatment credit for chlorine dioxide or ozone under 43.11(13)*"b"* or *"c"* must calculate CT at least once each day, with both C and T measured during peak hourly flow as specified in 43.5(4).

(2) Systems with several disinfection segments in sequence may calculate CT for each segment, where a disinfection segment is defined as a treatment unit process with a measureable disinfectant residual level and a liquid volume. Under this approach, systems must add the *Cryptosporidium* CT values in each segment to determine the total CT for the treatment plant.

b. CT values for chlorine dioxide and ozone.

(1) As described in 43.11(13)*"a,"* systems receive the *Cryptosporidium* treatment credit listed in Table 1 of Appendix B by meeting the corresponding chlorine dioxide CT value for the applicable water temperature.

(2) As described in 43.11(13)*"a,"* systems receive the *Cryptosporidium* treatment credit listed in Table 2 of Appendix B by meeting the corresponding ozone CT value for the applicable water temperature.

c. Site-specific study. The department may approve alternative chlorine dioxide or ozone CT values to those listed in 43.11(13)*"b"* on a site-specific basis. The department must base its approval on a site-specific study conducted by the system. The study must follow a department-approved protocol.

d. Ultraviolet light. Systems receive *Cryptosporidium*, *Giardia lamblia*, and virus treatment credits for ultraviolet (UV) light reactors by achieving the corresponding UV dose values shown in Table 3 of Appendix B. Systems must use the following procedures to validate and monitor UV reactors in order to demonstrate that the reactors are achieving a particular UV dose value for treatment credit.

(1) Reactor validation testing. Systems must use UV reactors that have undergone validation testing to determine the operating conditions under which the reactor delivers the required UV dose (i.e., validated operating conditions). These operating conditions must include flow rate, UV intensity as measured by a UV sensor, and UV lamp status.

1. When determining validated operating conditions, systems must account for the following factors: UV absorbance of the water; lamp fouling and aging; measurement uncertainty of on-line sensors; UV dose distributions arising from the velocity profiles through the reactor; failure of UV lamps or other critical system components; and inlet and outlet piping or channel configurations of the UV reactor.

2. Validation testing must include the following: full-scale testing of a reactor that conforms uniformly to the UV reactors used by the system and inactivation of a test microorganism whose dose response characteristics have been quantified with a low-pressure mercury vapor lamp.

3. The department may approve an alternative approach to validation testing.

(2) Reactor monitoring.

1. Systems must monitor their UV reactors to determine if the reactors are operating within validated conditions, as determined under 43.11(13)*"d"*(1). This monitoring must include UV sensor, flow rate, lamp status, and other parameters the department designates based on UV reactor operation. Systems must verify the calibration of UV sensors and must recalibrate sensors in accordance with a protocol approved by the department.

2. To receive treatment credit for UV light, systems must treat at least 95 percent of the water delivered to the public during each month by UV reactors operating within validated conditions for the

required UV dose. Systems must demonstrate compliance with this condition by the monitoring required under 43.11(13)*"d"*(2)"1."

43.11(14) *Reporting requirements.*

a. Sampling schedules and monitoring results. Systems must report source water sampling schedules and monitoring results under 43.11(3)*"c"* and 43.11(3)*"e,"* unless the systems notify the department that they will not conduct source water monitoring due to meeting the criteria of 5.5-log treatment for *Cryptosporidium* under 43.11(3)*"a."*

b. Cryptosporidium bin classification. Systems must report their *Cryptosporidium* bin classification determined under 43.11(5).

c. Disinfection profiles and benchmarks. Systems must report disinfection profiles and benchmarks to the department as described in 43.11(4)*"a"* and 43.11(4)*"b"* prior to making a significant change in disinfection practice.

d. Microbial toolbox options. Systems must report to the department in accordance with Table 7 for any microbial toolbox options used to comply with treatment requirements under 43.11(6).

Table 7: Microbial Toolbox Reporting Requirements

Toolbox Option	Systems must submit this information	Information must be submitted on this schedule
1. Watershed control program	Notice of intention to develop a new or continue an existing watershed control program	No later than two years before the applicable treatment compliance date in 43.11(7)
	Watershed control plan	No later than one year before the applicable treatment compliance date in 43.11(7)
	Annual watershed control program status report	Every 12 months, beginning one year after the applicable treatment compliance date in 43.11(7)
	Watershed sanitary survey report	- For community water systems, every three years beginning three years after the applicable treatment compliance date in 43.11(7) - For noncommunity water systems, every five years beginning five years after the applicable treatment compliance date in 43.11(7)
2. Alternative source/intake management	Verification that system has relocated the intake or adopted the intake withdrawal procedure reflected in monitoring results	No later than the applicable treatment compliance date in 43.11(7)
3. Presedimentation	Monthly verification of the following: - Continuous basin operation - Treatment of 100 percent of the flow - Continuous addition of a coagulant - At least 0.5-log mean reduction of influent turbidity or compliance with alternative department-approved performance criteria	Monthly reporting within 10 days following the month in which the monitoring was conducted, beginning on the applicable treatment compliance date in 43.11(7)
4. Two-stage lime softening	Monthly verification of the following: - Chemical addition and hardness precipitation occurred in two separate and sequential softening stages prior to filtration - Both stages treated 100 percent of plant flow	Monthly reporting within 10 days following the month in which the monitoring was conducted, beginning on the applicable treatment compliance date in 43.11(7)

Toolbox Option	Systems must submit this information	Information must be submitted on this schedule
5. Bank filtration	Initial demonstration of the following: - Unconsolidated, predominantly sandy aquifer - Setback distance of at least 25 feet for 0.5-log credit or 50 feet for 1.0-log credit	No later than the applicable treatment compliance date in 43.11(7)
	If monthly average of daily maximum turbidity is greater than 1 NTU, then system must report result and submit an assessment of the cause.	Report within 30 days following the month in which the monitoring was conducted, beginning on the applicable treatment compliance date in 43.11(7)
6. Combined filter performance	Monthly verification of combined filter effluent (CFE) turbidity levels less than or equal to 0.15 NTU in at least 95 percent of the 4-hour CFE measurements taken each month	Monthly reporting within 10 days following the month in which the monitoring was conducted, beginning on the applicable treatment compliance date in 43.11(7)
7. Individual filter performance	Monthly verification of the following: - Individual filter effluent (IFE) turbidity levels less than or equal to 0.15 NTU in at least 95 percent of samples each month in each filter - No individual filter effluent turbidity levels greater than 0.3 NTU in two consecutive readings 15 minutes apart	Monthly reporting within 10 days following the month in which the monitoring was conducted, beginning on the applicable treatment compliance date in 43.11(7)
8. Demonstration of performance	Results from testing following a department-approved protocol	No later than the applicable treatment compliance date in 43.11(7)
	As required by the department, monthly verification of operation within conditions of department approval for demonstration of performance credit	Within 10 days following the month in which the monitoring was conducted, beginning on the applicable treatment compliance date in 43.11(7)
9. Bag filters and cartridge filters	Demonstration that the following criteria are met: - Process meets the definition of bag or cartridge filtration - Removal efficiency established through challenge testing that meets criteria in this subpart	No later than the applicable treatment compliance date in 43.11(7)
	Monthly verification that 100 percent of plant flow was filtered	Within 10 days following the month in which the monitoring was conducted, beginning on the applicable treatment compliance date in 43.11(7)
10. Membrane filtration	Results of verification testing demonstrating the following: - Removal efficiency established through challenge testing that meets criteria - Integrity test method and parameters, including resolution, sensitivity, test frequency, control limits, and associated baseline	No later than the applicable treatment compliance date in 43.11(7)

Toolbox Option	Systems must submit this information	Information must be submitted on this schedule
	Monthly report summarizing the following: - All direct integrity tests above the control limit - If applicable, any turbidity or alternative department-approved indirect integrity monitoring results triggering direct integrity testing and the corrective action that was taken	Within 10 days following the month in which the monitoring was conducted, beginning on the applicable treatment compliance date in 43.11(7)
11. Second-stage filtration	Monthly verification that 100 percent of flow was filtered through both stages and that first stage was preceded by coagulation step	Within 10 days following the month in which the monitoring was conducted, beginning on the applicable treatment compliance date in 43.11(7)

Toolbox Option	Systems must submit this information	Information must be submitted on this schedule
12. Slow sand filtration as a secondary filter	Monthly verification that both a slow sand filter and a preceding separate stage of filtration treated 100 percent of the flow from surface or influenced groundwater sources	Within 10 days following the month in which the monitoring was conducted, beginning on the applicable treatment compliance date in 43.11(7)
13. Chlorine dioxide	Summary of CT values for each day as described in 43.11(13)	Within 10 days following the month in which the monitoring was conducted, beginning on the applicable treatment compliance date in 43.11(7)
14. Ozone	Summary of CT values for each day as described in 43.11(13)	Within 10 days following the month in which the monitoring was conducted, beginning on the applicable treatment compliance date in 43.11(7)
15. Ultraviolet light (UV)	Validation test results demonstrating operating conditions that achieve required UV dose	No later than the applicable treatment compliance date in 43.11(7)
	Monthly report summarizing the percentage of water entering the distribution system that was not treated by UV reactors operating within validated conditions for the required dose as specified in 43.11(13)*"d"*	Within 10 days following the month in which the monitoring was conducted, beginning on the applicable treatment compliance date in 43.11(7)

43.11(15) *Record-keeping requirements.*

a. Source water monitoring records. Systems must keep results from the initial round of source water monitoring under 43.11(3)*"a"* and the second round of source water monitoring under 43.11(3)*"b"* until three years after bin classification under 43.11(5) for the particular round of monitoring.

b. Systems meeting 5.5-log treatment for Cryptosporidium. Systems must keep for three years records of any notification to the department that the systems will meet the 5.5-log *Cryptosporidium* treatment requirements and avoid source water monitoring.

c. Microbial toolbox treatment monitoring records. Systems must keep the results of treatment monitoring associated with microbial toolbox options under 43.11(8) through 43.11(13) for three years.

[**ARC 9915B**, IAB 12/14/11, effective 1/18/12; **ARC 3735C**, IAB 4/11/18, effective 5/16/18]