**Guideline for Clarifier and Granular Media Filter Ratings at Surface Water Treatment Plants**

Division: DDAGW
Number: ENG-01-003
Category: Engineering – Guidance
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## I. Purpose

To establish the design criteria for clarifier and granular-media filter loading rates:

- higher than those referenced in Ten-State Standards and/or the Approved Capacity document, or
- for technologies for which design criteria are not specifically listed in Ten-State Standards and/or the Approved Capacity document.

This guideline does not affect existing clarifier and filter loading rates approved by the Director. This guideline provides suggestions for developing protocols to conduct pilot- and full-scale demonstration studies and list approval criteria that should be met during these demonstration studies to establish the alternate design criteria. If the approval criteria are not met, then additional discussions with Ohio EPA will be necessary to determine if alternate design criteria are approvable.

It is intended that the successful application of this guideline will result in the design of a treatment system that will provide drinking water that complies with requirements of the Ohio Primary Drinking Water Rules for treatment of surface waters at reasonable cost. It should be recognized additional treatment may be required to address other water quality problems such as hardness, taste and odor, color, disinfection byproduct formation, organics removal, or other contaminants which might be present.

## II. Background

Ohio Administrative Code rule 3745-81-73 requires public water systems that use a surface water source, or a groundwater source under the direct influence of surface water, to provide conventional filtration, direct filtration, slow sand filtration, or other filtration technology.

Combined, filtered water turbidity levels for conventional and direct filtration must be <0.3 nephelometric turbidity units (NTU) in at least 95 percent of the samples analyzed each month and no samples shall exceed a turbidity of 1 NTU.

Combined, filtered water turbidity levels for slow sand filtration must be <1 NTU in at least 95 percent of the samples analyzed each month and no samples shall exceed a turbidity of 5 NTU.

The regulations and other applicable guidance allow other clarification and filtration technologies based on demonstration studies or other means to demonstrate, in combination with disinfection, a minimum 99 percent reduction of Cryptosporidium, 99.9 percent reduction of Giardia lamblia cysts, and 99.99 percent reduction of viruses.

Every surface water treatment plant (WTP) should strive to consistently produce a filtered water turbidity of less than 0.1 NTU from each individual filter. The turbidity goal for clarifier effluent should result in an acceptable gross water production (GWP) and/or production efficiency (PE).

The objective of this guideline is to achieve consistency throughout the State of Ohio in administering provisions of the Ohio Administrative Code and standard design criteria in regard to clarification and filtration at surface WTPs.

## III. Other Applicable Guidance

U.S. Environmental Protection Agency. *Guidance Manual for Compliance with the Filtration and Disinfection Requirements for Public Water Systems Using Surface Water Sources*. March 1991.

*The Great Lakes Upper Mississippi River Board of State Public Health and Environmental Managers. Recommended Standards for Water Works*. 2007. (Ten-State Standards or TSS)

Ohio EPA. *Planning and Design Criteria for Establishing Approved Capacity for: 1) Surface Water And Ground Water Supply Sources, 2) Drinking Water Treatment Plants (WTPs), and 3) Source/WTP Systems. May 2010*. (Approved Capacity document)

## IV. Guidance

### 1.0 GENERAL CRITERIA

1.1 The clarification and filtration design parameters are those listed in Ten-State Standards (TSS) and the Approved Capacity document.

1.2 A demonstration study with an approved protocol shall be performed (see TSS 1.1.8). The demonstration study should use an existing, full-scale WTP or, if this is impractical, a pilot-scale unit.

1.3 Demonstration studies are classified into three categories:

1.3.1 The use of a complete, pilot-scale treatment plant for those cases in which there is no existing, full-scale WTP.

1.3.2 The use of a pilot-scale clarifier and/or filter unit operated at higher rates for comparison with the full-scale clarifier(s) and/or filters of an existing WTP.

1.3.3 The isolation of full-scale clarifier(s) and/or filter(s) at an existing WTP operated at higher rates for comparison with all or some of the remaining full-scale clarifiers and/or filters. It may be necessary to install a pilot-scale filter to accept water from the high-rate clarifier when the clarified

water (effluent of the clarification process, normally consisting of coagulation, flocculation, and clarification) cannot be conveyed to an individual filter.

1.4 Prior to performance of a demonstration study for an existing full-scale WTP; the combined, filtered-water turbidity shall, within the last twelve months, have been less than or equal to 0.3 NTU at least 95 percent of the time, and have not exceeded 1 NTU (see TSS 1.1.8 and OAC rule 3745-81-73). Otherwise, the existing WTP (e.g., rapid mix, flocculation, clarification and/or filtration) should be upgraded to the extent that the above criteria can consistently be met for at least three consecutive months prior to performing the demonstration study.

1.5 Additional requirements that must be met prior to performing a demonstration study for an existing surface WTP are:

1.5.1 The WTP shall be under the responsible charge of a properly certified operator (OAC rule 3745-7-02).

1.5.2 The WTP shall meet the redundancy requirements in Section D of the Approved Capacity document.

1.5.3 Components must be in-service in accordance with Section D of Approved Capacity document.

## 2.0 DEMONSTRATION STUDY CRITERIA

2.1 Prior to the performance of a demonstration study, it is strongly recommended that a plan be submitted and approved. The plan should include:

2.1.1 Results from analysis of raw water quality data for the previous 12-month period, if any are available.

2.1.2 Statement of objectives and conclusions from an evaluation of the raw water quality identifying critical water quality parameters and conditions to be evaluated during the demonstration study.

2.1.3 Schematic drawings and detailed descriptions of the facilities to be used.

2.1.4 Mode(s) of operation to be tested.

2.1.5 Time schedules for each mode of operation, in relation to the critical conditions to be evaluated (see Item 2.1.2).

2.1.6 Sampling locations to be monitored.

2.1.7 Parameters to be monitored at each sampling location.

2.1.8 Frequency of monitoring for each parameter.

2.1.9 Description of on-line and bench analytical equipment to be used for monitoring each parameter.

2.1.10 Quality assurance/quality control procedures to be used.

2.1.11 Description of analyses to be used for evaluating the data collected.

2.1.12 Discussion of how the system will be able to provide adequate quantities of water meeting all water quality standards when one clarifier is taken out of service for normal maintenance or for emergency repair.

2.2 The demonstration study should be conducted for at least one period of data collection lasting six weeks for either a pilot-scale or full-scale study. If historical data suggests a time period of the year likely to provide the most challenging water and the demonstration study does not include this period, an engineering submission should be provided as justification. Based on results of a successful demonstration study, the system can proceed to operate existing components at the demonstrated approved capacity, or proceed to design and construct the WTP improvements.

2.3 In case of existing, full-scale WTPs, at least one control clarifier and/or filter should be operated at the currently approved rate. Alternating periods of operating a clarifier at the control and high-rate may be considered.

2.4 It is strongly recommended that the following data be collected for the demonstration study:

2.4.1 Turbidity

| | |
|---|---|
| Raw Water: | at least daily, more frequently when raw water turbidity is expected to be changing based on historical experience. |
| High-rate filter influent: | every four hours (recommend continuous recording*) |
| Control filter influent: | every four hours (recommend continuous recording*) |
| High-rate filter effluent: | continuous recording* |
| Control filter effluent: | continuous recording* |

*Continuous turbidity analyzers shall be calibrated in accordance with Ohio EPA's Laboratory Manual for Chemical Analyses of Public Drinking Water.

2.4.2 Total Organic Carbon (TOC) Removal Ratio

Bi-weekly raw water and filtered water TOC data should be collected and the three paired sample sets should be averaged to determine if the TOC removal ratio of ≥ 1 is met. Otherwise, the alternative compliance criteria of OAC rule 3745-81-77 "Treatment techniques for control of disinfection byproduct (DBP) precursors" must be met.

2.4.3 Other data:

Length of each filter run.

Initial and terminal headloss for each filter run.

Filtration rate and method of control.

Backwash volume and rate for full-scale demonstration studies.

Additional data may be recommended for surface WTPs which provide softening.

2.4.4 The filterability index should be measured daily on the effluents from the control and high-rate demonstration clarifiers.

2.5 It is strongly recommended that data analysis consist of at least:

2.5.1 Turbidity:

2.5.1.1 Raw water, high-rate and/or control filter influent, high-rate and/or control filter effluents:

Maximum, average, minimum and standard deviation for each filter run, and for the 6-week time frame in which the demonstration study is conducted.

2.5.1.2 High-rate and/or control filter effluents:

Percent of time exceeding 0.3 NTU for each filter run, and for the 6-week time frame in which the demonstration study is conducted.

2.5.2 TOC Removal Ratio:

The bi-weekly raw water and filtered water TOC data (i.e., three paired sets) should be averaged to determine if the TOC removal ratio of ≥ 1 is met. Otherwise, the alternative compliance criteria of OAC rule 3745-81-77 “Treatment techniques for control of disinfection byproduct (DBP) precursors” must be met.

2.5.3 Other data:

High-rate and/or control filters.

Gross water production (gal/sf) for each filter run.

## 3.0 APPROVAL CRITERIA FOR HIGH-RATE CLARIFICATION AND/OR FILTRATION

3.1 A report should be submitted in which the data collected, results of the data analysis, and the conclusions and recommendations are presented and clearly summarized. The turbidity data should be presented in an ensemble average or

other acceptable format. Data should also be submitted in electronic format. The report should also include all other data collected during start-up prior to the demonstration study, or other operation periods.

For each operation mode performed during the demonstration study, the pertinent parameters (i.e., raw water source, coagulant type and dose, pH, etc.) should be clearly defined and presented in the report.

3.2 Turbidity from high-rate filter shall:

3.2.1 Be less than 0.3 NTU for at least 95 percent of the time for the 6-week period in which the pilot-scale or full-scale demonstration study is conducted (OAC rule 3745-81-73).

3.2.2 Be less than 1 NTU at all times (OAC rule 3745-81-73).

3.2.3 A surface WTP that can successfully meet turbidity requirements of Paragraph 3.2 will receive credit for 2.5 log removal of *Giardia lamblia* and 2.0 log removal *of Cryptosporidium* (OAC rule 3745-81-71).

3.3 Total Organic Carbon (TOC) Removal Ratio

3.3.1 The bi-weekly raw water and filtered water TOC data (i.e., three paired sets) should be averaged to determine if the TOC removal ratio of ≥ 1 is met. Otherwise, the alternative compliance criteria of OAC rule 3745-81-77 "Treatment techniques for control of disinfection byproduct (DBP) precursors" must be met.

3.4 For high-rate clarification, in addition to the criteria in Paragraphs 3.1, 3.2 and 3.3, one of the following three criteria should be met:

3.4.1 The average PE for the 6-week period of the demonstration study should be at least the percentage agreed upon with the DDAGW [i.e., no more than (100 minus PE) percent of the finished water is used to backwash the filters; the American Water Works Association cites one to five percent as typical; the DDAGW recommends a goal of no more than two percent; past WTP performance may be considered]. The production efficiency for each filter run should be at least 90 percent (i.e., no more than 10 percent of finished water should be used to backwash the filter).

The production efficiency for each filter run is defined as:

$$PE = \frac{(GUFRV - UBWV)}{GUFRV} \times 100,$$

Where: GUFRV is the gross unit filter run volume.

The unit backwash volume (UBWV), in gallons per square foot per backwash, should be determined for the 6-week demonstration-study period in accordance with the following procedure. The UBWV to be used to determine the PE for each filter run is based on multiplying the

optimum backwash rate (in gpm per square foot) by the optimum backwash time (in minutes). The optimum backwash rate is to be determined from Figure 1 based on filter media characteristics and water temperature. The optimum backwash time is to be determined by: (a) backwashing the filter for at least 10 minutes at the optimum backwash rate; (b) collecting a sample every 15 seconds of the spent backwash water from the filter trough; and, (c) measuring the turbidity of these samples.

The filter should be run to terminal headloss or 0.2 to 0.3 NTU terminal filtered water turbidity prior to this test. The turbidity values (in NTU) of the backwash samples should be plotted on the Y-axis versus the time (in minutes) at which the sample was collected during the backwash on the X-axis. The optimum backwash time is defined as the time when the turbidity value of the spent backwash water decreases to less than 10 to 15 NTU (see example in Figure 2); or

3.4.2 The average value of the clarified water turbidity for all filter runs during the six-week demonstration-study period should not exceed 2 NTU, and the 95th-percentile value of the clarified water turbidity data points should not exceed 5 NTU; or

3.4.3 Gross water production should be at least 5,000 gallons per square foot of filter area for each filter run. Backwashing should be initiated (or extrapolated) based on the lesser of: (a) reaching the total headloss available for filtration at the full scale; or (b) turbidity breakthrough of 0.2 to 0.3 NTU through the filters.

## V. Figures:

Figure 1 – Optimal Backwash Rates
Figure 2 – Example Spent Backwash Turbidity Profile

## VI. History:

The Division of Drinking and Ground Waters first proposed this document on August 20, 1993, and finalized it on August 1, 1996. The document was first revised on December 8, 1999 to incorporate portions of the surface water treatment rules and to include graphical representations of optimal backwash rates and spent backwash turbidity profiles. The document was revised a second time on March 21, 2014 to incorporate newer portions of the surface water treatment rules and to shorten the time period for demonstration studies from four, 2-week seasonal periods to one 6-week period.

FIGURE 1

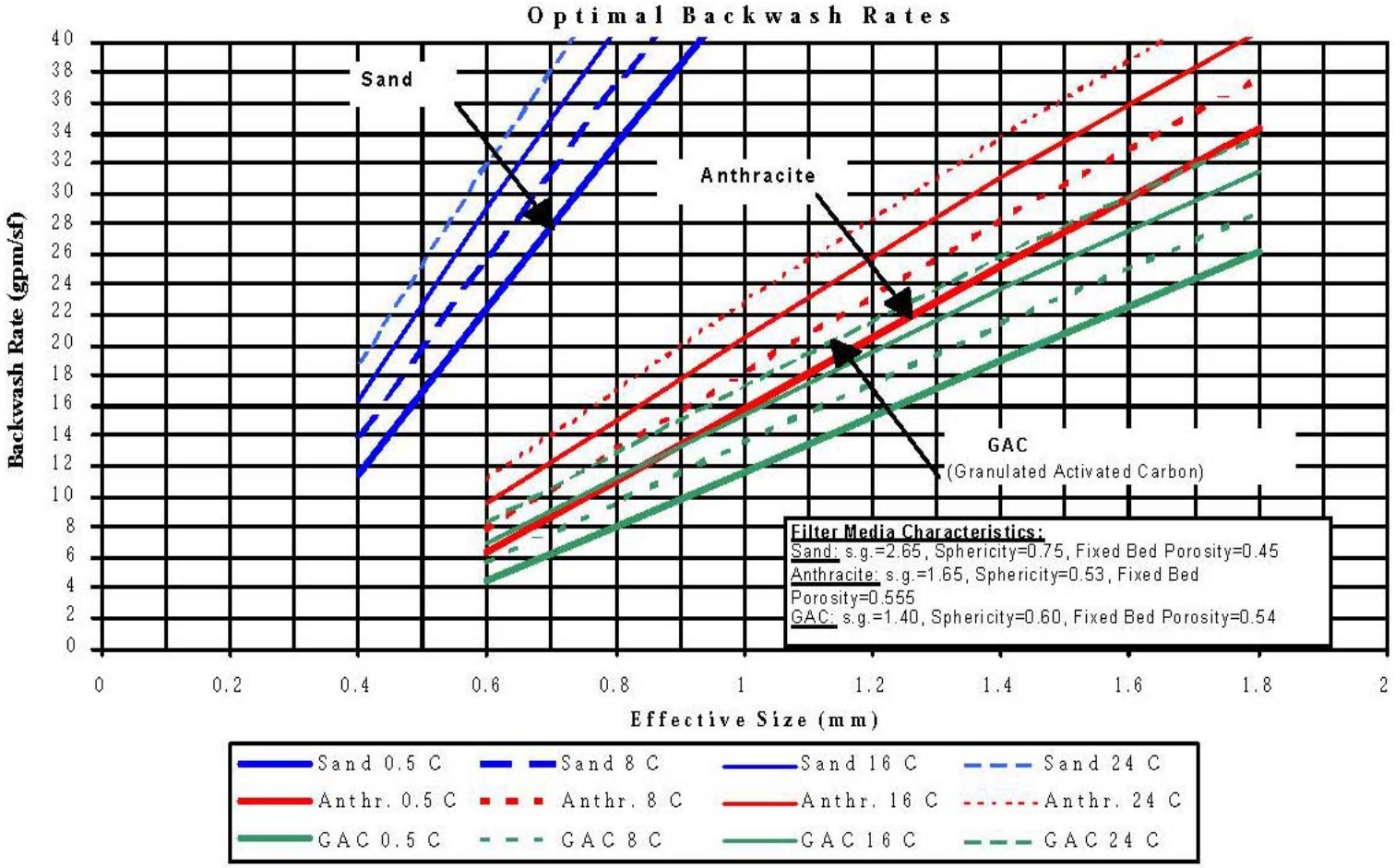
Optimal Backwash Rates
Backwash Rate (gpm/sf)
Effective Size (mm)
Sand
Anthracite
GAC
(Granulated Activated Carbon)
Filter Media Characteristics:
Sand: s.g.=2.65, Sphericity=0.75, Fixed Bed Porosity=0.45
Anthracite: s.g.=1.65, Sphericity=0.53, Fixed Bed Porosity=0.555
GAC: s.g.=1.40, Sphericity=0.60, Fixed Bed Porosity=0.54
Sand 0.5 C
Sand 8 C
Sand 16 C
Sand 24 C
Anthr. 0.5 C
Anthr. 8 C
Anthr. 16 C
Anthr. 24 C
GAC 0.5 C
GAC 8 C
GAC 16 C
GAC 24 C

**FIGURE 2**

**Example Spent Backwash Turbidity Profile**