STATE OF COLORADO DESIGN CRITERIA FOR POTABLE WATER SYSTEMS

Safe Drinking Water Program
Implementation Policy DW005

Design Criteria for Potable Water Systems

Adoption date:	May 9, 2022
Effective date:	July 1, 2022
Scheduled review date:	July 1, 2026
Version:	1.0
Signatures:	Ron Falco Digitally signed by Ron Falco Date: 2022.06.15 15:00:21 -06'00' — Ron Falco, Drinking Water Program Manager
	Bret A. Icenogle Digitally signed by Bret A. Icenogle Date: 2022.06.14 10:05:50 -06'00' — Bret Icenogle, Engineering Section Manager

OVERVIEW

The *Design Criteria for Potable Water Systems* (Design Criteria) are used by the Colorado Department of Public Health and Environment (the Department) for reviewing waterworks at public water systems.

What types of waterworks get reviewed?

While the statutory authority exists to review all waterworks, the Department's current policy is to review new and substantial modifications to sources, treatment, and protected water storage.

ACKNOWLEDGEMENTS

The chapter structure of this document and much of the content is based upon the "Recommended Standards for Water Works, 2018 Edition" (Reference 1 - found at https://www.health.state.mn.us/communities/environment/water/tenstates/standards.html). These are commonly referred to as the "10 States Standards". These standards are published by the Great Lakes – Upper Mississippi River Board of State and Provincial Public Health and Environmental Managers. However, beyond the chapter structure, much of the content has been drafted or modified to meet the needs of the State of Colorado. The Department would like to thank the board for permission to utilize these standards as a guide for development.

TABLE OF CONTENTS

Title Page

TABLES AND FIGURES

LIST OF TABLES

LIST OF FIGURES

ABBREVIATION LIST

ANSI	American National Standards Institute
ASTM	American Society of Testing and Materials
AWWA	American Water Works Association
BDR	Basis of Design Report
CCR	Colorado Code of Regulations
CDPHE	Colorado Department of Public Health and Environment
CEB	Chemically enhanced backwash (membranes)
CFR	Code of Federal Regulations
CIP	Clean in place (membranes)
CRS	Colorado Revised Statutes
CT	Contact time
CWS	Community water system (defined in Regulation 11)
DAF	Dissolved air flotation
Department	Colorado Department of Public Health and Environment
Design Criteria	Policy DW-005: Design Criteria for Potable Water Systems
Division	Water Quality Control Division of the Colorado Department of Public Health and Environment
DORA	Colorado Department of Regulatory Agencies
EPA	United States Environmental Protection Agency
FEMA	Federal Emergency Management Agency
GAC	Granular activated carbon
gpd	Gallons per day
gpm	Gallons per minute
gpm/ft^2	Gallons per minute per square foot
GW	Groundwater (defined in Regulation 11)
GWUDI	Groundwater under the direct influence of surface water (defined in Regulation 11)
LSI	Langelier Saturation Index
MFGM	Membrane filtration guidance manual (published by EPA)
MGD	Million gallons per day
MCL	Maximum Contaminant Level (as defined by EPA)
NEC	National Electrical Code
NEMA	National Electrical Manufacturers' Association
NFPA	National Fire Protection Association
NSF	NSF International, formally known as National Sanitation Foundation
NTNC	Non-Transient Non-Community Water System (defined in Regulation 11)
NPWSCPM	New Public Water System Capacity Planning Manual
O&M	Operations and maintenance
OSHA	Occupational Safety and Health Administration
PFD	Process flow diagram
P&ID	Process and instrumentation diagram/drawing
POU	Point of use device
POE	Point of entry device
Regulation 11	*Regulation No. 11: Colorado Primary Drinking Water Regulations* (5 CCR 1002-11)
RFI	Request for information
SCADA	Supervisory Control and Data Acquisition
SSCT	Small System Compliance Technologies
Supplier	Supplier of water or supplier (as defined in Regulation 11)
SW	Surface water (as defined in Regulation 11)

TMP	Transmembrane pressure
UVT	Ultraviolet transmittance
UVDGM	Ultraviolet disinfection guidance manual (published by EPA)
TNC	Transient Non-Community Water System (defined in Regulation 11)
WQCC	Water Quality Control Commission
WTP	Water treatment plant

INTRODUCTION
AUTHORITY, APPLICABILITY, AND DEFINITIONS

Based on the regulatory authority granted in *Regulation No. 11: Colorado Primary Drinking Water Regulations* (Regulation 11, Reference 2), Section 11.4, the Colorado Department of Public Health and Environment (Department) reviews and approves plans and specifications relating to new or modified waterworks at public drinking water systems.

Specific authority to review facility design is given under Regulation 11, Section 11.4(1)(b)(iv), which states:

> *Decisions regarding the review and approval of plans and specifications for new waterworks or improvements or modifications to existing waterworks shall be based on conformance to the design criteria developed by the Department specified in Policy DW- 005, State of Colorado Design Criteria for Potable Water Systems.*

Furthermore, Regulation 11, Section 11.4(1)(b) and 11.4(1)(b)(iii) specifies exactly which types of activities require design review and by whom they should be submitted:

> *(b) For all public water systems, the supplier must not begin construction of any new waterworks, make improvements to or modify existing waterworks, or begin using a new source until the supplier submits and receives Department approval of plans and specifications for such construction, improvements, modifications, or use.*
>
> *(b)(iii) For community water systems, a Professional Engineer registered in the State of Colorado must design all treatment systems.*

Using the *Policy DW-005: Design Criteria for Potable Water Systems* (Design Criteria) the Department evaluates whether a given set of plans and specifications, or a given design, is adequate to reliably produce drinking water in compliance with Regulation 11. When changes need to be incorporated into these criteria, changes will be added as approved addenda, enabling the document to evolve in response to new information and technological innovations. Approved addenda, as well as any minor revisions made to this document by the Department will be noticed in the AquaTalk publication, posted on the Department website, and announced via other means.

I.1 SCOPE AND APPLICABILITY

The Department reviews plans and specifications of waterworks to evaluate and ensure substantial conformance with this document. Review of plans and specifications by the Department is not intended to provide quality control of the proposed project. Approval of a project by the Department does not relieve the sole responsibility of the design engineer for successful implementation of the project nor does it relieve the supplier from the responsibility of operation of the water system and compliance with Regulation 11. “Plans and specifications” refer to the design of waterworks and are defined in Regulation 11 Section 11.3 (55) as:

> ….*the technical design drawings and specifications for waterworks. For new waterworks, this also includes technical, financial and managerial plans.*

“Waterworks” are defined in Regulation 11 Section 11.3 (90) as:

> … *the facilities that are directly involved in the production, treatment, or distribution of water for public water systems.*

Review of plans and specifications is also called “design review” because plans and specifications, when submitted together with the appropriate basis of design report, are considered to comprise a complete design. Henceforth, the term "plans and specifications" will be synonymous with the term "complete design". In all cases, for a complete design to be acceptable and for the Department to perform a review, it must include a Basis of Design Report (BDR) and all applicable plans and specifications as required by the Department.

For the purposes of these Design Criteria, "Complete design" means a submittal which includes a BDR, plans at least at the 60% completion stage, and technical specifications where appropriate.

Specifically, submission of a complete design and subsequent approval by the Department is required for:

a. Proposed construction of:
    i. New water treatment plants (WTP).
    ii. New groundwater/surface water sources (including replacement wells).
    iii. New storage tanks.
    iv. New protected water pump station wetwells. See Chapter 7.
b. Substantial modifications to any of the above waterworks.
c. Emergency waterworks that become permanent/seasonal/interim waterworks.
d. Inactive waterworks that become active. Note: inactive waterworks must be physically disconnected from the water system until approved by the Department.
e. Demonstration scale projects.
f. In certain cases, existing waterworks not previously submitted to or approved by the Department.

<u>I.1.1 Fees Required for Design Review Submittals</u>

The Department is not authorized to assess fees for drinking water design reviews at the time that this document was finalized.

<u>I.1.2 Review Period</u>

The Department seeks to act expeditiously on complete design submittals. To facilitate expeditious review, submitting entities and their engineers must address all criteria applicable to the unit processes for a project in the design submittal. Per Section 1.4, when a criterion is not satisfied, the submitting engineer or supplier is required to request a site-specific deviation from the Design Criteria.

The Department's target review period for design submittals for drinking water projects is 45 calendar days after receipt of the submittal regardless of project type. This time period does not include days when the supplier and their engineers are responding to a request for information (RFI) letter from the Department. If the supplier does not respond to a Department's request for information (RFI) letter within three years, then the Department may inactivate the design review case without issuing a decision. Thereafter, the supplier must submit a new design package to reinitiate the design review process.

<u>I.1.3 Modifications to Waterworks – Approval Required</u>

All substantial modifications to waterworks must have Department approval. This item defines which types of projects must be approved by the Department. The Department does not desire to significantly increase the number of design reviews nor does the Department desire to review operations and maintenance (O&M) activities at public water systems. However, the Department maintains that certain activities that some systems believe are operations or maintenance activities may qualify as substantial modifications depending on the circumstances. Suppliers that make substantial modifications are required to have prior approval per Regulation 11, Section 11.4. If a supplier makes a substantial modification without Department approval, the system will be in violation of Regulation 11 and subject to the applicable public notice and potential enforcement actions. The Department does not require submittal or written approval for operations and maintenance activities.

Certain projects are clearly substantial modifications or O&M while other projects may be ambiguous. The Department has established specific definitions for operations and maintenance versus substantial modifications to help systems identify which projects require review by the Department. These terms are defined below.

To be used in conjunction with the definitions, the Department has provided a list of typical projects and their classification in Appendix A, Table A.1 for “Substantial Modification” and “Operations and Maintenance” projects. The Department intends for suppliers and engineers to utilize the definitions herein and the table in Appendix A in order to properly plan the degree of review. If still unclear, the Department welcomes and encourages suppliers to inquire via email or telephone to determine if the* proposed project is a substantial modification prior to initiating construction.

I.1.3.1 Substantial Modifications

“SUBSTANTIAL MODIFICATION” means the modification or replacement of any waterworks that can affect the quality of the finished water, the hydraulic profile of treatment, the plant design flow rate, or the typeof treatment processes at a water plant.

- Example 1: If a water treatment plant wishes to increase its rated capacity from 1 million gallons per day (MGD) to 2 MGD, the Department will consider this a substantial modification and a complete design is required, even if construction is not. The term ‘rated capacity’ as referenced above means the maximum instantaneous flow assigned to a treatment plant by the Department after completing the design review process for a complete design. The Department will assign a rated capacity for each treatment plant approved.
- Example 2: A water treatment plant has traditionally added soda ash to adjust pH. Due to maintenance issues, the water treatment plant wishes to switch from soda ash to caustic soda. This treatment process change is a substantial modification that must be submitted to the Department. Since the project involves chemical feed equipment modifications that must be engineered, a complete design is required.
- Example 3: A supplier needs to do some work on their granular media filters. This work includes changing out filter media with similar specified media. Also, the work is to include changing the clay underdrain system to a new underdrain without support gravel. Because this change affects the hydraulic profile of the

water treatment plant, the project is a substantial modification that requires Department approval.

I.1.3.2 Operations and Maintenance

"OPERATIONS AND MAINTENANCE" (O&M) means the standard practice of maintaining water quality and water production through continuous repairs, replacement of parts or equipment, and servicing of equipment. For O&M, the supplier is not required to notify the Department.

- Example 1: Replacing an outdated on-site hypochlorite generation system with a similar on-site hypochlorite generation system with newer technology NOT resulting in an increase in water treatment plant capacity.
- Example 2: Replacing media in a granular media filter per original specifications which does NOT result in an increase in water treatment plant capacity.
- Example 3: Upgrading finished water pumping with variable frequency drive (VFD) capability that does not impact the disinfection process and does NOT result in an increase in water treatment plant capacity.
- Example 4: Replacing chemical feed equipment with new equipment of the same type – similar chemical compatibilities. The intent of such replacement must be to deliver a similar dose of the same chemical with the same treatment goal
- Example 5: Tank re-coating or re-lining. The original coating and the new coating material are ANSI/NSF standard 61 certified (meet Section 2.21 and Section 2.15).
- Example 6: Modify existing storage tank access hatch (meet Item 7.0.8). Add flapper valve or screen to overflow or vent (meet Item 7.0.7 or Item 7.0.8, as applicable).
- Example 7: A groundwater system adding or removing a sediment filter that is ANSI/NSF standard 61 certified.
- See additional examples in Table A.1: Design Review Matrix.

<u>I.1.4 Must vs. Should</u>

"Must" and "Shall" mean the criterion is a requirement. "Must" is considered the equivalent of "Shall". If the design does not address a requirement and does not request a site-specific deviation, then the design will not be approved. The Department will instead issue a request for information (RFI) letter requiring additional information to be submitted.

"Should" means the criteria is 'best practice' but not a design requirement. For the most part, statements that use 'should' will be omitted from this document. The Department contends there are many other comprehensive industry publications which present industry best practices that are not considered a minimum standard for producing potable water but should be considered as a project enhancement. In certain legacy cases, a 'should' statement may be retained in this document; however it ceases to be a design requirement and is intended as guidance.

I.1.5 Definition of term 'supplier of water'

Throughout this document, reference is made to both public water systems, supplier, and suppliers of water. The terms "public water system", "supplier", and "supplier of water" are defined within Regulation 11. Supplier of water means any person (i.e., entity) who owns or operates a public water system.

I.1.6 Legacy Infrastructure

Waterworks installed and in operation prior to October 1, 1999 do not need to apply for approval by the Department. Waterworks that have been installed or have undergone substantial modifications since the installation date and do not have prior Department approval must submit for approval. For all water storage tanks, any tanks constructed prior to January 1, 2010 do not need to apply for approval by the Department. For all protected water pump station wetwells, any wetwells constructed prior to <<effective date of Design Criteria>> do not need to apply for approval by the Department.

Legacy waterworks may be subject to review during future sanitary surveys or during system modifications that directly impact those components, in accordance with the Design Criteria, Department Policy, and best practices. If legacy infrastructure cannot comply with Regulation 11, then the Department will require improvements which will make the waterworks subject to review and approval. For example, if a clearwell was installed in the 1980s to have 30 minutes of contact time but cannot meet the surface water treatment rule log-inactivation requirements for *Giardia lamblia*, typically 0.5 or 1.0 log depending on removal technology used, then the water treatment plant must perform modifications to its existing clearwell, relocate the entry point sample location or install new treatment. These treatment changes would be considered substantial and require a design submittal for review.

I.1.7 New Public Water Systems

In addition to the requirements to receive design approval for waterworks, Regulation 11, Section 11.4(1)(a) specifies a technical, managerial, and financial capacity review for all **new** community and non-transient, non-community water systems. Regulation 11, Section 11.4(1)(a) states:

> *No person shall commence construction of a new community or non-transient, non-community public water system unless such system performs and receives Department approval of a capacity (technical, managerial, and financial) assessment conducted in accordance with the criteria of the New Public Water System Capacity Planning Manual.*

These Design Criteria do not address the requirements contained within the *New Public Water System Capacity Planning Manual* (NPWSCPM); Drinking Water Program Policy DW-011 (Reference 3). Therefore, all new community and non-transient, non-community public water systems must demonstrate substantial conformance with this design criteria and the NPWSCPM prior to receiving Department approval.

I.1.8 Design Criteria Exemptions

The Department acknowledges that these criteria apply to very large municipal suppliers and very small suppliers that meet the Regulation 11 definition of the Public Water System. Very small water systems are public water systems that serve less than 500 people. Typically, very small suppliers consist of a groundwater well and a disinfection step. The Department identifies some design components that may not be applicable for small treatment plants or tanks.

Throughout the document, typical design criteria are listed in statements or perhaps in lettered or numbered lists. See italics excerpt below. If a specific sized system or design component is exempted from a requirement, it will always be listed as a bulleted list item – see bulleted item below.

a. *A scaled map showing size and location of proposed structures for new buildings and/or treatment processes*
b. *A vicinity map showing any new or effected sources with regard to the pertinent watershed must be provided*

- For non-community systems serving less than 500 people, an aerial photograph (e.g. Google® Earth) or equivalent showing existing and proposed structures may be sufficient to meet the requirements.

I.1.9 Industry Best Practices and Standards

Water technology and practices are constantly evolving and the Design Criteria is intended to include the minimum requirement to meet Regulation 11. Many sources of industry best practices and standards are available including: EPA guidance, text books, and professional journals. Additionally, the American Water Works Association (AWWA) routinely publishes and updates a variety of documents reflecting the best practices and standards for public drinking water treatment plants, designers, operators and regulators. The Department expects that designs of waterworks incorporate guidance and best practices such as those found in various AWWA standards or other industry best practice documents.

CHAPTER 1
DESIGN REVIEW PROCESS AND SUBMITTAL REQUIREMENTS

1.1 DESIGN REVIEW PROCESS

The Department approves plans and specifications in writing on Department letterhead; verbal approvals or email approvals are not permitted or valid.

1.1.1 Design Review Steps

When construction of new waterworks is planned, the supplier must submit a complete design to the Department for approval. For modifications to waterworks, the supplier must either submit a complete design or request limited scope approval.

A successful design review is dependent on two key factors: 1) a complete design represented in the submittal package and 2) appropriate conformance to the Design Criteria. In order to be considered a complete design, a submittal package must contain all pertinent information for the Department to issue a decision. The pertinent information that must be submitted for a given project varies depending upon several key factors:

a. Type of new or modified waterworks.
    i. Limited scope or complete design.
b. Magnitude of the change to existing waterworks.
c. The availability of water quality data (as required in Item 1.2.3 below or other chapters of these criteria).
d. The degree to which the design seeks to deviate from the applicable criteria.

In an effort to clarify what types of information must be submitted for each type of project, Appendix A, Table A.1 contains a summary of project and submittal types for Department approval.

Appendix A, Figure A.1 demonstrates the design submittal process. At a minimum, the process will include the following steps:

1. Submittal of a complete design including:
    i. Basis of Design Report (BDR) which includes an application for construction approval, and
    ii. Plans and Specifications – where applicable.
2. Obtain Department approval on Department letterhead
    i. For design-build projects, final design approval must be issued for each phase of the project prior to commencement of construction of that project phase.
3. Commencement and completion of construction of the project.
4. Submittal of construction completion form.

1.1.2 Design Review Document Submittals

For community water systems, documents submitted for review must be prepared under the supervision of a Colorado professional engineer (PE) and be submitted with the PE's seal and signature. The engineer must be licensed to practice engineering in the State of Colorado in accordance with the requirements of the Colorado Department of Regulatory Agencies (DORA) – Division of Registrations, and is expected to seal and sign design documents consistent with the requirements of the current version of *4 CCR 730-1 Architects, Professional Engineers, and Professional Land Surveyors Rules and Regulations* (Reference 4).

For non-community water systems, Regulation 11 does not require that a professional engineer submit the documents; however, the Department highly recommends the use of and consultation with professionals qualified and experienced in designing waterworks.

One (1) electronic copy (PDF) with bookmarked sections must be submitted to the Department for review and approval. The applicant must supply a hard copy of the design submittal, if requested by the Department.

For complete design submittals, the Basis of Design Report (BDR) must demonstrate compliance with the Design Criteria, or justify requested site-specific deviations from the criteria under Section 1.4, and include supporting calculations, analyses, historical data, and technical assumptions. The engineering plans and specifications must confirm that the appropriate information reflected in the BDR has been designed into the system.

1.2 BASIS OF DESIGN REPORT

The purpose of the Basis of Design Report (BDR) is to provide sufficient design information so the Department can evaluate whether the proposed waterworks (including modification or improvement) can ***reliably achieve*** compliance with Regulation 11. To this end, the BDR must demonstrate conformance with the applicable Design Criteria provided in subsequent chapters of these *Design Criteria for Potable Water Systems*. To facilitate the Department's review, the BDR must document references and include the following sections (as applicable):

1. Basic project information.
2. Sources of potential contamination.
3. Water quality data.
4. Process flow diagram/hydraulic profile.
5. Capacity evaluation and design calculations.
6. Monitoring and sampling evaluation.
7. Geotechnical report.
8. Residuals handling plan.
9. Preliminary plan of operation.
10. Impact to corrosivity.
11. Security and emergency response program.
12. Supplemental or other pertinent information.

A template for the BDR has been provided in Appendix B. To determine which sections of the BDR are required for a given project, the Department has provided a matrix of projects in Appendix A, Table A.1. This matrix will specify whether a section of the BDR is required for a specific project category; for example, certain treatment projects may not require a geotechnical report or a residuals handling section if they do not involve construction of new buildings or produce residuals.

1.2.1 Application for Construction Approval - Basic Project Information (for all submittals)

All BDRs must include basic project information. Basic project information must include the following information:

a. Name and mailing address of the supplier (i.e., system owner).

b. Identification of the public water system (i.e., municipality) and area served.

c. Description and purpose of the project including the description of existing waterworks, water treatment plants, unit processes, tank sizes, and distribution systems flows that affect and are affected by the project including specific description of which items are being requested for approval.

d. A scaled map showing size and location of proposed structures for new buildings and/or treatment processes.

- Suppliers serving less than 500 people may submit an aerial photograph (e.g. Google® Earth) or equivalent showing existing and proposed structures.

e. A vicinity map showing any new or affected sources with regard to the pertinent watershed must be provided.

- Suppliers serving less than 500 people may submit an aerial photograph (e.g. Google® Earth) or equivalent showing existing and proposed structures.

f. List the requested rated capacity for the project.

   i. Sources: maximum flowrate in gallons per minute.

   ii. Water treatment plants: maximum flowrate in gallons per minute for each unit process and the overall treatment plant flow based on the limiting treatment process.

   iii. Protected water storage tanks: volume in gallons.

g. Approximate total project cost including construction and design costs.

- Suppliers serving less than 500 people are exempt from this requirement (Item 1.2.1(g)).

h. List of proposed site-specific deviations from the Design Criteria with justification for each deviation. See Section 1.4 below for specific information necessary to receive a site-specific deviation from the Department.

i. Implementation plan and schedule including estimated construction time and estimated start-up/completion date.

1.2.2 Sources of Potential Contamination

Per Table A.1 in Appendix A, when the BDR requires an evaluation of sources of potential contamination, the following must be submitted at a minimum:

a. 100-year floodplain elevation map and completion of floodplain form (see Section 2.4).

b. Location of existing and potential sources of contamination that may affect the proposed waterworks within distances as proposed below:

   i. Groundwater sources: 500 feet.

   ii. Surface water sources: Not applicable – the Department recommends updating the source water protection plan.

   iii. Water treatment: 500 feet.

   iv. Storage: Underground - 500 feet; ground level or above – 100 feet.

c. Discussion of how the water system intends to mitigate risks from the potential sources of contamination identified above.

   - Example 1: a groundwater source has a leach field within 500 ft – the water system may choose to routinely monitor nitrate to confirm no effects from the source of contamination.
   - Example 2: an underground storage tank is located down-gradient within 500 ft. of a gas station – the water system must discuss plans to mitigate risks from possible groundwater and soil contamination.
   - Example 3: a surface water treatment plant is located within 500 ft of a lift station (wastewater) that may impact the site in the case of a sanitary sewer overflow (SSO). The water system must discuss what measures have been taken to protect the potable water from possible SSO contamination.

1.2.3 Water Quality Data

Per Table A.1 in Appendix A, when the BDR requires water quality data to be collected or existing data summarized to either confirm the quality of a new source or to justify the selection of a treatment process, the following must be submitted:

a. Raw water sampling requirements: Design submittals for new sources must include raw water quality data. Raw water data requirements depend on the public water system type and population served. Required water quality parameters and frequencies are outlined in Table 1.1. Additional water quality monitoring will depend on the downstream treatment, as outlined in Tables 1.2 and Table 1.3.

Table 1.1: New source water quality data requirements

Row	Public water system type	Regulation 11 MCL parameters (Regulation 11 section) or acute health parameter	Frequency for design application
i	CWS, all systems	Total coliform (11.11) Nitrate/nitrite (11.18) Inorganic chemicals (11.19) Organic chemicals (11.21) Radionuclides (11.22) Manganese (11.33)	2 full sample sets in different calendar quarters

		Design Criteria Table 1.2 / Table 1.3 parameters based on downstream treatment.	
ii	NTNC serving greater than or equal to 500 people	Total coliform (11.11) Nitrate/nitrite (11.18) Inorganic chemicals (11.19) Organic chemicals (11.21) Manganese (11.33) Table 1.2 / Table 1.3 parameters based on downstream treatment.	2 full sample sets in different calendar quarters
iii	NTNC serving less than 500 people	Total coliform (11.11) Nitrate/nitrite (11.18) Inorganic chemicals (11.19) Organic chemicals (11.21) Manganese (11.33) Table 1.2 / Table 1.3 parameters based on downstream treatment.	2 full sample sets in different calendar months
iv	TNC	Total coliform (11.11) Nitrate/nitrite (11.18) Manganese (11.33) Table 1.2 / Table 1.3 parameters based on downstream treatment.	2 full sample sets in different calendar months

Table 1.1 notes:

1. For all sources: one sample set must be sampled during the critical period. The critical period for surface water/GWUDI is typically run-off, summer months or lake turnover. The critical period for groundwater is the peak pumping month.
2. Seasonal wells must be sampled in the months that the wells will be utilized.
3. For Rows i, ii, and iii: Two sets of organic chemicals (Section 11.21 of Regulation 11) are not required if the first set results are all below the detection limit.
4. Replacement wells meeting Item 3.2.1(e) requirements may not have to include organic chemicals (Section 11.21 of Regulation 11) if a comparison of the well construction and all other collected water quality data demonstrates that the replacement well and the existing well are similar/produce same water quality. If water quality data comparison indicates different water quality, the Department may require additional water quality data be collected, including organic chemicals.
5. Suppliers with wells in the same aquifer may only need to submit one quarter of data. A comparison of the well construction and collected water quality data must demonstrate the water quality is consistent with other wells. If water quality data comparison indicates different

water quality the Department may require additional water quality data.

6. The Department recommends that sufficient data be collected in all cases to capture seasonal variability or any other varying conditions.
7. Previously collected data is acceptable when collected within the past four years.

b. Process design sampling requirements: Design submittal for all waterworks projects that impact treatment must include water quality results depending on the proposed or installed treatment process(es). Examples of waterworks projects that impact treatment works include, but are not limited to: new public water systems, new treatment plants, new sources treated at existing treatment plants, and modifications to existing treatment processes.

Required water parameters and frequencies are outlined in Table 1.2 and Table 1.3. Please note that additional water quality data results may be required depending on manufacturer requirements or the treatment's impact on corrosivity. See Appendix A, Table A.2.

Table 1.2: Waterworks projects that impact treatment – water quality data requirements

Row	Treatment process	Treatment or design parameters
Treatment processes not for Regulation 11 compliance		
i	Treatment is not for compliance or has no impact(s) to Regulation 11 compliance (e.g., no corrosion impacts, no impact to disinfection)	No additional parameters
Filtration for Regulation 11 compliance		
ii	Conventional filtration	- Turbidity - Alkalinity *For CWS/NTNC systems only - DBP precursors parameters:* - Total organic carbon (TOC) / Dissolved organic carbon (DOC)
iii	Direct filtration	- Turbidity - Alkalinity *For CWS/NTNC systems only - DBP precursors parameters:* - TOC / DOC
iv	Engineered biologically active filters	- Turbidity *Biological growth parameters:* - Total nitrogen - Total phosphorus - Temperature - pH - Dissolved oxygen (DO) *For CWS/NTNC systems only - DBP precursors parameters:* - - TOC / DOC

v	Slow sand filtration	- Turbidity - TOC /DOC - Total nitrogen - Total phosphorus - Temperature
vi	Diatomaceous earth filtration	- Turbidity
vii	Alternative filtration – bag/cartridge	- Data justifying filter selection (e.g. turbidity, particulate analysis) in accordance with Item 4.3.9.5 - Total iron - Total manganese - Hardness
viii	Alternative filtration – membrane	- Turbidity - TOC/DOC - Total iron - Total manganese
ix	Reverse osmosis (RO)	- Target contaminant (e.g., nitrate) - Total dissolved solids (TDS) - All additional ions and water quality that may inhibit treatment
Disinfection dosing		
x	Chlorine (see note 1 below)	- Total iron - Total manganese - Hydrogen sulfide - Total organic carbon - Ammonia
xi	Ozone	- Total iron - Total manganese - Dissolved manganese - Bromide - TOC/DOC
xii	Ultraviolet (UV)	- Total iron - Total manganese - Temperature - UV transmittance (UVT) at 254 nm - Total hardness - pH - Alkalinity - Calcium
xiii	Chloramines	- Total iron - Total manganese - Hydrogen sulfide - Total organic carbon - Ammonia
Disinfection log inactivation (see note 2 below)		
xiv	Disinfection log inactivation a.k.a. contact time	- pH, maximum - Temperature, minimum

Ion exchange and adsorptive media processes		
xv	Ion exchange and adsorptive media	- Target contaminate - Manufacturer required water quality data. - Consult with the Department on additional water quality data depending on project scope. - pH - Temperature - Alkalinity - Conductivity - Nitrate - Sulfate - Chloride - Iron - Any competing ions (e.g. uranium, fluoride, radium) *For cation exchange projects:* - Iron - Manganese *For GAC projects:* - TOC
Blending for MCL compliance		
xv	Blending when used to meet a Regulation 11 MCL	- - MCL parameter data from each source being blended
Lead and copper rule treatment (see note 3)		
xvi	Lead and copper treatment processes	- Lead - Copper - pH - Temperature - Alkalinity - Calcium - Total dissolved solids - Conductivity - Silica - Orthophosphate - Total phosphorus - Chloride - Sulfate - Total iron - Total manganese
Fluoridation		
xvii	Fluoridation	- Fluoride analysis (at point of fluoride application)

Table 1.2 notes:

1. Non-community systems (NTNC/TNC) serving less than 500 people and using free chlorine are not required to sample for additional parameters except total iron and total manganese.
2. For disinfection log inactivation calculations, the water supplier may elect to use the Department's standard parameters for pH and temperature rather than collecting data.

- Temperature: The minimum temperature will depend on the source type and active operating season (seasonal systems only).
  - Alluvial Wells (vertical with 20 ft casing): 4 degrees Celsius (39.2 degrees Fahrenheit).
  - Springs and Gallery Wells: 2 degrees Celsius (35.6 degrees Fahrenheit).
  - Creeks/Rivers: 0.5 degrees Celsius (32.9 degrees Fahrenheit).
  - Lakes with intake structure within lake: 2 degrees Celsius (35.6 degrees Fahrenheit).
  - Groundwater: 5 degrees Celsius (41.0 degrees Fahrenheit).
- pH: pH of 8.0.

3. Required water quality sampling tables for a lead and copper optimal corrosion control treatment recommendation and corrosion control studies are available in Appendix K.

Table 1.3: Waterworks projects that impact treatment - Water quality data frequency

Project Type	Frequency
Surface water treatment project	2 data sets in different calendar quarters (one set must include critical period (e.g., run-off, lake turnover))
GWUDI treatment project	2 data sets in different calendar months
Groundwater treatment project	2 data sets in different calendar months

Table 1.3 notes:

1. The Department recommends that sufficient data be collected in all cases to capture seasonal variability or any other varying conditions.
2. Previously collected data is acceptable when collected within the past four years unless an event has occurred which could impact water quality (e.g., a new or amended wastewater treatment project, development near source, forest fire, hazardous material spill).
3. If data collected is variable and may cause public health concerns, the Department may require additional water quality data to be collected to ensure sufficient treatment.

1.2.4 Process Flow Diagram/ Hydraulic Profile

Per Table A.1 in Appendix A, when the BDR requires plans and specifications to be developed, the plans and specifications must include a hydraulic profile and process flow diagram.

a. Process Flow Diagram

The process flow diagram (PFD) must show all major liquid and solids flow paths through various unit processes and include proposed sampling locations and bypasses. Also, the PFD must show chemical feed locations, flow metering and control locations.

b. Hydraulic Profile

At a minimum, the hydraulic profile(s) must include hydraulic elevations associated with the maximum and minimum water treatment plant flow conditions. Include the summary of calculations or a summary of the model used to arrive at the elevations presented. Additional evidence of calculations may be required by the Department on a case-by-case basis.

- Suppliers serving less than 500 people are exempt from this requirement (Item 1.2.4 (b)).

<u>1.2.5 Capacity Evaluation, Design and Calculations</u>

Per Table A.1 in Appendix A, when the BDR requires a capacity evaluation and design calculations, the following must be submitted at a minimum:

a. Sources.

   i. Demonstration of adequate water rights and permits through the Office of the State Engineer, Department of Natural Resources.

   ii. Groundwater sources: a copy of the well permit.

   iii. Source flow rate including permitted and pump capacity (pump curves preferred).

b. Treatment.

   i. Identification of treatment goals including regulatory compliance requirements and process goals.

   ii. Identification of disinfection compliance method:

      1. For water treatment plants that treat groundwater sources, the BDR must identify whether the treatment plant will seek certification for continuously providing 4-log treatment of viruses per Section 11.11(3) of Regulation 11 or operate under provisions for “triggered source water monitoring” per Section 11.11(4) of Regulation 11.

      2. For water treatment plants that treat surface water or groundwater under the direct influence of surface water (SW/GWUDI), the submission of monthly operating reports (MOR) is required. The BDR must identify whether the treatment plant will utilize the “minimum chlorine residual” MOR or the “calculated log inactivation MOR". Refer to WQCD Safe Drinking Water Program Policy DW-004 guidance document entitled “Policy 4 Guidance: Guidance on Proper Operations of Water Treatment Processes for the Control of Microbiological Contaminants” (Reference 5).

   iii. Desired or existing treatment plant design flowrate (i.e., rated capacity) in gallons per minute (See Item 4.0.2).

      1. Rate limiting step must be specified (e.g., disinfection, raw water pumping, filtration rate) – rate limiting step will determine rated capacity of the water treatment plant.

      2. The Capacity Evaluation Form must be completed and included in the BDR (template in Appendix B).

   iv. Design flow rates and hydraulic loading rates for each unit process must be provided.

v. Process and equipment design parameters for each affected treatment unit process.

vi. Supporting calculations and technical assumptions for each unit process within a water treatment plant that is included in the project or will be affected by the project. Calculations supporting the unit design flow rate (i.e., unit process treatment capacity) must be provided.

c. Storage.

i. Description of materials of construction and coatings to be employed.

ii. For storage tanks, supporting calculations and technical assumptions for venting capacity, overflow capacity, buoyance (if applicable) and tank mixing system (if applicable).

- For protected water storage tanks less than 11,000 gallons, venting/overflow calculations are not required.

iii. Description of distribution system and storage tank hydraulics and proposed operating regimes to promote adequate turnover and to minimize water age.

- Suppliers serving less than 500 people are exempt from this requirement (Item 1.2.5(c)(iii)).

d. Pumping and distribution system work.

i. For new and updated pumping installations: supporting pump curves and limitations to provide adequate pumping capacity.

ii. For distribution system work: line sizing, construction materials, and construction standards must be provided.

1.2.6 Monitoring and Sampling Evaluation

Per Table A.1 in Appendix A, when the BDR requires an evaluation of sampling and monitoring locations (and parameters), the following must be included at a minimum:

a. Proposed flow metering for sources and treatment. See Section 2.13.

b. Description of water quality sampling locations, the purpose and parameters being measured at the identified locations, and the means for feedback to operators (e.g., chlorine residual and turbidity compliance with Regulation 11, pH to monitor coagulation process via grab sample, online monitoring). See Section 2.9 and Section 2.10.

1.2.7 Geotechnical Report

Per Table A.1 in Appendix A, the BDR requires a geotechnical report in such instances where the waterworks structural integrity may be affected by the local geotechnical nature of the surrounding soils. When the scope of the project includes a new structure with a foundation associated with the treatment works, a geotechnical report will be required. For example, a small slab on grade is typically not considered a foundation (e.g., supports a 10 ft by 10 ft shed).

At a minimum, the geotechnical report must include the following information as applicable to the design: site specific soil boring information that discusses seasonal and measured groundwater conditions, soil bearing capacity, excavation benching, shoring and sloping, bedding and backfill, compaction and moisture conditioning, alternative foundation design, an analysis of geotechnical hazards, and design recommendations based on the findings.

1.2.8 Residuals Handling

Per Table A.1 in Appendix A, when the BDR requires residuals handling (including treatment process wastewater) components to be addressed, a summary of residuals handling must be submitted. This summary must conform to the requirements set forth in Chapter 9.

1.2.9 Preliminary Plan of Operation

Per Table A.1 in Appendix A, a preliminary plan of operation must be submitted for all projects which will impact storage or treatment. The plan of operation must include a discussion of the following items, if applicable:

a. Staffing recommendations for the water treatment plants including staffing levels and expected operator certification requirements.

b. As part of the final design approval, the Department will specify the appropriate level of operator certification for a given water treatment plant per *Regulation 100: Water and Wastewater Facility Operators Certification Requirements* (Reference 6).

c. The expected basic operating configuration and process control procedures. Where initial operating conditions will be significantly less than design capacity, BDR must document design flexibility allowing the system to operate under differing flow regimes.

d. Phased operation of existing waterworks to maintain compliance during construction, if applicable.

   - Suppliers serving less than 500 people are exempt from this requirement (Item 1.2.9(d)).

e. Safety issues for the source or water treatment plant, and individual components and equipment.

   - Suppliers serving less than 500 people are exempt from this requirement (Item 1.2.9(e)).

f. General description of redundancy provisions. See Section 2.1.

1.2.10 Impact to Corrosivity

All treatment and source related projects at public water systems subject to Section 11.26 of Regulation 11 (i.e., Lead and Copper Rule) must consider impacts to corrosivity. Suppliers of water must utilize Table A.2 in Appendix A. Each project will be considered one of four categories. Depending on the category, the supplier must develop appropriate discussions, analysis, and reports to explain the possible impacts of the proposed project to corrosivity.

For category 4 projects from Appendix A, Table A.2, the supplier must complete the information found in Appendix K utilizing appropriate sampling data as outlined in Department communications, Item 1.2.3 of this document, and Appendix K. Category 4 projects will apply to suppliers of water who have been required to develop optimal corrosion control treatment (OCCT) or desiring to modify an OCCT designation (under Section 11.26(3) of Regulation 11).

If the supplier has questions about how the Department will classify any given project, the Department recommends that suppliers communicate and receive written confirmation of the classification.

1.2.11 Security and Emergency Response Program

Security must be an integral part of drinking water system design.

a. Physical security design: Design considerations must address physical infrastructure security, and facilitate security related operational practices and institutional controls. All public water suppliers must identify and address security needs in design and construction for new projects and for retrofits of existing drinking water systems. The following items must be included in the design and construction of new water system waterworks and improvements to existing water systems:

   i. Physical controls such as fencing must be included to restrict access to all waterworks to only those conducting authorized official business, and to detect unauthorized physical intrusions.

   ii. Sturdy, weatherproof, locking hardware must be included in the design for the access to tanks, vaults, wells, well houses, pump houses, buildings, power stations, transformers, chemical storage, delivery areas, chemical fill pipes, and similar facilities.

   iii. Human and vehicle access must be through controlled locations only.

b. Security and emergency response program: Because drinking water systems cannot be made immune to all possible attacks, the design must address critical asset redundancy, monitoring, response and recovery. The Department requires that the design include security and emergency response measures. The BDR must include a statement which indicates that the supplier has developed a security and/or emergency response program that at a minimum addresses the following components.

   i. Water treatment plant layout design must consider critical system assets and the physical needs of security for these assets.

   ii. The design must identify, evaluate, and mitigate single points of failure that could render a system unable to meet its design basis.

   iii. Procedural controls to restrict access to both physical and digital utility infrastructure to only those conducting authorized official business and to detect unauthorized physical intrusions. This could include external actors, internal actors at different levels, and previous employees.

   iv. Computer based control technologies such as SCADA must be secured from unauthorized physical access and potential cyber attacks. All automated control systems must be equipped with manual overrides to provide the option to operate manually. All highly automated or sensitive systems must be equipped with manual overrides that isolate the system from other networks and information transfer. The procedures for manual operation including a regular schedule for exercising and ensuring the operator's competence with the manual override systems must be included in treatment plant operation plans.

   v. Consideration must be made to ensure effective response and timely replacement of critical components that are damaged or destroyed.

Critical components that comprise single points of failure (e.g., high volume pumps) that cannot be eliminated must be identified during design and given special consideration. The supplier should create a list of critical components with a vendor contact and an approximate lead time.

vi. Water treatment plants and procedures for delivery, handling and storage of chemicals must be designed to ensure that chemicals delivered to and used at the water treatment plant cannot be released, introduced or otherwise used to debilitate a water system, its personnel, or the public.

- Non-community suppliers serving less than 500 people with only sodium hypochlorite treatment are exempt from this requirement (item 1.2.11(b)).

Security and emergency response resources are available on the Division's website. The supplier does not have to submit these plans but the plans may be confirmed during sanitary surveys.

1.2.12 Supplemental and Other Pertinent Information

Any additional information that the designer or supplier desires to provide to aid in design review should be addressed in the Supplemental or Other Pertinent Information section of the BDR.

1.3 PLANS AND SPECIFICATIONS

The purpose of plans and specifications are to confirm information contained in the BDR and to facilitate construction of the project. The Department recognizes that for different scale projects, the terms final plans and specifications, 60% design drawings, and other terms may have different applicable definitions. If a submittal contains plans and specifications that are clearly preliminary and do not show sufficient detail to demonstrate conformance with the Design Criteria, the Department will issue a request for information (RFI) letter requesting the entity to resubmit the package with the appropriate detail contained in the plans and specifications so substantial conformance with the Design Criteria can be demonstrated.

Plans must be clear, legible, and drawn to scale permitting necessary information to be shown plainly, and include industry-standard items, such as listed below:

a. Project title, owner's name, date, seal and signature of design engineer (if required). Plans must indicate what stage of design the plans represent (e.g., 60% stage for drawings, for state review only, for construction).

b. Index to sheets and vicinity map with project site location.

c. List of abbreviations, definitions, and symbols used within the plans, or reference to the source of this information.

d. Each sheet must contain the project title, sheet title and number, and date. Plan drawings must include a north arrow, and a scale as well as a graphical bar.

e. Consistent expression of numerical units.

f. Drawings showing plan views, elevations, sections, profiles, and general layouts, to adequately represent the design.

g. Basis of all horizontal and vertical datum control.

h. Design criteria summary table (alternatively can be included in the BDR).

The items below must be included in the plans where the proposed modification affects or is affected by these items:

a. Site plan and/or general layout map including.

  i. Easements.

  ii. Property lines.

  iii. Right of Way.

i. Existing and proposed topography with contours and/or spot elevations as well as significant natural or manmade features such as streams, lakes, streets, buildings, etc.

j. Estimate of normal stream flow and 100-year flood elevations.

k. Location of known structures, utility lines (gas, water, power, telephone, storm sewer, etc.), or possible obstructions, both above and below ground, that potentially may affect the proposed construction.

Technical specifications must accompany the plans. Specifications must include design requirements not shown on the drawings, including the quality and type of materials and equipment, mechanical and electrical requirements, instructions for testing of materials and equipment, operating performance tests, and measures to mitigate construction activities regarding noise, traffic, stormwater, operations and maintenance manuals, operator training, etc.

For suppliers utilizing the pre-accepted design packages or serving less than 500 people, process schematics and equipment cut sheets may be sufficient to replace plans and specifications.

1.3.1 Source Plans

In addition to the requirements above and found in Section 1.2, submitted design plans for source projects must include:

a. Detail of source construction.

b. Detail drawings, made to a scale to clearly show the tie in with existing water plants or distribution/source collection system.

1.3.2 Storage Tank Plans

In addition to the requirements above and found in Section 1.2, submitted designs for storage tank projects must include plans and specifications of the proposed storage tank including the following details:

a. Hatches.

b. Vents.

c. Level detection.

d. Cathodic protection.

e. Overflow.

f. Drains.

g. Associated appurtenances (e.g., valves, flappers, screens, vaults, and sealing mechanisms).

1.3.3 Water Treatment Plant Plans

In addition to the requirements above and found in Section 1.2, submitted design plan and specifications for water treatment plants must include the following:

a. Process flow diagram and hydraulic profile.

b. Location, dimensions, elevations, and details of all affected existing and proposed plant including applicable details and appurtenances.

c. Roads and access points for the treatment plant.

d. Number, type, capacity, motor horsepower and head requirements of proposed pumping and process equipment.

e. Process and instrumentation diagram.

f. Proposed sampling locations and monitoring equipment.

g. Other drawings, as appropriate, such as structural, electrical, instrumentation and controls, mechanical, and civil components.

h. Geotechnical test borings and groundwater elevations (as required by the project).

i. Provisions for future capacity and space for future equipment.

   - Suppliers utilizing the pre-accepted design packages or serving less than 500 people, submitting process schematics meeting certain elements of a, e, and f above may be sufficient.

1.4 SITE-SPECIFIC DEVIATIONS

Site-specific deviations from the Design Criteria may be requested. Deviations from the Design Criteria must be explicitly identified in the BDR. The request must include a technical justification for each site-specific deviation. The justification must specifically address how the proposed site-specific deviation meets or exceeds the intent of the applicable criteria, such as:

a. Theory and calculations demonstrating how the waterworks will function if the site-specific deviation is granted.

b. Actual operating experience and/or pilot test work, if available.

c. Documentation of alternative peer-reviewed design basis.

d. Demonstration of documented experience through similar facilities.

The Department may request additional administrative or technical information. If the Department determines that a site-specific deviation may potentially endanger public health or the environment, or does not provide equal protection to that which would be provided by these criteria, the Department will deny the site-specific deviation and/or require compensatory measures be taken.

1.5 LIMITED SCOPE APPROVAL

Projects under a limited scope submittal process do not have a reduced timeline for decision but rather have reduced submittal requirements. The purpose is to limit the submittal scope for substantial modification projects which need Department approval but are not new or the scope of a significant design project. If a supplier proceeds with a substantial modification without Department approval, even if limited scope, the supplier may be in violation of Regulation 11.

The Department requires suppliers with proposed modifications of waterworks classified as limited scope in Appendix A submit certain elements of the BDR. The submittal expectation always includes the Section 1 elements of the BDR. In this section, the supplier or their representative must indicate the desire for the project to be considered limited in scope.

Once the Department has reviewed the proposed limited scope application, the Department will take one of three actions:

1. Issue written decision (e.g., approval or denial) letter for the project.
2. Issue a request for additional information (RFI) letter.
3. Issue a statement that the modifications are considered O&M by the Department and no further action is necessary.

This process does not require a Professional Engineering stamp from community water systems.

Examples of limited scope projects include:

- Switching between coagulant types – not redesigning the coagulant feed system.
- Modifications to the air scour system or adding an air scour system (in some cases).
- Modifications to storage tanks (including all of the following: re-lining a storage tank, adding/modifying: hatches, corrosion protection, overflows, and drains). Changing vent sizes requiring vent calculations will be considered a substantial modification.
- Ceasing to use certain chemicals or treatment processes not required for compliance (e.g., removing sediment filters, removing fluoridation equipment).

Non-community water systems may not submit for limited scope approval unless they utilize a professional engineer in order to submit plans and specifications. The Department highly recommends that non-community systems utilize the pre-packaged design documents located on the Department's website (http://www.colorado.gov/cdphe/wqcd).

1.6 PILOT SCALE EVALUATIONS

Suppliers are encouraged to consult with the Department prior to initiating bench or pilot scale evaluations of treatment to be used for the basis of design. This consultation is important in cases where the data will justify a deviation from the Design Criteria. For the purposes of these Design Criteria:

"Pilot Scale" means an evaluation of waterworks or water treatment that will not produce water meant for human consumption. All water produced at pilot scale will be wasted – not provided for human consumption. Any waterworks that are used for a pilot scale evaluation and then returned to service of potable water must be fully rinsed and disinfected after the pilot scale evaluation is completed before returning to service. Bench scale analyses, for the purpose of this document, are considered pilot scale.

"Pilot Plant" means a low-flow water treatment system installed and operated on a source water representative of source of supply for a water system NOT serving potable water. The pilot plant provides the design engineer crucial information about treatment design such as water quality and loading rates of individual units without requiring full-scale demonstration testing or full treatment design and installation.

The Department will receive and comment on proposed pilot scale and pilot plant evaluations. See Appendix C for templates. The primary purpose of this initial review will be to confirm for the supplier that the data being proposed will be sufficient to justify any deviations from the Design Criteria should they be requested or to justify treatment decisions should they be required. This preliminary review has particular applicability for exceedances of the action level in the lead and copper regulations, and seeking approval for higher filtration rates.

As long as the pilot scale evaluation or pilot plant does not provide potable water for human consumption, no prior approval is required per Section 11.4 of Regulation 11.

1.7 DEMONSTRATION SCALE EVALUATIONS

Frequently, suppliers request temporary approval to evaluate whether or not modifications to a treatment system or the addition of a new process will provide long-term benefits. The Department offers temporary approval of demonstration scale evaluations. For the purposes of these Design Criteria:

“Demonstration Scale” means installation and evaluation of a treatment technology or treatment technique at a full-scale water treatment plant. A demonstration scale evaluation serves potable water to the public during the evaluation. Therefore, prior approval is required in accordance with Section 11.4 of Regulation 11.

Demonstration scale applications must include the following:

a. BDR sections 1.2.1, 1.2.4, 1.2.5, 1.2.9, and 1.2.10.

e. Written water quality sampling plan and strategy to determine treatment effectiveness.

Typical demonstration-scale evaluations consider alternative chemicals to be fed to existing processes. For example, a temporary coagulant feed on a current membrane filtration system to help reduce disinfection by-products. Applications for approval of this type of temporary installation may be approved on a temporary basis; the Department will specify the date that the demonstration-scale evaluation expires. A template for submitting a demonstration scale plan is included in Appendix C. After the expiration of the demonstration scale evaluation, the supplier must re-submit to receive approval for any permanent installation of the equipment used during the evaluation. This submittal is required even if it is the same equipment, as the Department will perform a more-thorough review of equipment for a permanent installation. Please note: demonstration scale projects must still consider Appendix A, Table A.2 for impacts to corrosivity unless the demonstration project will be online for 60 consecutive days or less in a 12 month period.

The Department expects an evaluation of the results of the demonstration scale to be performed and submitted along with the BDR, plans, and specifications for approval of any permanent infrastructure installed as a result of the demonstration scale evaluation.

1.8 CONSTRUCTION COMPLETION FORM

Upon completion of construction, the supplier must submit a construction completion form indicating the project was constructed in conformance with the Department’s design approval letter and the project’s operational date. The form must be signed by a person knowledgeable about the project construction status, such as, supplier's representative, Colorado professional engineer, or entity responsible for construction.

1.9 CHANGES DURING CONSTRUCTION

Any changes from approved plans or specifications affecting capacity, flow, or operation of units must be submitted in writing for Department review and approval before such changes are made. Changes following the completion of construction require a new design submittal; changes made during the construction may require a new design submittal or reduced submittal qualifying as an addendum to the approved design.

Examples of changes that require Department review and approval include but are not limited to:

- Modifying basins or pumping to affect the hydraulic profile of the water plant.
- Modifying the size of water storage or the amount of effective storage.
- Changes that affect the rated capacity of a water treatment plant.
- Changes that affect the baffling characteristics of a contact basin.

Examples of changes that *usually* do not require Department review and approval are:

- Changes to access roads.
- Changes to the building architecture, façade, or other architectural features which are not related to treatment or production of finished water.
- Changes to building electrical, plumbing, or mechanical systems not related to treatment or production of finished water.
- Changes to laboratory or maintenance facilities located onsite which do not relate to treatment or production of finished water.

1.10 CONDITIONS OF APPROVAL

Typically, the Department grants conditional approval and outlines conditions under which the design approval has been granted. Section 11.4(3) of Regulation 11 states the implications of a supplier not conforming to the conditions of approval:

> *If the supplier refuses to accept any conditions of a conditional approval, it constitutes a denial.*

The Department will confirm that conditions of approval are being met during sanitary surveys or other periodic inspections of the public water system.

1.11 ALTERNATIVE TECHNOLOGIES

The alternative technology review process is for technologies that are not represented in the current Design Criteria. The term refers to an established or innovative technology with a compliance record that is in use in other states or countries but is alternative in the sense that standards do not exist within these Design Criteria and thus is not currently accepted for use in Colorado. The alternative technology review process is not intended for emerging treatment techniques that are still being developed and are without an existing compliance history. To prevent significant delays in the design review process, a request for alternative technology acceptance should be submitted as soon as practical before, but no later than at the same time as, the application for construction approval by a supplier.

Alternative technology submittals can be made either by the manufacturer of the technology or by a supplier with a site-specific design utilizing the alternative technology. When a proposed design includes an alternative technology not covered by the Design Criteria, then, upon request by the owner, design engineer, or Department staff, the

Department will review the design of the alternative technology. The Department will review the history of successful operations, evaluate the efficacy of the technology in providing reliable treatment under a range of operating conditions, and, if accepted for use in Colorado, develop appropriate criteria for inclusion as addenda to this document. If full-scale operating experience is not available for inclusion in an alternative technology submittal, then pilot test data may be considered for an alternative technology review.

Design approval is required for each location where use of an accepted alternative technology is proposed.

The request for Colorado acceptance of a treatment technology that is not covered by the current Design Criteria (or not previously provided with alternative technology acceptance in Colorado) must include:

a. Discussion of manufacturer's warranty and/or performance warranty, including all exclusions or limitations on the warranty.

b. A description of specific operator knowledge and skill that are needed to operate the proposed technology, including an estimate of increased operator attention needed during startup and the first year of operation.

c. Documentation of how operators will be trained to properly operate, control and maintain the plant.

d. Documentation of how the alternative technology functions.

    i. Proprietary information must be marked as 'confidential' in the submittal and include an explanation regarding why the information is confidential.

    ii. All assumptions must be clearly documented and explained.

    iii. Calculations performed with the use of any type of process modeling must be based on applicable data and not solely upon textbook references unless it can be demonstrated that the text book references are appropriate.

e. A discussion of actual, full-scale operating experience and/or pilot test work.

    i. For full-scale operating experience, the length of time that each installation has been in operation must be included.

    ii. For pilot test work, a copy of the associated pilot test plan and final pilot test report must be included.

f. Comparison of hydraulic capacity of other installations of the technology with the proposed application (within +/- 25% preferable).

g. Comparison of water quality conditions of other installations of the technology with the proposed application (within +/- 25% preferable).

h. Comparison of operating conditions (including temperature, altitude, flow, raw water quality, etc.) of other installations of the technology with the proposed application (similar conditions preferable).

    i. Specific sensitivities of the proposed technology to any operating condition(s) must be discussed and viable means to address specifically included.

i. Operating performance data of other installations for the technology, preferably for a continuous period of at least 12 months.

j. Discussion of operational controls to provide flexibility for responding to varying raw water characteristics and treatment conditions.

k. Discussion of process control and finished water sampling and monitoring that is proposed to be performed to verify the performance of the alternative technology.

l. Discussion of known and/or anticipated start-up issues and operational issues that have occurred or may occur during the first year of operation.

CHAPTER 2
GENERAL DESIGN CRITERIA

2.0 GENERAL

The design of a water source system or treatment process encompasses a broad area. Application of this chapter is dependent upon the type of system or process involved.

2.1 REDUNDANCY

Maintaining potable water in the distribution system is a main objective of public water systems. This objective not only requires the ability to produce potable water but also to have resiliency and redundancy to conduct routine and non-routine activities. To prepare for routine operational and maintenance activities and unforeseen events such as equipment failures, the design must address the ability of the supplier to continuously provide potable water. In most instances, the design is required to incorporate a level of redundancy into systems, equipment and processes. The Department recognizes that the means whereby specific designs provide redundancy may vary based on the project's scope of work and the operational needs of the supplier. Although recommended, the Department does not require redundant sources and finished water storage tanks.

For treatment plants, the design must include plant treatment redundancy unless an exemption is outlined in the Design Criteria (e.g., under Item 5.1.1 treatment plants with a flow less than 20 gpm do not have to have a redundant chemical feed pump if a spare pump can be installed within 72 hours). If the supplier believes that redundancy requirements are not applicable to the design, the supplier may request the Department to consider a site-specific deviation per Section 1.4 with supporting justification. Redundancy requirements may be met using distribution system storage and/or additional sources of finished water (e.g., multiple treatment plants, consecutive connections.

> Plant treatment redundancy means redundancy within an individual treatment plant. This type of redundancy is prescribed in the unit process criteria in Chapter 4 and Chapter 5. Treatment redundancy allows an individual treatment plant to continue producing potable water at the design flow rate during normal operations, routine shutdown, or emergency events by having redundant equipment. Under plant treatment redundancy, when equipment is necessary for compliance with Regulation 11 (e.g., chlorination, SW/GWUDI filtration, nitrate removal), a standby unit or a combination of units of sufficient size to meet design capacity must be provided to replace the largest unit when out of service. Plant treatment redundancy is not required if the treatment process is for aesthetics or a secondary MCL (e.g., hardness removal). The Department may require plant treatment redundancy when the treatment equipment appears to be for Regulation 11 compliance (e.g., arsenic at 90% of the MCL) or for EPA health advisory levels.

The BDR must identify and justify how the design meets the redundancy requirements.

2.2 PLANT LAYOUT

Design must consider:

a. Functional aspects of the plant layout.

b. Provisions for future plant expansion.

c. Provisions for waste treatment and disposal facilities.

d. Chemical delivery.

e. Plant security.

f. Site grading and drainage.

g. Utility easements.

h. Yard piping.

In addition to the items above, design should also consider the following:

i. Access roads.

j. Snow storage and removal.

k. Walks and driveways.

2.3 BUILDING LAYOUT

Design must provide for:

a. Accessibility of equipment for operation, servicing, and removal.

b. Flexibility of operation.

c. Operator safety.

d. Convenience of operation.

2.4 LOCATION OF STRUCTURES

All waterworks must be certified as being out of the 100-year floodplain or sufficient flood protection must be provided to protect the waterworks from a 100-year flood event.

- Non-community systems serving less than 500 people that can demonstrate the ability to shut down the water system and choose to utilize that option in the event of flooding can be exempt from the floodplain certification requirement above. A description of this option and plan to implement system shutdown must be included in the BDR.

Site specific environmental conditions must be considered when determining locations of structures. This includes exposure to ultraviolet light, extreme heat or freezing conditions, wind or hail events, localized flooding, rock / ice fall, avalanches, etc. Any special considerations taken for structure locations should be documented in the BDR.

Treatment plants must be above grade unless a subterranean mitigation plan is submitted (e.g., drainage, access, worker safety).

2.5 ELECTRICAL CONTROLS

Main switchgear electrical controls must be located above grade. All electrical work must conform to the requirements of the National Electrical Code or to relevant State and/or local codes.

2.6 STANDBY POWER/ ALTERNATE SUPPLY

Design must have provisions for standby power or alternate water supply so that water may be treated and/or pumped to the distribution system during power outages to meet the average day demand. The average day demand is the total volume of water used during a year divided by the number of days the public water system was in operation, usually expressed in terms of million gallons per day (mgd) or gallons per minute (gpm). Other alternatives to water supply during power outages may be considered by the Department with proper justification, such as interconnections with other systems, shut down of the public water system (e.g., non-community such as a restaurant or school), and hauling water.

2.7 SHOP SPACE AND STORAGE

Adequate facilities should be included for maintenance shop space and storage consistent with the designed facilities.

2.8 LABORATORY FACILITIES

Each supplier must have its own equipment and facilities for process control and compliance testing necessary to ensure proper operation.

2.9 MONITORING EQUIPMENT

Monitoring equipment requirements will vary depending on: treatment processes employed, source water (e.g., groundwater), selected method of compliance with either Section 11.8 of Regulation 11 (i.e., Surface Water Treatment Rule) or Section 11.11 of Regulation 11 (i.e., Groundwater Rule), and target constituents of concern (e.g., nitrate).

The design must include monitoring equipment to demonstrate compliance with Regulation 11. Monitoring equipment must meet the analytical requirements in Section 11.46 of Regulation 11 (i.e., Analytical Requirements and Laboratory Certification Rule). In certain instances, Regulation 11 requires that continuous monitoring equipment be used and in other instances hand-held instrumentation may be used for “grab sample” monitoring. If online chlorine monitoring equipment is proposed then the BDR must address verification methods including weekly verification with handheld equipment or parallel analyzers. See “CDPHE Policy 4 Guidance Manual” (Reference 5).

The BDR must clearly identify all required monitoring equipment and the type (continuous on-line or hand-held). Water treatment plants must be provided with equipment (including recorders, where applicable) to monitor the water quality and flow as follows:

a. All treatment plants: Flow monitoring must be provided per Section 2.13.

b. Groundwater treatment plants: Design must have equipment to monitor residual disinfection concentration (e.g., free chlorine residual) at the entry point. Free chlorine residual monitors are required for free chlorine systems; total chlorine residual monitors are required for chloramine systems (see f below).

c. Surface water and ground water under the direct influence of surface water plants: Design must have equipment to monitor and record turbidity, residual disinfectant concentration, water temperature, pH, flow through disinfection segments at locations necessary to comply with Section 11.8 of Regulation 11 (i.e., Surface Water Treatment Rule) and other process control variables as determined by the Department

d. Acute organic/inorganic treatment: Design must have the capability of monitoring the constituent of concern (e.g., nitrate) or a surrogate constituent at the entry point. Nitrate treatment plants must have the ability to monitor entry point nitrate at least once per day that water is served to the public.

e. Corrosion control treatment required under Section 11.26 of Regulation 11 (i.e., Lead and Copper Rule): Design must have equipment to monitor pH and treatment technology applicable concentrations (e.g., alkalinity, orthophosphate residual).

f. Chloramine treatment plants: Design must have equipment to monitor total chlorine residual disinfectant concentration at entry point and, if required under Regulation 11for microbial inactivation, equipment to monitor free chlorine residual concentration before the addition of ammonia.

i. The design must address adequate process control and any process control monitors (e.g., free chlorine, ammonia, nitrite, nitrate).

ii. The BDR must address how process control instrumentation is used to prevent the over/under feeding of ammonia.

2.10 SAMPLE TAPS

The design must include sample taps to collect Regulation 11 compliance samples and for water system operations. Sample taps must be provided as follows:

a. All sources must have individual source water sample taps (as defined in Section 11.3 of Regulation 11), or the provision for obtaining grab samples from each source.

b. All treatment plants using blending of water sources for compliance with Regulation 11 must have a sample tap on each blended water source and a combined blended water tap located downstream from the point at which source water is commingled.

c. All treatment plants must have:

   i. Entry point sample tap(s) as defined in Section 11.3 of Regulation 11. The entry point must be located after all treatment processes, including disinfection. The entry point sampling location must be located prior to any branching of the flow leaving the treatment plant.

   ii. Microbial inactivation sample tap(s): When multiple log inactivation disinfection segments are used, monitoring locations are required downstream of each disinfection segment. For many plants utilizing a single disinfection segment, the entry point sample tap will also function as the microbial inactivation sample tap.

d. All surface water and ground water under the direct influence of surface water plants (See EPA *SWTR Turbidity Provisions Guidance Manual*, Reference 7) must have:

   i. A combined raw water sample tap or representative sample location located downstream from the point at which source water is commingled and prior to the point at which any treatment occurs or chemical feed is administered.

   ii. Regardless of the filtration method employed, a sample tap for combined filter effluent (CFE), as defined in Section 11.8(1) of Regulation 11. The CFE tap must be located as close as practical to the point at which filtered water from multiple filters commingles and prior to any chemical feed and/or zone which could allow for settling of particulate matter.

   iii. If conventional filtration is employed, sample taps or representative sample locations for the disinfection byproduct precursors paired total organic carbon sample set, as defined in Section 11.24(1) of Regulation 11, must be provided.

   iv. If conventional or direct filtration is employed, sample taps for individual filter effluent (IFE), as defined in Section 11.8(1) of Regulation 11, must be provided. IFE sample taps must be located as close as practical to each filter’s effluent connection and prior to commingling of water from any other filter.

v. If membrane filtration is employed, individual membrane unit (IMU) sample taps for indirect integrity monitoring samples must be provided. IMU sample taps must be located as close as practical to each membrane unit's effluent connection and prior to commingling of water from any other membrane unit.

e. The BDR must discuss the provision of process control sample taps to facilitate optimizing and controlling treatment plant operations. For example:

i. Chemical feed process control sample taps should be located as close as possible to the feed point while also allowing for complete mixing of the chemical and allowing for chemical reaction time considerations.

ii. Treatment process performance sample taps (i.e., raw water turbidity, settled water turbidity, etc.) should be located immediately downstream of the associated treatment process.

f. Other sampling locations required in Regulation 11.

g. When a sample tap is used to obtain samples for process control or compliance with Regulation 11, the design location and size of the sample tap, sample conveyance line, and instrumentation must minimize the amount of lag time between the time that the sample is obtained from the bulk flow and the time that the sample is analyzed. Lag times must be less than two (2) hours.

2.11 PLANT WATER

The plant water service line must be supplied from a finished water location where the required disinfection and minimum residual disinfectant concentration have both been achieved.

2.12 NOT USED

2.13 METERS

a. All treatment plants must have a means of accurately measuring the flow from each source, the washwater, the recycled water, any blended water, water that bypasses treatment, and the finished water.
b. A calculation of flows will be allowed if the contributing flows are metered on a case-by-case basis.
c. Flow meters must be installed in accordance with the manufacturer's recommended configurations including minimum upstream and downstream distances to ensure accuracy.
d. Flow meters must be located in an orientation that minimizes the potential for inaccuracies due to entrapment of entrained air in the bulk fluid.

2.14 PIPING COLOR CODE

To facilitate identification of piping in plants and pumping stations, it is recommended that the following color scheme be considered:

Water Lines

Raw or Recycle	Olive Green
Settled or Clarified	Aqua
Finished or Potable	Dark Blue

Chemical Lines

Alum or Primary Coagulant	Orange
Ammonia	White
Carbon Slurry	Black
Caustic	Yellow with Green Band
Chlorine (Gas and Solution)	Yellow
Chlorine Dioxide	Yellow with Violet Band
Fluoride	Light Blue with Red Band
Lime Slurry	Light Green
Ozone	Yellow with Orange Band
Phosphate Compounds	Light Green with Red Band
Polymers or Coagulant Aids	Orange with Green Band
Potassium Permanganate	Violet
Soda Ash	Light Green with Orange Band
Sulfuric Acid	Yellow with Red Band
Sulfur Dioxide	Light Green with Yellow Band

<u>Waste Lines</u>

Backwash Waste	Light Brown
Sludge	Dark Brown
Sewer (Sanitary or Other)	Dark Gray

<u>Other</u>

Compressed Air	Dark Green
Gas	Red
Other Lines	Light Gray

For liquids or gasses not listed above, a unique color scheme and labeling should be used. In situations where two colors do not have sufficient contrast to easily differentiate between them, a 6-inch band of contrasting color should be on one of the pipes at approximately 30 inch intervals. The name of the liquid or gas should also be on the pipe. In some cases, it may be advantageous to provide arrows indicating the direction of flow.

<u>2.15 DISINFECTION</u>

All wells, pipes, tanks, and equipment which can convey or store water intended for potable use must be disinfected in accordance with current AWWA procedures prior to initial use. If the initial bacteriological sample fails, the waterworks must not be placed back into service until two successive bacteriological samples, taken at least 24 hours apart, have passed the bacteriological testing.

Plans or specifications must outline the selected procedure and include the disinfectant dosage, contact time, and method of testing the results of the procedure. The disinfection method used must consider the effects of disinfection byproducts being discharged into the distribution system.

For surface water treatment, filtration and all unit processes downstream of the filters must be disinfected.

- Disposal of heavily chlorinated water from the disinfection process must be in accordance with federal, state, and local environmental regulation since it may impact the environment. Discharge of highly chlorinated water may require special provisions (e.g., dechlorination) or a permit. The Department has a low risk discharge policy which may be applicable for discharge of potable water used in the disinfection process (see Item 9.2.8).

2.16 OPERATION AND MAINTENANCE MANUAL

Plans and specifications must include a statement that O&M equipment manuals (either paper or electronic versions) will be provided to the supplier prior to project completion.

2.17 OPERATOR INSTRUCTION

A statement must be included in the BDR outlining provisions that will be made for operator instruction prior to or during the startup of a WTP or pumping station.

2.18 SAFETY

a. Consideration must be given to the safety of water plant personnel and visitors. The design must comply with all applicable local, state, and federal safety codes and regulations.
b. If AWWA standards, or safety data sheets (SDS) provide safety recommendations, the design must address such safety considerations.

2.19 SECURITY

Security must be an integral part of drinking water system design. See Item 1.2.11 for security and emergency response program requirements.

2.20 NOT USED

2.21 MATERIALS IN CONTACT WITH PARTIALLY TREATED OR POTABLE WATER

The purpose of ANSI/NSF requirement is to avoid leaching of contaminants or introduction of other contaminants to ensure the safety of drinking water.

Chemicals added to the treatment process must be ANSI/NSF 60 certified. Note: ANSI/NSF 60 certifications do not exist for certain gaseous chemicals such as gas chlorine, anhydrous ammonia, or chemicals generated onsite like chlorine dioxide or ozone and therefore ANSI/NSF 60 certifications are not required.

Suppliers must use materials, lubricants, and products that will not substantially degrade the quality of the water or threaten public health by introducing new contaminants into the drinking water. Many products have been tested and certified as meeting the specifications of American National Standard Institute/NSF International (ANSI/NSF) 61, Drinking Water System Components – Health Effects, Federal Drug Administration (FDA) Food Compliant, United States Pharmacopeia (USP), and other reputable, certifiable and recognized entities, and therefore can be substantiated as being appropriate for contact with potable water.

Drinking Water System components that must be verified as being appropriate for contact with potable water include the list found in Appendix E. This requirement must be met by verifying testing was conducted by a product certification organization accredited for this purpose by the American National Standards Institute. If ANSI/NSF products are not available or practical, food grade (FDA compliant) products may be substituted.

- Transient Non-Community Water Systems are not required to use ANSI/NSF 61 compliant materials, as long as the substitute is intended for use with drinking water except for tank painting, concrete curing, release and corrosion protection coatings.

Some types of materials are allowed for use in waterworks given the long-standing and wide use of the materials and generally low risk of introducing contamination as evidenced by lack of water quality data showing contamination. Water suppliers may use the following materials, or products without verifying they are certified under ANSI/NSF 61:

a. Concrete (see Appendix E for concrete related compounds).
b. Carbon Steel.
c. Ductile Iron.
d. Stainless Steel.
e. Galvanized steel ladders and appurtenances for protected water storage tanks.
f. Wood (redwood).
g. Aluminum.
h. Plastic components made of polyethylene, polypropylene, PVC (excluding DWV pipe), or FDA food compliant plastics intended for potable water.
i. A material or product constructed of individual components meeting the requirements of ANSI/NSF 61.
j. Small parts or components with minimal surface area such as probes, sensors, wires, nuts, bolts, pump impellers, gaskets, and tubing or for which there are no certified alternatives.

The ANSI/NSF 61 requirement applies to partially treated water (beginning with the first Department approved treatment process) within the water treatment plant. Raw water structures, collection systems, and other waterworks prior to the water treatment plant are not required to meet the ANSI/NSF 61 Standard.

The Department is highlighting the importance of the following activities due to the likelihood they can contaminate the water. All water suppliers, including TNC systems, must use ANSI/NSF 61 certified materials and follow proper procedures for the following:

k. Tank Painting: Interior protective coating systems must be ANSI/NSF standard 61 certified and be acceptable to the Department. Interior paint must be applied, cured, and used in a manner consistent with the manufacturer's ANSI/NSF approval.
l. Concrete Curing, Release and Corrosion Protection Coatings: Concrete curing compounds and materials used in concrete form releasing or corrosion control must be ANSI/NSF standard 61 certified and be acceptable to the Department. They must be applied and used in a manner consistent with the manufacturer's ANSI/NSF approval.

2.22 OTHER CONSIDERATIONS

Consideration must be given to the design requirements of other federal, state, and local regulatory agencies for items such as safety requirements, special designs for the handicapped, plumbing and electrical codes, construction in the flood plain, freeze protection, environmental conditions (e.g,. hail), etc. The criteria listed in this document are not intended to supersede other requirements.

CHAPTER 3
SOURCE DEVELOPMENT

3.0 GENERAL

In selecting the source of water to be developed, the supplier and/or designing engineer must prove to the satisfaction of the Department that an adequate quantity of water will be available, and that the water which is to be delivered to the consumers will meet the current requirements of the Department with respect to microbiological, physical, chemical and radiological qualities. Each water supply should take its raw water from the best available source which is economically reasonable and technically possible.

3.1 SURFACE WATER AND GROUNDWATER UNDER THE DIRECT INFLUENCE OF SURFACE WATER (GWUDI)

For surface water or GWUDI sources – no construction standards apply as these sources must have surface water treatment as outlined in Section 11.8 of Regulation 11 (i.e., Surface Water Treatment Rule (SWTR)).

A surface water source includes all tributary streams and drainage basins, natural lakes and artificial reservoirs or impoundments above the point of water supply intake. A GWUDI source will be defined by the “Safe Drinking Water Program Policy DW-003, Determination of GWUDI of Surface Water” (Reference 8). As defined in Policy DW-003, GWUDI sources include all new or discovered:

a. Gallery type wells.

b. Infiltration galleries.

c. Other sources determined to be GWUDI through the GWUDI evaluation process.

    i. Springs are considered GWUDI by the Department unless sufficient evidence exists for the spring to justify a Groundwater classification. This data must be collected by the supplier prior to initiating use of the spring.

3.2 GROUNDWATER

A groundwater source includes all water classified as groundwater according to the “Safe Drinking Water Program Policy DW-003, Determination of GWUDI of Surface Water”.

3.2.1 Well Construction

a. All wells must be constructed in accordance with the latest edition of 2 CCR 402-2 *Rules and Regulations for Water Well Construction, Pump Installation, Cistern Installation, and Monitoring and Observation Hole/Well Construction* (a.k.a. Colorado Well Driller Regulations, Reference 9).

b. All waterworks must be certified as out of the 100 year floodplain or sufficient flood protection must be provided to protect the waterworks from a 100 year flood event.

c. If used in the sanitary seal, vents must be covered with a non-corrodible screen. Screens may not have openings that exceed 0.07 inches (typically 12 or 16 mesh screen).

d. Well information required in Policy DW-003 must be submitted for all groundwater sources to verify groundwater status including aquifer type, well construction details, and time of travel.

e. Wells may be considered replacement if they meet: 1) The definition of "Replacement Well" that is contained within the Well Driller Regulations; 2) Rule 6.2 of Replacement Well Permits of the Rules and Regulations for the Management and Control of Designated Ground Water (2 CCR 410-1); 3) The well construction and test reports show that the original well and the replacement well are in the same aquifer (i.e., the wells are screened at approximately the same intervals and the wells are approximately the same total depth; 4) The paperwork to and from the Colorado Department of Natural Resources, Division of Water Resources, Office of the State Engineer indicates that the well is a replaced (e.g., well construction and test report, permit to construct, etc.); and 5) Water quality data from the original well and from the replacement well are similar.

3.2.2 Spring Construction

If the spring is considered groundwater, the following standards apply:

a. All waterworks must be certified as out of the 100-year floodplain or sufficient flood protection must be provided to protect the waterworks from a 100-year flood event.
b. Springs must not be constructed in an area where either underground or surface contamination can impact such a water source.
c. Springs must be enclosed by reinforced concrete walls and cover, or other durable and watertight material.
d. Spring boxes must have an overlapping, lockable, watertight access cover.
e. Water from springs must be carried by gravity flow directly into storage or the distribution system. Pumping is allowed only from a sump or other storage.
f. Spring boxes and storage basins must meet the criteria in Chapter 7 in order to protect the water from contamination.
g. Spring Design must include:
    i. Screened drain pipe with exterior valve.
    ii. Overflow pipe just below maximum water level elevation protected by a non-corrodible screen. Screens may not have openings that exceed 0.07 inches (typically 12 or 16 mesh screen).
    iii. Supply outlet from the spring will be located 6 inches above the drain outlet and be protected by a non-corrodible screen. Screens may not have openings that exceed 0.07 inches (typically 12 or 16 mesh screen).
    iv. Perforated collection pipe.
    v. An earth cover, natural or fill, depth of at least 5 feet.
        1. Hypalon or similar waterproof fabric may be required as a seepage barrier.
    vi. A surface water drainage ditch must be located uphill from the source so as to intercept surface water runoff and carry it away from the source.
    vii. Fencing

1. Fences must be constructed to prevent entry of unauthorized persons and all but small animals.
2. Fence must be uphill of the drainage ditch and completely surround the area where the spring emanates from the ground. The fence must also surround any equipment associated with the development of the spring source (e.g., spring box, exposed collection pipe).

3.2.3 Aquifer Recharge and Recovery

If a supplier intends to utilize a groundwater well for the purposes of storing water in aquifer recharge and recovery, the supplier must submit to the department the following information:

a. Permits from appropriate regulatory authorities allowing the activity (e.g. USEPA and Department of Natural Resources).

b. Water quality information for the water being added to the well compared to the intrinsic water quality of the natural groundwater from the well.

c. Analysis of potential impacts to well water quality for the recharge activities including any potential impacts to disinfection byproducts (DBPs).

d. The Department may require an analysis of the impacts to water corrosivity on a case by case basis.

CHAPTER 4
TREATMENT

4.0 GENERAL

The design of treatment processes and devices will depend on evaluation of the nature and quality of the particular water to be treated, seasonal variations, the desired quality of the finished water and the planned mode of operation. The design of a water treatment plant must consider the most challenging water quality conditions that may occur during the life of the plant.

Design criteria must be presented in the BDR addressing seasonal variations and verifying that the designer has accounted for negative impacts to process performance.

4.0.1 Minimum treatment requirements

Treatment projects (including modifications or improvements) must be designed to ***reliably achieve*** compliance with Regulation 11.

a. All public water systems must have treatment that ensures compliance with all requirements of Regulation 11. Generally if a treatment process is for compliance with Regulation 11 then the design must meet all applicable design criteria including the Chapter 4 requirements. If a treatment process is intended primarily for aesthetic or secondary MCL purposes and will not impact compliance with Regulation 11, then the design must meet the requirements of Chapter 2, Chapter 5 (as applicable for chemical feed), and Section 11.39 of Regulation 11 (i.e., Backflow Prevention and Cross-Connection Control Rule). An example of a treatment process primarily for aesthetic treatment is a filter installed to remove sand from a groundwater well.

b. For groundwater systems, the treatment system must be designed to meet Section 11.11 of Regulation 11 (i.e., Groundwater Rule). The treatment system must include chemical disinfection and must be designed to be capable of providing 4-log virus inactivation.

c. For surface water and groundwater under the direct influence of surface water (SW/GWUDI) systems, the treatment system must be designed to meet Section 11.8 of Regulation 11 (Surface Water Treatment Rule (SWTR)). The treatment process must include a multi-barrier treatment approach using compliance filtration and disinfection process designed to meet the SWTR log removal/inactivation requirements for *Cryptosporidium*, *Giardia lamblia* and viruses. Typical compliance filtration methods include: inline, direct, conventional, and alternative filtration (e.g., membrane, bag/cartridge filtration).

    - Conventional filtration consists of: coagulation (rapid mix and chemical addition), flocculation, sedimentation, and filtration.
    - Direct filtration consists of: coagulation (rapid mix and chemical addition), flocculation, and filtration.
    - In-line filtration consists of: coagulation (rapid mix and chemical addition), and filtration. For log removal credits, inline filtration is considered direct filtration.

d. CDPHE Policy Number DW-004 (Reference 10) outlines the compliance filtration log removal credits except for alternative filtration (membrane and bag/cartridge).

4.0.2 Plant Design Flow Rate

The BDR must identify the plant design flowrate (i.e., rated capacity) in gallons per minute (gpm). The plant design flowrate is typically the maximum flowrate through the smallest capacity unit process (i.e., rate-limiting process). The Department will approve a plant design flowrate for each treatment plant taking into account treatment plant redundancy requirements (see Section 2.1) unless an exemption is outlined in the Design Criteria or a deviation under Section 1.4 is granted.

The BDR must identify the design flow rate for each unit plant treatment process (i.e., unit process treatment capacity). The BDR must include calculations supporting each unit process capacity and the plant design flow rate as required in Item 1.2.5.b.

Suppliers may opt to specify the plant design flowrate based on operator certification levels in Regulation 100 (rather than based on a rate limiting unit process). In these cases, the BDR must identify the operational and/or physical constraints employed to limit the plant design flow rate for these plants. The BDR must describe the use of such constraints in the preliminary operation plan per Item 1.2.9. The Department will consider these requests on a case by case basis.

4.1 MICROSCREENING

Microscreening is a mechanical treatment process capable of removing suspended matter and organic loading by straining. Microscreening is considered pre-treatment and is not a SWTR compliance filtration method and cannot be used in lieu of filtration or coagulation.

4.1.1 Design

a. Consideration must be given to the:
   - i. Nature of the suspended matter to be removed.
   - ii. Corrosiveness of the water.
   - iii. Effect of chemicals used for pre-treatment.
   - iv. Duplication of units for continuous operation during equipment maintenance.
   - v. Provision of automated backwashing.
   - vi. Provision for measuring headloss (or differential pressure).
   - vii. Headloss through the screen at peak flow considering a 50% blinded condition.

b. The design must provide:
   - i. A durable, corrosion-resistant screen.
   - ii. Provisions to allow for by-pass of the screen.
   - iii. Protection against back-siphonage when potable water is used for backwashing.
   - iv. Proper disposal of backwash waters (See Chapter 9).

4.2 CLARIFICATION

Clarification is generally considered to consist of any process or combination of processes which reduce the concentration of suspended matter in drinking water prior to filtration.

Redundancy: Conventional filtration plants designed for SW/GWUDI treatment or for the removal of a primary drinking water contaminant must have a minimum of two trains for coagulation, flocculation, and clarification (solids removal). For those systems evaluating alternative filtration technologies, alternatives to having a minimum of two trains may be considered.

Unit design flow rate: In most cases, the Department evaluates the unit design flow rate (i.e., unit process capacity) based on the overall capacity of the clarification process (i.e., not individual trains).

Design of the clarification process must:

a. Allow operation of the units either in series or parallel where softening is performed.
b. Be constructed to allow units to be taken out of service without disrupting operation, and with drains or pumps sized to allow draining or dewatering.

4.2.1 Presedimentation

Presedimentation basins must be designed to reduce raw water turbidity to levels which can be adequately and effectively treated using selected downstream treatment process(es). Standard practices must be developed identifying the intended service (e.g., intermittent, full-time) of the presedimentation basin.

a. Presedimentation basins must have hopper bottoms or be equipped with continuous mechanical sludge removal systems, and provide arrangements for dewatering. The BDR must indicate the means for maintaining and cleaning basins without plant interruption.
b. Incoming water must be dispersed across the full width of the line of travel; short-circuiting must be prevented.
c. Provisions for bypassing presedimentation basins must be included.
d. Detention time, at the maximum rated capacity, must be designed for a minimum of three hours.
e. Provisions for passive overflow back to the source water must be provided.

4.2.2 Coagulation

For surface water or GWUDI water treatment plants using granular media filtration for compliance with Section 11.8 of Regulation 11, the use of a primary coagulant is required at all times. The minimum design criteria presented below for coagulation apply to conventional and direct filter pretreatment.

The submittal must include the design basis for the velocity gradient (G value) selected, considering the chemicals to be added and the water temperature and other related water quality parameters.

a. The mixing equipment must be capable of imparting a minimum velocity gradient (G) of at least 500 second^{-1}. The design engineer must justify the selected range of appropriate G values.
b. The devices must be capable of providing adequate mixing for all treatment flow rates.
c. If flow is split between basins, a means of measuring and controlling the flow to each train or unit must be provided.

4.2.3 Flocculation

The minimum design criteria presented below for flocculation apply to conventional and direct filter pretreatment

a. Inlet and outlet design of the basin must minimize short-circuiting and destruction of floc. Plug flow through a series of a minimum of three baffled compartments (either serpentine, over/under flow pattern, or baffled walls) must be provided. The basin must provide decreasing flocculation mixing energy through each subsequent pass and the engineer must provide mixing energy calculations with the design. Basins must be designed so that individual trains may be isolated without disrupting plant operation. A drain and/or pumps must be provided to handle dewatering and sludge removal during cleaning operations.

b. The minimum theoretical hydraulic detention time (HDT) for floc formation must be at least 30 minutes.

c. When mechanical agitation is used, agitators must provide decreasing flocculation mixing energy through each subsequent baffled pass.

d. The velocity of flocculated water through pipes or conduits leaving the flocculation process must be neither less than 0.5 nor greater than 1.5 feet per second (fps). Allowances must be made to minimize turbulence at bends and changes in direction.

e. If flow is split, means of measuring and controlling the flow to each train or treatment unit must be provided.

f. The design must allow for visible observation of floc formation.

4.2.4 Sedimentation

The minimum design criteria presented below for sedimentation apply to conventional filter pretreatment (coagulation, flocculation, sedimentation).

a. Surface overflow rate must not exceed 0.7 gpm/ft^2. A minimum of four hours (4 hrs) of settling time must be provided. Lime-soda softening plants treating only groundwater must provide a minimum of two hours (2 hrs) of settling time. Reduced detention time may also be approved when equivalent effective settling is demonstrated or when the overflow rate is not more than 0.5 gpm/ft^2.

b. Inlets must be designed to distribute the water equally and at uniform velocities.

c. The horizontal velocity through a sedimentation basin as determined from the horizontal cross section must not exceed 0.5 feet per minute.

d. Outlet weirs or submerged orifices must maintain velocities suitable for settling in the basin and minimize short-circuiting. Outlet weirs and submerged orifices must be designed as follows:

    i. The rate of flow over the outlet weirs or through the submerged orifices must not exceed 20,000 gallons per day per foot of the outlet launder or total orifice circumference.

    ii. Submerged orifices must not be located lower than three feet (3 ft) below the flow surface in the basin.

    iii. The entrance velocity through the submerged orifices must not exceed 0.5 feet per second.

e. Sedimentation basins must be provided with a means for dewatering.

f. Flushing lines or hydrants must be provided.

g. Sludge collection systems must be designed for maximum sludge loading and ensure the collection of sludge from the basin. Provisions for cleaning and flushing the system piping must be provided.

4.2.5 Solids Contact Unit

Solids contact units for compliance will be approved on a case-by-case basis. A pilot-scale test must be performed to verify conformance with design parameters.

4.2.6 Tube or Plate Settlers

Settler units consisting of variously shaped tubes or plates installed in multiple layers and at an angle to the flow across the sedimentation basin may be used to enhance settling of solids.

The following general criteria must be followed:

a. Inlet and outlet are designed to maintain velocities suitable for settling in the unit and to minimize short-circuiting. Plate units must be designed to minimize maldistribution across the plate rack.

b. Application rate for tubes must maintain a maximum rate of 2.0 gpm/ft^2 of cross-sectional area for tube settlers.

c. Application rates for plates must maintain a maximum plate loading rate of 0.4 gpm/ft^2, based on the projected horizontal plate area.

d. Hose bibs must be provided to facilitate washdown and maintenance.

e. Basins must be provided with a means for dewatering.

f. Inlets and outlets must conform with Items 4.2.4(b) and 4.2.4(d).

g. The support system must be able to carry the weight of dirty tubes / plates when the basin is drained plus any additional weight to support maintenance.

h. A method for periodic cleaning of the tubes or plates must be specified.

4.2.7 High Rate Clarification Processes

High rate clarification processes may be approved upon demonstrating satisfactory performance under on-site pilot plant conditions or documentation of full scale plant operation with similar raw water quality conditions as allowed by the Department. Reductions in detention times and/or increases in weir loading rates must be justified. Examples of such processes may include dissolved air flotation, ballasted flocculation, contact flocculation/clarification, and helical upflow, solids contact units.

4.3 FILTRATION

Filtration is a process for removing particulate matter from the water by passing through porous media.

Acceptable filters include the following types:

a. Rapid rate gravity filters (Item 4.3.1).

b. Rapid rate pressure filters (Item 4.3.2).

c. Diatomaceous earth (Item 4.3.3).

d. Slow sand filtration (Item 4.3.4).

e. Direct filtration (Item 4.3.5).

f. Deep bed rapid rate gravity filters (Item 4.3.6).

g. Biologically active filters (Item 4.3.7).

h. Membrane filtration (Item 4.3.8).

i. Bag and cartridge filters (Item 4.3.9).

j. Natural filtration (Item 4.3.10).

The application of any one type of filtration must be supported by water quality data obtained over a reasonable period of time to characterize the variations in water quality (see Item 1.2.3). If the supplier chooses to perform a pilot study, it may be used to demonstrate the applicability of the method of filtration proposed. Specific requirements for pilot studies are included in Appendix C.

SW/GWUDI compliance filtration log removal credit: Log removal credit for compliance with the surface water treatment rules for all filtration types will be granted by the Department in accordance with the “Safe Drinking Water Program Policy DW-004” (Reference 10).

SW/GWUDI compliance filtration bypasses: When filtration is required by Section 11.8 of Regulation 11, bypasses around the filtration process are not permissible.

SW/GWUDI compliance filtration redundancy: When filtration is required by Section 11.8 of Regulation 11 (i.e., Surface Water Treatment Rule), at least two units must be provided. For designs that include only two units, each unit must be capable of meeting the plant design flowrate. For designs that include more than two filter units, the filters must be capable of meeting the plant design flowrate with the largest filter removed from service. Deviations can be granted under Section 1.4 for redundancy with storage and/or additional sources of finished water (e.g. multiple treatment plants, consecutive connections).

Groundwater filtration: For filtration systems proposed on groundwater sources where filtration is not required by Section 11.8 of Regulation 11(i.e., Surface Water Treatment Rule), the following design criteria are considered guidance. The supplier with groundwater source(s) may request that the Department review a proposed filtration system for compliance with Section 11.8 of Regulation 11, in the event that the source is ever classified as GWUDI. Please note that groundwater filtration and backwash basins are considered protected water storage and must meet Chapter 7 requirements.

4.3.1 Rapid Rate Gravity Filters

4.3.1.1 Pretreatment

a. The use of rapid rate gravity filters (granular media) must include pretreatment including primary coagulation which operates continuously.

b. Direct or inline filtration must not be used with waters having turbidities greater than 10 NTU. In-line filtration means a coagulation and granular media filtration system that does not provide flocculation.

c. Designs for in-line or direct filtration plants must include a pilot study which is acceptable to the Department. Where in-line or direct filtration is proposed, the Department recommends that an engineering report be submitted under Section 1.6 for review and comment prior to conducting pilot plant studies.

4.3.1.2 Rate of Filtration

a. The rate of filtration must be determined through consideration of such factors as raw water quality, degree of pretreatment provided, filter media, water quality control parameters, and other factors. The maximum design filter hydraulic loading rate must not exceed 5 gpm/ft^2 without pilot or demonstration-scale study data.

b. Where declining rate filtration is provided, the variable aspect of filtration rates and the number of filters must be considered when determining the design capacity for the filters. Calculation of the filtration rate for declining rate filtration must be performed to show the peak loading rate of a single filter with all other filters at maximum headloss (with one filter out of service).

4.3.1.3 Redundancy and Unit Flow Rate

a. Redundancy: When filtration is required by Section 11.8 of Regulation 11, Section 11.8 (i.e., Surface Water Treatment Rule), at least two units must be provided. For designs that include only two units, each unit must be capable of meeting the plant design flowrate. For designs with more than two filter units, the filters must be capable of meeting plant design flowrate with the largest filter removed from service.

b. Unit design flow rate: The unit design flow rate will be the approved filter loading rate with the largest unit out of service.

4.3.1.4 Structural Details and Hydraulics

The filter structure must be designed to provide for:

a. No protrusion of the filter walls into the filter media.

b. Cover by superstructure.

c. Head room to permit normal inspection and operation.

d. Minimum water depth over the surface of the filter media of 3-feet.

e. Trapped effluent to prevent backflow of air to the bottom of the filters.

f. Prevention of floor drainage to the filter with a minimum 4-inch curb around the filters.

g. Prevention of flooding by providing an overflow device.

h. Maximum velocity of filter influent pipe and conduits of 4 ft/second.

i. Washwater drain capacity to carry maximum flow.

j. Walkways around filters.

k. Construction to prevent cross connections and common walls between filter effluent and backwash waste water or water that has not yet been filtered.

4.3.1.5 Washwater Troughs

Washwater troughs must be constructed to have:

a. The bottom elevation be a minimum of 12 inches above the maximum level of the top of the expanded media during washing.
b. Minimum 2-inch freeboard at the maximum rate of wash.
c. The top edge level is at the same elevation.
d. Equal spacing such that each trough serves the same number of square feet of filter area.
e. Maximum horizontal travel of suspended particles to reach the trough not to exceed 3 feet.

4.3.1.6 Filter Material

The BDR must identify the type of filtration being designed for: monomedia, dual media, or mixed media filtration. All filter materials must meet the current applicable AWWA standards for filtering materials.

a. The ratio of bed depth to effective size in granular media filters must be at least 1000 (referred to as the L/d ratio calculated either through the summation or weighted method).
b. Minimum depths:
   i. For monomedia filters.
      1. Sand must be 24 inches deep.
      2. Anthracite/GAC must be 48 inches deep.
   ii. For dual media or mixed media filters total filter media depth must be 30 inches.
   iii. Additional layers of media or support material may be provided. The BDR must confirm that multiple layers are compatible.
c. Types of filter media – media must conform to AWWA B100.
   i. Filter anthracite must consist of hard, durable anthracite coal particles free of detrimental contaminants. Blending of non-anthracite material is not acceptable. Anthracite must have:
      1. Specific gravity greater than 1.4.
      2. Acid solubility less than 5 percent.
      3. A Mohs scale of hardness greater than 2.7.
   ii. Filter sand must consist of hard durable grains of at least 85% silica material free of detrimental contaminants, and must have:
      1. Specific gravity greater than 2.5.
      2. Acid solubility less than 5 percent.

3. A uniformity coefficient less than 1.5.

iii. High density sand must consist of hard durable, and dense grain garnet, ilmenite, hematite, magnetite, or associated minerals of those ores that are free of detrimental contaminants and must:

1. Contain at least 95 percent of the associated material with a specific gravity of 3.8 or higher.
2. Have an acid solubility less than 5 percent.

iv. Granular activated carbon (GAC) must be free of detrimental contaminants and conform with AWWA B604.

d. Media support.

The filter media support system must include: graded gravel layers, torpedo sand, and/or a proprietary underdrain media retention system. Justification of the filter media support system must be provided within the BDR and must be based on reference material, experimental data, or operating experience. Supporting justification must address compatibility with the media, underdrain, and backwash approach.

4.3.1.7 Filter Underdrains

Underdrains must be provided to ensure even distribution of air and/or washwater, and an even rate of filtration over the entire area of the filter. The underdrain design must be documented using standard engineering practices, reference material, experimental data, or operating experience. Underdrains must be designed to support the proposed filter media and backwash operations.

4.3.1.8 Auxiliary Cleaning System

An auxiliary cleaning system is required for all filters except for those exclusively used for iron, radionuclides, arsenic or manganese removal, and may be accomplished by:

a. Surface or subsurface wash: must be accomplished by a system of fixed nozzles or revolving-type systems. All devices must be designed with:

i. Provisions for water pressures of a minimum 50 psi for fixed nozzle systems and revolving-type systems.

ii. A properly installed reduced pressure zone backflow preventer to prevent back siphonage if connected to the filtered or finished water system.

iii. Minimum rate of flow of 2.0 gpm/ft^2 of filter area with fixed nozzles or 0.5 gpm/ft^2 with revolving arms.

b. Air scouring.

i. Air flow for air scouring the filter must be in the range of 2 to 4 standard cubic feet per minute per square foot of filter area.

ii. Air scour systems must be designed to provide filtered air.

iii. Air scour distribution systems should be placed below the media and supporting bed interface; if placed at the interface the air scour nozzles must be designed to prevent media from clogging the nozzles or entering the air distribution system.

iv. Air distribution system piping must be designed for operating pressures and operating conditions. Flexible hoses must not be used unless the design demonstrates that cross connections are controlled.

v. Air delivery piping must not pass down through the filter media unless stop collars are used to prevent short circuiting. All arrangements in the filter design must not allow short circuiting between the applied unfiltered water and the filtered water.

vi. Air scouring controls must allow the operator to control the air flow rates and duration. Rate of flow indicators for air and water must be provided.

vii. The provisions of Item 4.3.1.11 must be followed.

4.3.1.10 Appurtenances

a. The following must be provided:

i. A common influent sample.

ii. Filter effluent sample for each filter (individual filter effluent).

iii. Combined filter effluent sample immediately downstream of the combined flow of all filters.

iv. An indicating loss of head measurement (e.g. differential pressure gauge/transmitter) for each filter.

v. A meter indicating the instantaneous rate of flow and a rate of flow controller for each filter.

b. Where used for surface water or ground water under the direct influence of surface water:

i. Provisions for filtering to waste with appropriate measures for cross connection control.

ii. Provisions for continuously monitoring turbidity must be provided when required by applicable regulations. On-line turbidimeters must accurately measure low-range turbidities and have an alarm that will sound when the effluent turbidity level exceeds a set point value.

4.3.1.11 Backwash

Provisions must be made for washing filters as follows:

a. A minimum rate of 15 gpm/ft^2, consistent with water temperatures and specific gravity of the filter media, and must provide a rate of 20 gpm/ft^2 or a rate necessary to provide for a minimum 20 percent expansion of the filter bed at the maximum design water temperature.

i. As an alternative, minimum backwash rates and expansion of the filter bed at the maximum water temperature must be based on the engineering design of the filter media.

ii. A minimum rate of 10 gpm/ft^2 for full depth anthracite or granular activated carbon filters.

iii. For backwash systems used in combination with air scour, a maximum concurrent water backwash flow rate of 10 gpm/ft^2. Control methods must be provided for allowing variable backwash flow rates up to the maximum backwash rate (e.g., 15 gpm/ft^2) to restratify filter media.

b. Filtered water provided at the required rate by washwater tanks, a washwater pump, from the high service main, or a combination of these sources.

c. Redundant washwater pumps unless an alternate means of obtaining washwater is available.

d. A backwash duration that is not less than 15 minutes or 3 filter box volumes at the design backwash flow rate.

e. A control method to obtain the desired rate of filter wash with the washwater valves on the individual filters open wide.

f. A flow meter on the main washwater line or backwash waste line.

g. Design to prevent rapid changes in backwash water flow.

h. Automated backwash with either operator initiation or automated sequencing, backwash parameters must be adjustable.

i. Appropriate measures to prevent cross-connections.

j. Design to allow for stepped reduction of flow at end of backwash sequence to allow for restratification of filter bed.

4.3.2 Rapid Rate Pressure Filters

Pressure filters must not be used as the compliance treatment technique for Section 11.8 of Regulation 11 (i.e., Surface Water Treatment Rule) for SW/GWUDI source(s) if directly following lime-soda softening. The use of rapid rate pressure filters (granular media) must have pretreatment which includes primary coagulation at all times. For the purpose of regulatory monitoring, the use of rapid rate pressure filters is considered “direct filtration” and will be subject to the design criteria in Item 4.3.1.

4.3.2.1 General

Minimum criteria relative to rate of filtration, structural details and hydraulics, filter media, etc., provided for rapid rate gravity filters also apply to pressure filters where appropriate.

4.3.2.2 Rate of Filtration

The rate must not exceed 4 gpm/ft^2 of filter area.

4.3.2.3 Details of Design

The filters must be designed to provide for:

a. Loss of head gauges on the inlet and outlet pipes of each filter.
b. A flowmeter or indicator and rate of flow controller on each filter.
c. Filtration and backwashing of each filter individually.
d. Continuous turbidity monitoring for each filter.
e. Minimum side wall shell height of five feet (5 ft).
    i. A corresponding reduction in side wall height is acceptable where proprietary bottoms permit reduction of the gravel depth.
f. The top of the washwater collectors to be at least 18 inches above the surface of the media.
g. The underdrain system to uniformly distribute the backwash water at a rate not less than 15 gpm/ft^2 of filter area.
h. Backwash flow indicators and controls that are visible while operating the control valves.
i. An air release valve on the highest point of the influent line or the filter vessel.
j. An accessible manhole greater than or equal to 24 inches diameter to facilitate inspection and repairs for filters 36 inches or more in diameter.
k. Sufficient handholes must be provided for filters less than 36 inches in diameter.
l. Means to observe the wastewater during backwashing.

4.3.2.4 Redundancy and Unit Flow Rate

a. Redundancy: When filtration is required by Section 11.8 of Regulation 11, Section 11.8 (i.e., Surface Water Treatment Rule), at least two units must be provided. For designs that include only two units, each unit must be capable of meeting the plant design flowrate. For designs with more than two filter units, the filters must be capable of meeting plant design flowrate with the largest filter removed from service.
b. Unit design flow rate: The unit design flow rate will be the approved filter loading rate with the largest unit out of service.

<u>4.3.3 Diatomaceous Earth Filtration</u>

Diatomaceous earth filtration will be approved on a case-by-case basis. A pilot-scale test must be performed.

<u>4.3.4 Slow Sand Filters</u>

The use of these filters requires prior engineering studies to demonstrate the adequacy and suitability of this method of filtration for the specific raw water supply.

4.3.4.1 Quality of Raw Water

Sufficient raw water analysis (per Item 1.2.3) must be submitted to justify design and necessary pre-treatment. Slow sand gravity filtration is limited to waters having maximum turbidities of 10 units and maximum color of 15 units; such turbidity must not be attributable to colloidal clay. Microscopic examination of the raw water must be made to determine the nature and extent of algae growths and their potential adverse impact, e.g., microscopic particle size distribution, on filter operations. Pretreatment, such as roughing filters, is an acceptable method to reduce the turbidity reaching the filters.

4.3.4.2 Redundancy and Unit Flow Rate

a. Redundancy: When filtration is required by Section 11.8 of Regulation 11, Section 11.8 (i.e., Surface Water Treatment Rule), at least two units must be provided. For designs that include only two units, each unit must be capable of meeting the plant design flowrate. For designs with more than two filter units, the filters must be capable of meeting plant design flowrate with the largest filter removed from service.
b. Unit design flow rate: The unit design flow rate will be the approved filter loading rate with the largest unit out of service.

4.3.4.3 Structural Details and Hydraulics

Slow sand gravity filters must be designed to provide:

a. A cover.
b. Headroom to permit normal movement by operating personnel for scraping, harrowing, and sand removal operations.
c. Adequate access hatches and access ports for handling of sand and for ventilation to meet confined access requirements.
d. An overflow at the maximum filter water level.
e. Protection from freezing.
f. Means to distribute the influent water over the top of the filter without scouring the sand surface.

4.3.4.4 Rates of Filtration

The permissible rates of filtration must be justified by the quality of the raw water and must be on the basis of experimental data derived from the water to be treated. The nominal rate must be 45 to 150 gallons per day per square foot of sand area (0.03 – 0.10 gpm/ft^2).

4.3.4.5 Underdrains

Each filter unit must be equipped with a main drain and an adequate number of lateral underdrains to collect the filtered water. The underdrains must be placed as close to the floor as possible and spaced so that the maximum velocity of the water flow in the underdrain will not exceed 0.75 feet per second. For manifold and pipe lateral underdrain systems, the maximum spacing of laterals must not exceed 3 feet and the system must be designed to uniformly collect filtered water through all of the laterals.

4.3.4.6 Filter Material

a. Filter sand must be placed on graded gravel layers for a minimum depth of 30 inches.
b. The effective size (ES) of filter material must be between 0.15 mm and 0.30 mm. Larger sizes will be considered by the Department when raw water conditions, literature, or the results from piloting support the use of a larger ES.
c. The uniformity coefficient (UC) must not exceed 3.0. A larger size will be considered by the Department when raw water conditions, literature, or the results from piloting support the use of a larger UC.
d. Specifications for sand must include cleaning and washing to remove foreign matter and sand fines at the place of manufacture. Specifications must also indicate requirements for testing for cleanliness and fines at the site immediately prior to placing in the filter box. (See Item 4.3.4.6(e) for requirements for sand fines.)
e. Sand fines, defined as passing #200 sieve, must be less than 3% for unwashed sand and <0.1% for washed sand.
f. A pilot study may be required to support the proposed sand specifications.

4.3.4.7 Filter Gravel

The supporting gravel must be similar to the size and depth distribution provided for rapid rate gravity filters. The mean support gravel size must be no more than four (4) times the mean grain size of the sand media to minimize intermixing.

4.3.4.8 Depth of Water on Filter Beds

Design must provide a minimum depth of three to six feet of water over the sand.

4.3.4.9 Control Appurtenances

Each filter must be equipped with:

a. A common influent flow meter and sampling tap.
b. Individual filter effluent sampling taps.
c. An indicating loss of head gauge or other means to measure head loss.
d. An indicating rate-of-flow meter.
e. An effluent control valve that limits the rate of filtration to a maximum rate may be used.
f. An orifice, venturi meter, or other suitable means of measuring flow on the effluent pipe from each filter. Must be used to independently control the rate of filtration through each filter that is in service.

g. Provisions for filter to waste with appropriate measures for cross connection control. Filter-to-waste piping must not be connected to the filter influent piping without an air gap.

h. An effluent pipe or control weir designed to maintain the water level above the top of the filter sand.

i. Filter overflow and supernatant drain.

j. Interconnection of the filter effluent pipes upstream of chlorine application to permit backfilling of a filter with filtered water.

4.3.4.10 Not Used

4.3.4.11 Harrowing

Filters that will be maintained using harrowing must include the following:

a. The supernatant drain must be sized large enough to convey adequate water to flush material from the filter surface.

b. Harrow waste washwater must be disposed of properly and must not be returned directly back to the influent of the slow sand filters (Chapter 9).

<u>4.3.5 Direct Filtration</u>

Direct filtration must comply with Item 4.3.1.

<u>4.3.6 Deep Bed Rapid Rate Gravity Filters</u>

Deep bed rapid rate gravity filters, as used herein, generally refers to rapid rate gravity filters with filter material depths equal to or greater than 48 inches. Filter media sizes are typically larger than those listed in Item 4.3.1.6.

Deep bed rapid rate filters may be considered based on pilot studies or full-scale filtration on similar raw water qualities.

The final filter design must be based on the pilot plant studies and must comply with all applicable portions of Item 4.3.1. Careful attention must be paid to the design of the backwash system, which usually includes simultaneous air scour and water backwash at subfluidization velocities.

<u>4.3.7 Engineered Biologically Active Filters</u>

Granular media filtration must comply with Item 4.3.1. Any granular media that is not pre-chlorinated will have ancillary biological activity. When biologically active filters do not meet the parameters specified in Item 4.3.1, then this item applies.

Engineered biologically active filters are media filters that are specifically designed to treat surface water (or a groundwater with iron, manganese, ammonia or significant natural organic material), through the establishment and maintenance of biological activity within the filter media. The BDR must indicate the basis of the proposed biological filtration. The use of these filters requires prior engineering studies to demonstrate the adequacy and suitability of this method of filtration for the specific raw water supply. Slow sand filters are a specific type of biologically active filters that are covered separately in Item 4.3.4.

4.3.7.1 Engineering Studies

Engineering studies must be performed prior to performing any pilot work to confirm that engineered biofiltration is a viable treatment method for treating the source water and the anticipated operating conditions (e.g., a base loaded plant). The engineering studies must include a historical summary of meteorological conditions and of raw water quality with special reference to fluctuations in quality and possible sources of contamination. Sufficient raw water analysis (per engineering report recommendations and Item 1.2.3, Table 1.2 and 1.3) must be submitted to justify design and necessary pre-treatment.

The engineering studies must include an experimental plan that contains a description of methods and work to be done during a pilot plant study, or, where appropriate, an in-plant demonstration study. The pilot study must be of sufficient duration to ensure establishment of full biological activity and to treat the most difficult water quality conditions experienced historically, or anticipated to be treated at full-scale. The following minimum items must be included in the experimental plan:

a. Clearly defined objectives.

b. A methodology to confirm that the filtered water microbial quality meets all applicable water quality regulations under all anticipated conditions of operation.

c. Justification for the pilot study duration (typically greater than three months).

4.3.7.2 Pilot Plant Studies

Engineered biologically active filters will be considered based on pilot studies. Retrofitting existing plants to achieve biologically active filtration may be accomplished using demonstration scale studies. Pilot plant studies must meet the requirements of Appendix C plus the additional requirements put forth in this item. Additional pilot study requirements:

a. Must be representative of the proposed treatment process, which would include but is not limited to type of filtration, depth of filter media, type of filter media, filtration rates, backwash system, dissolved oxygen content, number of filters in series, seeding method (if applicable), and air addition.

b. Must be run through the anticipated temperature range after the required amount of bacteriological growth is present.

c. Must discharge all filtered water to waste.

d. Must monitor and record initial raw water total organic carbon (TOC); dissolved oxygen content; water and air flow rates; filter run times; pH; temperature; conductivity; oxidation reduction potential (ORP); concentration of the proposed contaminant to be removed (iron, manganese, ammonium, nitrite, nitrate, perchlorate, and/or TOC) in the raw water, effluent from each filter, and finished water.

e. Must be provided with a means to measure head loss through the filter.

f. Must provide the results of bacteriological tests of the finished water with and without the disinfectant applied at the target plant level (The maximum heterotrophic plate count (HPC) of the disinfected water must not exceed 500 cfu/mL).

g. Must be backwashed after any period of time that the filter is shutdown.

h. Must incorporate backwash reclaim when it is to be used in the final water treatment plant design

The pilot study must establish the following:

a. Water quality goals.

b. Biomass loading.

c. Biomass profile within the filter.

d. Media type, depth, and characteristics (e.g., effective size, uniformity coefficient).

e. Filtration rates and the impact of hydraulic loading rate on effluent quality.

f. Required empty bed contact time (EBCT), temperature and hydraulic loading rate impacts on EBCT.

g. Methods for controlling extracellular polymeric substance (EPS).

h. Chemical addition requirements that are necessary to provide sufficient nutrients and oxygen to the biomass and application points in the process train.

i. Requirements for downstream water stabilization (e.g., pH adjustment).

j. The period of time and/or volume of water required for the filter effluent to meet the established water quality goals after backwash and after shutdown for 1 hour, 4 hours, 8 hours, 12 hours, 24 hours and 48 hours (This will help determine the time and/or volume of water that will need to be filtered to waste upon filter startup after a backwash and/or shutdown in the full-scale operation).

k. Appropriate air and water backwash rates and time for proper removal of loose clusters of bacteria that may break through the filter (Air backwash must be provided at full-scale).

l. Source of microbiological seed and characterized as not containing human pathogens, except when indigenous biota is selected to inoculate the bed (The use of indigenous microorganisms to seed the process negates this requirement).

m. Other parameters necessary for successful operation as required by the Department.

4.3.7.3 Quality of Raw Water

If biologically active filters are being used for treating raw waters that do not contain a carbon source sufficient to support continuous biological growth, provisions must be included in the design for providing a supplementary carbon source.

4.3.7.4 Filter Design

Engineered biologically active filters must be designed to operate at steady state conditions once the biomass has developed. The design basis must be the pilot study. The final filter design must comply with all applicable portions of Items 4.3.1 and 4.3.6, and include the following additional provisions:

a. Minimization of underdrain clogging by EPS.
b. Supplemental oxygen to maintain aerobic conditions within the filter bed at all times.
c. Unchlorinated backwash water.
d. Stabilization of the filter effluent per Section 4.9.
e. Air backwash for all engineered biologically active filters
f. Sufficient storage for all necessary chemicals, plus space for at least one additional chemical to be used in the event the bio-filter becomes unreliable or to enhance performance.

4.3.7.5 Basis of Design Report

The BDR must include a discussion on how the biomass concentration profile developed in the pilot study was used to develop the filter design.

4.3.8 Membrane Filtration

Membrane filtration is a gravity, pressure, or vacuum-driven separation process in which particulate matter is rejected by an engineered barrier, primarily through a size-exclusion mechanism and which has a measurable removal efficiency of a target organism that can be verified through the application of a direct integrity test or surrogate membrane integrity testing protocol. Membrane filtration includes common membrane classifications: microfiltration (MF), ultrafiltration (UF), nanofiltration (NF), and reverse osmosis (RO), as well as any “membrane cartridge filtration” (MCF) device that satisfies this definition.

This section describes the use of membranes primarily for compliance with Section 11.8 of Regulation 11 (i.e., Surface Water Treatment Rule) for removal of *Giardia, Cryptosporidium*, turbidity and the minimum criteria associated with that purpose.

- If this technology is used for Regulation 11 MCL compliance purposes (not Section 11.8) and sidestream blending will be used then the requirements of Section 2.21, Items 4.3.8.4, 4.3.8.5, 4.3.8.6, 4.3.8.7.a, 4.3.8.8, 4.3.8.9, 4.3.8.10, 4.3.8.11 (except 4.3.8.4.a.i), and Section 4.11 apply.
- If this technology is used for non-compliance purposes (e.g. prefiltering before compliance filtering, aesthetic enhancement), only the requirements of Section 2.21 and Item 4.3.8.8 apply.

Once a technology has been accepted as an Alternative Technology (See Section 1.11), the acceptance will be recorded in Appendix F. The acceptance process will verify that Item 4.3.8.1 has been satisfied sufficiently to justify the credits granted in Item 4.3.8.2.

Membrane filtration systems are designed and constructed in one or more discrete types that can be called operating units, racks, trains, skids, etc. General descriptions are provided below as a basis of how the department interprets these discrete types and their subdivided components since some membrane manufacturers have vendor/product specific terminology.

Module - the smallest membrane filtration component in which a specific membrane surface area is housed. Membrane modules typically consist of a single removable pressure vessel.

Rack – can be a single module or a collection of modules manifolded together. Modules within a rack are operated or isolated as a single grouping for filtering, backwashing, testing or cleaning in place.

Train – can be a single module or a collection of racks. Trains also include piping, instruments, valves and fittings all working as a single unit. A train, similar to a rack, is the smallest operating collection of equipment that is generally operated or isolated as a single group for filtering, backwashing, testing or cleaning in place.

Skid / unit - can be a single train up to a collection of multiple trains. A unit consists of a number of membrane modules or elements which are defined as a discreet single membrane unit contained in a single housing. Modules and elements typically share feed and filtrate valving, and each respective unit can usually be isolated from the rest of the system for testing, cleaning, or repair. A typical system is composed of a number of identical units that combine to produce the total filtrate.

4.3.8.1 General – Acceptance Checklist and Third Party Validation

All membrane systems must receive third party validation for removal of *Giardia* and *Cryptosporidium* or an acceptable surrogate approved by the Department. Third party validation must be accomplished in a similar manner to the latest edition of the EPA *Membrane Filtration Guidance Manual* (a.k.a., EPA MFGM, Reference 11) or an approved alternative.

The checklist attached in Appendix D presents the minimum information that must be reviewed by the Department for an individual membrane manufacturer. Membrane manufacturers can choose to submit for Department acceptance of their alternative filtration technology (not site-specific approval for installation). The material that must be submitted to the Department is as follows:

a. Third party validation testing establishing:

   i. Removal of pathogens.

   ii. Performance with compromised fibers.

   iii. Feed water quality and flux rates tested.

   iv. Transmembrane pressures of operation.

v. Clean in place (CIP) and chemically enhanced backwash (CEB)/Maintenance Clean (MC) protocols.

vi. Integrity testing procedures.

b. Membrane specifications: submerged or pressure-driven, material of construction, surface area per module, effective pore size, maximum and minimum operating pressure, supporting media.

c. Optional: Operations and maintenance manuals and process descriptions establishing pressure decay test protocols and cutoff rates (for 3 log removal), backwash protocols, CEB protocols, CIP, and fiber repair protocols.

- Note: If the manufacturer chooses not to submit the optional information, each site-specific project submittal must include it. The material will then be reviewed at that time.

The Department can also pre-accept membrane skids with the complete system mounted on the skid should the manufacturer desire this. The membrane skids will then be listed as pre-accepted technology, however individual site-specific approval must be obtained. In addition to accepting the membrane module above, requirements for membrane skid acceptance are:

a. Detailed dimensioned skid layout drawings.

b. Process and instrumentation diagrams.

c. Functional description of the system operation including backwash, CIP, CEB, and integrity test.

d. Valve schedule and operating position during each cycle of membrane operations.

e. Clear delineation of block and bleed assembly or equivalent assembly equally or more protective against cross-connections.

f. Operational protocol to assure backflow prevention during CIP (and CEB as necessary).

g. Filtrate sample locations to determine compliance and direct integrity testing.

- Note: If the manufacturer chooses not to submit the above information, each site-specific project submittal must include it and it will be reviewed at that time.

4.3.8.2 Compliance Removal Credit

The table below represents the maximum amount of removal credit that can be granted after Department review and acceptance of a membrane technology unless a demonstration of a performance project is performed as detailed in the EPA MFGM (Reference 11).

Table 4.1 – Log removal compliance credit for membrane filtration

Giardia lamblia	3.0 – Log
Cryptosporidium	3.0 – Log

Viruses	no credit granted

Membranes may be used as final compliance filters as part of a multiple treatment barrier approach to meet Section 11.8 of Regulation 11 (i.e., Surface Water Treatment Rule).

* NOTE: Compliance credit awarded is merely for meeting minimum requirements of Section 11.8 of Regulation 11 and does NOT reflect demonstrated performance of the micro or ultrafiltration system in any way. Actual removals in these types of systems can frequently exceed 4.5-5.0 log removal of *Giardia*, *Cryptosporidium*, or testing surrogates. The Department highly recommends that suppliers compare manufacturer literature to determine the absolute performance of any system selected.

4.3.8.3 Log Inactivation Requirements

The Department does not credit virus removal to any membrane because of the requirement to maintain multiple barriers for pathogens.

All surface water and GWUDI systems using membrane technology must provide disinfection that meets 4.0-Log virus inactivation.

a. The Department will evaluate any additional filter log removal credit and compliance monitoring criteria for systems that are classified as Bin 2 or higher under Section 11.10 of Regulation 11 (i.e., Surface Water Treatment Rule: Enhanced Treatment For *Cryptosporidium*) on a case- by-case basis.

4.3.8.4 Rate of Filtration - Flux

a. Membrane flux (design basis) and basis for the flux selection must be provided in the BDR. This must include:
    i. A clear identification of the source raw water quality, including temperature.
    ii. The quality of the feed water to the membrane system used to rate the water treatment plant production capacity.
    iii. Membrane system redundancy (along with disinfection capacity).
b. The submission must include identification of any pretreatment chemicals and their application that could affect the membrane flux including but not limited to polymers, oxidants and coagulants.

4.3.8.5 Minimum Raw/Feed Water Quality

a. Sufficient raw water analysis (per Item 1.2.3) is required to justify the membrane filtration design, necessary pre-treatment steps prior to the membrane system and feed water quality to the membrane system.
b. Where pretreatment is installed upstream of the membrane system, a statement of compatibility between the membrane material and upstream processes must be provided.

4.3.8.6 Transmembrane Pressure (TMP)

a. Maximum TMP must not exceed the maximum as specified in the specific membrane acceptance listed in Appendix F.

4.3.8.7 Performance Monitoring Provisions

a. For all membranes:
    i. Direct and indirect integrity testing method or surrogate membrane integrity testing protocol with failure criteria clearly delineated.
    ii. Protocol requirements for repair of broken fibers must be provided as applicable to the specific membrane type.
    iii. RO/NF membranes: Monitoring location for TDS, conductivity, and/or approved performance parameters.

b. For membrane for compliance with Section 11.8 of Regulation 11 (i.e., Surface Water Treatment Rule)
    i. Ability to monitor turbidity on combined filter effluent.
    ii. Ability to continuously monitor turbidity on individual membrane units for indirect integrity monitoring samples.
    iii. Continuous monitoring on each skid and combined filter effluent less than 0.1 NTU 95% of the time, never to exceed 0.5 NTU.
    iv. Direct integrity testing or surrogate membrane integrity testing protocol for each unit must be performed once per week that the membrane is in operation.

4.3.8.8 Backwash, CEB, and CIP requirements

a. Backwash/CEB protocol must be provided including:
    i. Functional Description of backwash/CEB protocol, frequency and duration of events, mechanism for backwashing, backwash water supply system and basis of the approach.
    ii. Description of the backwash/CEB supply and waste systems.
    iii. Identification and summary of the chemicals and chemical systems used in the CEB system and the treatment and disposition at completion of the backwash/CEB process
    iv. Cross Connection Control description including operation of block and bleed for the CEB system if deemed necessary.

b. CIP protocol must be provided including:
    i. Identification of the chemical system used in the CIP.
    ii. Functional Description of the CIP including but not limited to the CIP event trigger (e.g., manufacturer's recommendations, timing, water quality), the expected frequency, CIP system chemical method to neutralize and dispose of the spent CIP chemicals.

iii. Post-CIP approach to return to a filtration mode including backwash/flushing and method to treat and dispose of the CIP chemical stream.

iv. Identification and summary of the chemicals and chemical systems used in the CIP system and the treatment and disposition at completion of the CIP process.

v. CIP system must also conform to Chapter 5.

vi. Cross Connection Control block and bleed description for the CIP system.

4.3.8.9 Pretreatment

a. Strainer system prior to the membrane system to protect the integrity of the fibers must be the same design basis as specified by the manufacturer of the membrane system.

   i. Identify the mesh size and provide a Functional Description including but not limited to the operation, head loss recovery and method to handle the waste stream.

b. Coagulation, flocculation, or sedimentation/clarification may be used as membrane pre-treatment however it does not have to conform to the requirements of Section 4.2 as it does not contribute to the compliance credit. Each design must discuss the basis for the design parameters used in the BDR for the individual unit operations.

4.3.8.10 Appurtenances

The following must be provided for every membrane filter unit (if not in the pre-accepted unit):

a. Influent and effluent sampling taps.

b. Appropriate pressure measurement for TMP and direct integrity testing or surrogate membrane integrity testing.

c. A meter indicating instantaneous rate of flow.

d. A flow rate controller to control membrane flux on each unit.

e. Compressed air for process and valve function must have a reliable supply of filtered, dry, and oil-free air.

4.3.8.11 Control Systems

a. Systems must include the following automatic shutdown processes:

   i. High raw or filtrate turbidity.

   ii. Equipment or control systems failure or shutdown.

   iii. MF/UF membranes: High pressure decay test.

   iv. High TMP.

4.3.8.12 Redundancy and Unit Flow Rate

a. Redundancy: When treatment is required for Regulation 11 compliance, at least two units must be provided. For designs that include only two units, each unit must be capable of meeting the plant design flowrate. For designs with more than two units, the unit must be capable of meeting plant design flowrate with the largest filter removed from service. For membrane plants, the term units typically refers to filtration skids.

b. Unit design flow rate: The unit design flow rate will be the approved filter loading rate with the largest unit out of service.

4.3.9 Bag and Cartridge Filtration

Bag and cartridge filtration refers to filtration via straining utilizing a disposable cartridge or bag. This item describes the requirements for using bags or cartridges for compliance with the Section 11.8 of Regulation 11 (i.e., Surface Water Treatment Rule) requirements. Therefore, the purpose of the treatment is for removing the required amounts of *Giardia* and *Cryptosporidium*. The requirements below represent the minimum criteria associated with that purpose. If this technology is used for non-compliance purposes, only the requirements of Section 2.21 will apply.

Once a technology has been accepted as an Alternative Technology (See Section 1.11), the acceptance will be recorded in Appendix F. The acceptance process will verify that Item 4.3.9.1 has been satisfied sufficiently to justify the credits granted in Item 4.3.9.2.

4.3.9.1 General – acceptance checklist and third party validation

All bag or cartridge filters must receive third party validation for removal of *Giardia* and *Cryptosporidium* or an acceptable surrogate. Third party validation must be accomplished in a similar manner to the validation of membranes in the EPA MFGM (Reference 11) or an approved alternative.

The checklist attached in Appendix D presents the minimum information that must be reviewed by the Department for an individual bag or cartridge filter manufacturer. Filter manufacturers can choose to submit for Department acceptance of their alternative filtration technology (not site-specific approval for installation). The material that must be submitted to the Department is as follows:

a. Third party validation testing establishing removal of pathogens with filters AND housings, flow rates tested, differential pressures of operation, etc.

b. Chemical compatibility limitations must be specified.

c. Filter and housing specifications: material of construction, surface area per filter, maximum and minimum operating pressure of housing.

d. Operations and maintenance manuals and process descriptions establishing filter change out protocols.

4.3.9.2 Compliance Removal Credit

The table below represents the maximum amount of removal credit that can be granted after Department review and acceptance of an alternative bag or cartridge technology.

Table 4.2 – Log removal compliance credit for bag/cartridge filtration

Giardia lamblia	2.5 – Log
Cryptosporidium	2.0 – Log
Virus	no credit granted

Bag or cartridge filters may be used as final compliance filters as part of a multiple treatment barrier approach to meet Section 11.8 of Regulation 11 (i.e., Surface Water Treatment Rule).

NOTE: Compliance credit awarded is simply for meeting minimum requirements of Section 11.8 of Regulation 11 and does NOT reflect demonstrated performance of the filtration system in any way. The Department recommends that water systems compare manufacturer literature to determine the absolute performance and relevance of any system selected.

4.3.9.3 Log Inactivation Requirements

All surface water and GWUDI systems using bag or cartridge technology must provide disinfection that meets:

a. 4.0-Log virus inactivation.

b. 0.5-Log *Giardia* inactivation by disinfection.

   i. The Department will evaluate any additional filter log removal credit and compliance monitoring criteria for systems that are classified as Bin 2 or higher under Section 11.10 of Regulation 11 (i.e., Surface Water Treatment Rule: Enhanced Treatment For *Cryptosporidium*).

4.3.9.4 Redundancy and Unit Flow Rate

a. Redundancy: When filtration is required by Section 11.8 of Regulation 11 (i.e., Surface Water Treatment Rule), at least two units must be provided. For designs that include only two units, each unit must be capable of meeting the plant design flowrate. For designs with more than two filter units, the filters must be capable of meeting plant design flowrate with the largest filter removed from service.

   - Bag or cartridge filtration treatment plants with flow less than 50 gpm are not required to have a redundant filtration train if the supplier has sufficient distribution system water storage to accommodate filter change outs and other maintenance activities. The submittal must address the distribution system's water storage volume or provide a redundant filtration train.

b. Unit design flow rate: The unit design flow rate will be the approved filter loading rate with the largest unit out of service.

4.3.9.5 Minimum Raw Water Quality

Sufficient raw water analysis (per Item 1.2.3) must be submitted to justify design and necessary pre-treatment. The BDR must include a discussion of the analyses done to determine the filterability of the raw water under different seasonal variations. Bag filter and cartridge filter systems may not be appropriate for water sources that contain significant raw turbidities and/or concentrations of submicron colloidal particles. The source water must be evaluated to determine if submicron particles are present in concentrations that may result in failure to achieve filter effluent turbidity requirements. The source water must also be evaluated to determine whether high raw water turbidities will result in rapid fouling of the compliance filters. The seasonal variability of source water quality, especially during spring runoff events, must also be taken into consideration. Pre-filtration or pre-treatment may be an effective method used to address colloidal particles and/or turbidity but must be sufficiently described in the BDR.

Suppliers should consider the affordability of frequent filter change out during challenging water quality events (i.e., high raw water turbidity) that rapidly blind the compliance filter resulting in excessively short filter runs.

Bag and cartridge filtration must not be used when the submicron, colloidal fraction of turbidity upstream of the final compliance filter is greater than 1.49 NTU. Roughing pre-filters or other pretreatment processes may be used to meet the 1.49 NTU turbidity requirement upstream of the compliance filter provided they have been demonstrated to be effective on a particular raw water. The ability for the selected pretreatment option to meet the turbidity requirement must be documented in the BDR.

Three options are available for evaluating whether bag or cartridge filtration is an acceptable filter treatment process:

a. Turbidity results: The supplier may submit weekly raw water turbidity results over a minimum of a period from March through June (one year period is preferred) to demonstrate that the raw water turbidity is reliably less than 1.49 NTU. If the proposed design includes roughing pre-filters or other pretreatment processes then the system may submit weekly turbidity results that demonstrate the turbidity downstream of the pretreatment process is reliably achieving 1.49 NTU. For systems where the critical or most challenging period (e.g., run-off, lake turnover) for the filtration process does not take place in March through June, the system must contact the Department to determine an alternative sampling timeline.

b. Pilot/demonstration study: The supplier may conduct a pilot study (Section 1.6) or a demonstration study (Section 1.7) that demonstrates the proposed compliance bag or cartridge filter is capable of reliably achieving 1.49 NTU downstream of the compliance filter. The pilot/demonstration study must take place for a minimum one month period during the critical or most challenging period (e.g., run-off, lake turnover) for the filtration process.

c. Particulate removal study: The supplier may submit weekly results from a particulate analysis size study demonstrating that any pre-filtration / pre-treatment (if applicable) and proposed compliance bag or cartridge filter effluent is capable of reliably achieving 1.49 NTU is acceptable. The particulate removal study must take samples weekly for a minimum two month period during the critical or most challenging period (e.g., run-off, lake turnover) for the filtration process. The particulate removal study may be either done via the standard testing procedure available in Appendix L or using an outside laboratory. Nylon membranes must not be used for any particulate analysis tests, and tests must use absolute instead of nominal pore sizes.

4.3.9.6 Differential Pressure

Maximum differential pressure must not exceed maximum as specified from third party validation. The submittal must include a discussion of failure criteria. The Department strongly recommends that an audible, visual, or computer program notification or alarm is triggered prior to the maximum differential pressure. If a notification or alarm system is not practical then, at minimum, the system must keep a daily log of differential pressures in order to anticipate when filter element change out is imminent and to build seasonal historical data. If used, differential pressure gauges must be designed to prevent possible gauge membrane failure and bypass issues, and alarm if such failure did occur.

4.3.9.7 Performance Monitoring Provisions

a. Ability to monitor turbidity on combined filter effluent and individual filter skids or banks of bag/cartridge filters must be provided.
b. Differential pressure testing method must be specified.

4.3.9.8 Filter Change out Requirements

a. Filter change-out protocol must be specified. The Department expects water systems to keep records of filter change out and maintenance.
b. Each filter must be used once and then discarded with no backwashing or chemical cleaning.

4.3.9.9 Pretreatment

Any pre-filtration based on raw water quality as specified in the acceptance of the technology must also be specified in the final design.

4.3.9.10 Appurtenances

The following must be provided for every filter or bank of filters:

a. Influent and effluent sampling taps.
b. Check valve after the filter vessel to prevent a backflow of filtered water into the filter vessels.
c. A pressure relief valve on inlet to each vessel or stage set to deploy at the appropriate maximum pressure for the filter housing.
d. Appropriate pressure measurement for differential pressure; differential pressure testing must be performed once per day that the filter is in operation per the acceptance letter. If used, differential pressure gauges must be designed to prevent possible

gauge membrane failure and bypass issues, and alarm if such failure did occur.

e. A meter indicating instantaneous rate of flow.

f. A mechanism to control flow rate to each filter – in the cases where a bank of filters is operated in parallel without individual flow control; provision for common header with all filters being changed at the same time.

g. Provisions for protection from water hammer and pressure surges in the overall water treatment system design.

4.3.10 Natural Filtration for Compliance

The Department will consider accepting natural filtration for compliance with Section 11.8 of Regulation 11 (i.e., Surface water treatment rule). Appendix G details the requirements for a supplier to apply for credits for natural filtration.

4.4 DISINFECTION

Disinfection with free chlorine has historically been the most common disinfecting agent in Colorado. Disinfection may be accomplished with gas and liquid chlorine, calcium or sodium hypochlorite, chlorine dioxide, ozone, ultraviolet light, and chloramines. Chlorocyanurate products are not approved for use due to their tendency to interfere with EPA-Approved analytical methods for measuring free chlorine. Other disinfecting agents will be considered, providing reliable application equipment is available and testing procedures for a residual are recognized in "Standard Methods for the Examination of Water and Wastewater," latest edition or an equivalent means of measuring effectiveness exists. Consideration must be given to the formation of disinfection byproducts (DBP) when selecting the disinfectant.

Continuous disinfection is required for all water supplies. Bypasses around the disinfection process will not be approved (Note: bypasses may exist for oxidation processes provided they are not used as primary disinfection).

4.4.1 Chlorination Equipment

This section applies to treatment systems using chlorine (e.g., gas, sodium hypochlorite) for disinfection.

4.4.1.1 Type

Chlorine chemical feed systems must meet the requirements of Part 5. Specific chemical requirements for chlorine gas and sodium hypochlorite are in Section 5.4.

4.4.1.2 Capacity

The chlorinator capacity must be such that a free chlorine residual of at least 2.0 mg/L can be maintained in the water once all demands are met after an effective contact time corresponding to the required amount of disinfection for a given treatment technique. These capacity calculations must correspond to maximum flow rate coinciding with anticipated maximum chlorine demand. The equipment must be of such design that it will operate accurately across the feeding range.

4.4.1.3 Redundancy

When treatment is required for Regulation 11 compliance, at least two units must be provided. For designs that include only two units, each unit must be capable of meeting the plant design flowrate. Spare parts must be made available to replace parts subject to wear and breakage.

4.4.1.4 Not used.

4.4.1.5 Automatic proportioning

Automatic proportioning is required where the rate of flow or chlorine demand varies by more than 20% on a daily basis.

4.4.1.6 Not used.

4.4.1.7 Not used.

4.4.2 Disinfection log inactivation and point of application

a. Sufficient raw water analysis (per Item 1.2.3) must be submitted to justify disinfection log inactivation and contact time. The design must include documentation of the contact time of the disinfectant in water with relation to pH, ammonia, taste-producing substances, temperature, bacterial quality, disinfection byproduct formation potential and other pertinent factors.

b. At all treatment plants, the design must be capable of applying the disinfectant to meet the minimum disinfectant residual required in Regulation 11 entering the distribution system.

c. All storage tanks, pipelines, or other basins used for disinfection must be designed to account for short circuiting using baffle factors (see Item 4.4.3).

d. The disinfectant must be applied at a point in the treatment process prior to any credited contact volume and must enter the contact volume fully mixed. Mixing of disinfectant with the bulk flow may be achieved via mixing devices or conduit turbulence.

e. The disinfectant must be applied at a point which will provide adequate disinfection contact time to achieve the required disinfection log inactivation. Disinfection may be achieved in multiple disinfection segments upstream and downstream of compliance filtration. See EPA's *Disinfection Profiling and Benchmarking Technical Guidance Manual* (Reference 12). For each disinfection segment, there must be monitoring equipment to verify disinfection parameters per Item 4.4.2(h). If a disinfection parameter will not significantly change between segments, then common monitoring equipment may be used (e.g., a single flowmeter may be used for two disinfection segments if the flowrate is the same through both segments).

f. Disinfection credits for compliance with the surface water treatment rules will be granted by the Department in accordance with the "Safe Drinking Water Program Policy DW-004" (Reference 10). The required disinfection log inactivation will depend on the type of source water and compliance filtration treatment installed:

   - **Surface waters and GWUDI**: the treatment plant must be designed to meet the log inactivation requirements for *Giardia* and viruses in accordance with the credited removal from filtration (Reference 6) to comply with Section 11.8 of Regulation 11 (i.e., Surface Water Treatment Rule) requirements. Certain water plants may have to provide additional log inactivation of *Cryptosporidium* when required by Section 11.10 of Regulation 11 (i.e., Surface Water Treatment Rule: Enhanced Treatment for *Cryptosporidium*). When log inactivation is required by Regulation 11, Section 11.8, bypasses around the disinfection contact volume are not permissible.

- **Groundwater:** the treatment plant must be designed for the capability to provide 4-log virus inactivation. Groundwater systems wishing to continuously provide 4-log viral treatment will be required to continuously monitor the process and provide a minimum chlorine residual corresponding to 4-log virus inactivation per Section 11.11 of Regulation 11 (i.e., Groundwater Rule).

g. Unit design flowrate for the disinfection process must be based on the peak hourly flowrate in gallons per minute (gpm). Peak hourly flowrate is defined as the plant's water production when the maximum volume (in gallons or millions of gallons) of water flows through the plant during a one-hour period.

h. The BDR must include log inactivation calculations (per Item 1.2.5(b)) and supporting design parameters including:

- Peak hour flow through the contact volume,
- Minimum disinfectant residual concentration,
- Minimum contact volume,
- Maximum pH,
- Minimum temperature, and
- Disinfection contact volume and baffle factor (see Item 4.4.3).

If a minimum chlorine residual MOR is proposed for use, the minimum disinfectant residual concentration units must be rounded up to the calculated nearest tenth of a mg/L (e.g., 1.2 mg/L, 0.2 mg/L).

i. When required by Regulation 11 for compliance, instrumentation is required to accurately measure flow through the disinfection contact volume. See Sections 2.8 and 2.13.

4.4.3 Disinfection contact volume and baffle factors

a. Baffling factor for disinfection contact volume must be justified based on: literature values, tracer study results, or computational fluid dynamics (CFD) modeling. Specialized tanks designed for contact time may apply for an accepted baffle factor using the Department's alternative technology process (see Section 1.11, Appendix D, and Appendix F).

Baffle factor information sources include the Department's *Baffling Factor Guidance Manual Determining Disinfection Capability and Baffling Factors for Various Type of Tanks at Small Public Water Systems* (Reference 13), the Department's *Technical Guidance Manual on Computational Fluid Dynamics Modeling of Chlorine Contact Basins Determining Baffling Factors Through the Use of CFD Modeling* (Reference 14), EPA's *Guidance Manual for Compliance* *with the Filtration and Disinfection Requirements for Public Water Systems Using Surface Water Sources* (Reference 15), American Water Works Association Research Foundation's *Improving Clearwell Design for CT Compliance* (Reference 16), and California State Water Resources Control Board, Division of Drinking Water's *Chlorine Contact Chamber Design and Flow Evaluation* (Reference 17).

i. Tanks with a common inlet and outlet or an inlet and outlet that are in close proximity will have a baffle factor of zero (0.0).

ii. Regardless of inlet and outlet piping configuration or basin geometry, Tanks with mixers will be granted a baffle factor of 0.1. Supporting evidence must be submitted to justify higher baffle factors for tanks with mixers.

iii. Generally, un-baffled tanks will be assigned a baffle factor of 0.1. Higher baffle factors may be justified based on tank geometry (e.g., installation of baffles) and inlet/outlet configuration. Supporting evidence must be submitted to justify higher baffle factors.

iv. Pipe segments will be assigned a baffle factor of 0.6 unless a higher baffle factor is justified as follows: To achieve a baffle factor of 1.0, pipe segments must have a total length to width ratio greater than 160:1 with no segment less than 40:1 prior to bends, a constant diameter, and fully turbulent flow under the minimum flow condition. The Department may require tracer studies for pipe segments if the design is outside the constraints listed in the *Baffling Factor Guidance Manual Determining Disinfection Capability and Baffling Factors for Various Types of Tanks at Small Public Water Systems* (Reference 13).

b. The Department only approves baffle factors to the tenth of a decimal (i.e., 0.6 and not 0.69). The Department is conservative with approved baffle factors and will round down to the nearest tenth (e.g., 0.69 will be rounded down to 0.6). Baffle factors will not be rounded up. The Department encourages suppliers and designers to conduct tracer studies or develop hydraulic models to justify baffle factors where feasible. The supplier may submit tracer study results, or other information, to the Department after construction to justify a revised baffle factor. The Department will review such information and may alter the approved baffle factor.

c. If a storage tank is used for disinfection contact time, the tank design must meet the requirements of Chapter 7.

d. The treatment plant design must allow for the disinfection contact volume to be taken offline for routine inspection, cleaning and maintenance activities. The preliminary plan of operations must address disinfection contact volume inspection, cleaning and maintenance activities.

e. If the disinfection contact volume is used to provide filter backwash water then the disinfection contact storage tank must be sized, in conjunction with distribution system storage, to relieve the filters from having to immediately meet peak fluctuations in water use.

f. If the treatment plant is operated intermittently then the design and operation of the disinfection contact storage tank must be capable of meeting all disinfection log inactivation requirements as soon as the treatment plant is returned to service. .

4.4.4 Testing Equipment

Refer to Sections 2.8 and 2.9 of this document and Regulation 11 for information pertaining to grab and/or continuous monitoring requirements and equipment.

4.4.5 Piping

4.4.5.1 Cross-connection protection

The dilution water supply piping must be designed to prevent contamination of the treated water supply. At all plants, the design must include an approved backflow prevention device to prevent possible siphoning of water prior to the compliance filtration step into the water post filtration. The water supply must have a shut-off valve.

4.4.5.2 Pipe material

Pipes carrying liquid or dry gaseous chlorine under pressure must be Schedule 80 seamless steel pipe or other materials recommended by the Chlorine Institute.

Pipes carrying liquid or dry gaseous ammonia under pressure must be Schedule 80 seamless steel piping, or other materials and installation methods recommended by the Compressed Gas Association, the International Institute of Ammonia Refrigeration or other relevant standards. For chlorine solution piping, rubber, PVC, polyethylene, or other materials recommended by the Chlorine Institute must be used for piping and fittings. Nylon products are not acceptable for any part of the chlorine solution piping system.

For 10% ammonia solution piping, EPDM, PVC, polyethylene, or other materials recommended by the solution feeder manufacturer must be used for piping and fittings. System piping components made of, or in part of, brass, copper, zinc, galvanized steel, or cast iron may NOT be used for ammonia service.

The BDR must indicate pipe and fitting materials of construction selected for the associated reagent or solution duties.

4.4.6 Housing

Adequate housing must be provided for chemical equipment and storage, see Chapter 5.

4.4.7 Ozone

4.4.7.1 Design considerations

Ozone will be reviewed in detail by the Department when used for regulatory compliance either for meeting log inactivation requirements of Sections 11.8, 11.10, and/or 11.25 of Regulation 11 (i.e., Surface Water Treatment Rules or Disinfection Byproduct Rule). When equipment is necessary for compliance with Regulation 11, a standby unit or a combination of units of sufficient size to meet design capacity must be provided to replace the largest unit when out of service.

When ozone is being used solely for aesthetic treatment (e.g., tastes and odors), the Department will perform a review of the safety aspects of the treatment and how it effects downstream compliance treatment.

The design submittal in those cases will not be required to include the redundancy components (although the system may wish to consider them), disinfection efficacy, or disinfection byproduct reduction. In all cases, disinfection byproduct formation must be addressed.

At a minimum, bench scale studies must be conducted to determine ozone demand and decay kinetics for the specific water being treated in order to establish the correct design dose for required log inactivation compliance and oxidation reactions. If ozone is being employed for the reduction of disinfection byproducts in response to a violation, simulated distribution system testing at a minimum must be performed to assess the impact of ozone addition on disinfection byproduct formation. In addition, more involved pilot scale studies must be considered, when necessary, to determine impacts of the ozonation process on downstream treatment processes like coagulation and filtration, and the treatment benefits of single or multiple points of ozone addition.

4.4.7.2 Feed gas preparation

a. Compressed air feed gas system

Air handling equipment on conventional low pressure air feed systems must consist of an air compressor, water/air separator, refrigerant dryer, heat reactivated desiccant dryer, and particulate filters. Some "package" ozonation systems for small plants may work effectively operating at high pressure without the refrigerant dryer and with a "heat-less" desiccant dryer. In all cases the maximum dew point of -76° F (-60° C) must not be exceeded at any time.

i. Air compression

1. Air compressors must be of the liquid-ring or rotary lobe, oil-less, positive displacement type for smaller systems or dry rotary screw compressors for larger systems.
2. Air compressors must have the capacity to simultaneously provide for maximum ozone demand, provide the air flow required for purging the desiccant dryers (where required) and allow for standby capacity.
3. Air feed for the compressor must be drawn from a point protected from rain, condensation, mist, fog and contaminated air sources.
4. A compressed air after-cooler and/or entrainment separator with automatic drain must be provided prior to the dryers to reduce the water vapor.
5. A back-up air compressor must be provided so that ozone generation is not interrupted.

ii. Air drying

1. Dry, dust-free and oil-free feed gas must be provided to the ozone generator. Sufficient drying to a maximum dew point of -76 ° F (-60° C) must be provided at the end of the drying cycle.
2. Drying for high pressure systems must be accomplished using heatless desiccant dryers only. For low pressure systems, a refrigeration air dryer in series with heat-reactivated desiccant dryers must be used.
3. A refrigeration dryer capable of reducing inlet air temperature to 40° F (4° C) must be provided for low pressure air preparation systems. The dryer must be of the compressed refrigerant type or chilled water type.
4. For heat-reactivated desiccant dryers, the unit must contain two desiccant filled towers complete with pressure relief valves, two four-way valves and a heater. In addition, external type dryers must have a cooler unit and blowers. The size of the unit must be such that the specified dew point will be achieved during a minimum adsorption cycle time of 16 hours while operating at the maximum expected moisture loading conditions.
5. Multiple air dryers must be provided so that the ozone generation is not interrupted in the event of dryer breakdown.
6. Each dryer must be capable of venting "dry" gas to the atmosphere, prior to the ozone generator, to allow start-up when other dryers are "on-line".

iii. Air filters

1. Air filters must be provided on the suction side of the air compressors, between the air compressors and the dryers and between the dryers and the ozone generators.
2. The filter before the desiccant dryers must be of the coalescing type and be capable of removing aerosol and particulates larger than manufacturer’s requirements. The filter after the desiccant dryer must be of the particulate type and be capable of removing all particulates greater than 0.1 microns in diameter, or smaller if specified by the generator manufacturer.

iv. Piping system - Piping in the air preparation system must be seamless copper or stainless steel and must be passivated and cleaned to prevent oil and fines from entering the ozone generation equipment. The piping must be designed to withstand the maximum pressures in the air preparation system.

b. Liquid oxygen feed gas system

i. Liquid oxygen storage system

1. The bulk oxygen storage system and associated equipment must comply with the latest standards and all applicable local, state, and federal codes.
2. The liquid oxygen storage system must include the liquid oxygen storage tank and all related safety devices, appurtenances, and equipment required for operation.
3. The liquid oxygen storage tanks must be horizontal or vertical tanks with double wall construction. The inner shell of the tank must be designed, fabricated, tested, inspected and stamped in accordance with the applicable ASME Code requirements and supported within the outer shell. The outer shell must be designed in accordance with applicable standards for exterior pressure due to full internal vacuum and must be carbon steel.
4. The liquid oxygen storage tank must be provided with a mounting base and anchor bolts. Mounting base and support framing for the storage tank must be welded to the tank.
5. The internal vessel pressure relief must consist of both automatic primary and secondary relief devices and manual tank vent valves. External vessel pressure relief must consist of an automatic relief device.
6. The tank must be insulated in the annular ring with a high vacuum packing or composite insulation, such that the tank boiloff rate must not exceed 0.25 percent of the tank capacity by weight per day.
7. The tank must be equipped with an economizer system to direct the boiled-off gaseous oxygen to the ozone generation feed-gas system rather than venting to the atmosphere.
8. The tank must be equipped with a pressure building system to maintain the minimum pressure and maximum flow required for the ozone generation system.

ii. Liquid oxygen vaporization system

1. At least two ambient air vaporizers must be provided for the liquid oxygen vaporization system including all related safety devices, appurtenances and equipment required for operation. The vaporizers must operate in a duty and defrost cycle mode of operation.
2. The vaporizer equipment must be designed to provide continuous vaporization of liquid oxygen for design

gaseous oxygen flow rate conditions at the minimum design ambient air temperature

3. The vaporizers must be single module ambient vaporizers, factory assembled unit complete with bracing, lifting lugs, pressure safety relief valves, necessary internal manifolding, flanged connections, and suitable for outside installation and operation. The materials of construction must be suitable for the design conditions and oxygen compatible.
4. The vaporizers must be equipped with automatic vaporizer valve controls to provide automatic switchovers to standby vaporizers on a timed or temperature basis to prevent vaporizer freeze-up.

iii. Piping and appurtenances

1. All piping between liquid oxygen storage tanks and vaporizers must be seamless copper pipe or stainless steel. All gaseous oxygen (GOX) piping, valves and fittings between the vaporizers and the ozone generators must be stainless steel. All piping and valves must be suitable for cryogenic and oxygen gas service at the specified operating pressure. All liquid oxygen piping systems must be insulated in accordance with applicable standards.
2. Tank fill system must include a standard oxygen hose connector, check valve, pressure relief valve and drain valve. Fill system must be designed for appropriate connections.
3. A pressure regulating valve station must be installed downstream of the vaporizers to reduce gaseous oxygen pressure to the delivery pressure required for the ozone generation system. The valves must be certified for oxygen service.
4. Gaseous oxygen cartridge-type particulate filter must be provided, complete with valves and appurtenances. The filter must be provided in the gaseous oxygen supply piping between the pressure regulating valve station and the ozone generators. The filter must retain particles as required by the manufacturer.

4.4.7.3 Ozone generator

a. Capacity.

i. The production rating of the ozone generators must be stated in pounds per day at a maximum cooling water temperature and maximum ozone concentration.

ii. Generators must be sized to have sufficient reserve capacity so that the system does not operate at peak capacity for extended periods of time.

iii. The design must ensure that the generators can produce the required ozone at maximum coolant temperature.

iv. Appropriate ozone generator backup equipment must be provided.

b. Ozone generation equipment.

i. All ozone generator metal parts that come in contact with ozone or cooling water must be constructed of compatible materials.

ii. Each ozone generator shell must be provided with safety valves to provide over-pressure and thermal relief protection for the generator.

c. Electrical.

i. Specifications must require that the transformers, electronic circuitry, other electrical hardware and components are designed for ozone service.

ii. An electrical power supply unit (PSU) package must be furnished for each ozone generator, containing all ozone generator electrical and control components with all components enclosed in one overall enclosure as specified below. The power supply unit design and components must provide for complete operation of the ozone generating equipment.

iii. The power supply enclosures must have separate compartments for low voltage, high voltage, control, and forced air or direct conductive cooling equipment, as applicable. Compartment design must be in accordance with recognized industry standards such as UL and NEMA.

iv. Harmonic Mitigation. Provide harmonic mitigation equipment to reduce power system harmonics levels. Harmonic mitigation equipment must be phase shift transformers, isolation transformers, harmonics filters, multi-pulse inverters, or other as required to meet IEEE 519 requirements.

v. Grounding. Provide copper ground bus within each PSU. Connect PSU enclosure, frame, doors, and metal surfaces to PSU ground bus to assure a completely grounded enclosure meeting the requirements of applicable safety codes.

4.4.7.4 Ozone contactors

The selection or design of the contactor and method of ozone application depends on the purpose for which the ozone is being used.

a. Bubble diffusers.

i. Where disinfection is the primary application a minimum of two contact chambers each equipped with baffles to prevent short circuiting and induce countercurrent flow must be provided. Ozone must be applied using porous-tube or dome diffusers.

ii. The minimum hydraulic residence time in the contactor at design flow must be 10 minutes. A shorter contact time may be approved by the Department if justified by appropriate bench scale, pilot scale, and/or log inactivation considerations.

iii. For ozone applications in which precipitates are formed, such as with iron and manganese removal, porous diffusers must be used with caution and at least two diffuser cells in each contactor must be provided for improved reliability.

iv. Contactors must be separate closed vessels that have no common walls with adjacent rooms. The contactor must be kept under negative pressure and sufficient ozone monitors must be provided for worker safety.

v. Large contact vessels should be made of reinforced concrete. All reinforcement bars must be covered with a minimum of 1.5 inches of concrete. Smaller contact vessels can be made of stainless steel or other material which will be stable in the presence of residual ozone and ozone in the gas phase above the water level.

vi. If foaming is expected to be excessive due to organics in the water supply, then a potable water spray system must be considered in the contactor head space.

vii. All openings into the contactor for pipe connections, hatchways, etc. must be properly sealed using embedded wall pipes with waterstops or ozone resistant gaskets such as Teflon or Hypalon.

viii. Multiple sampling ports must be provided for sampling of the ozone contactor for log inactivation calculations.

ix. A pressure/vacuum relief valve must be provided in the contactor and piped to a location where there will be no damage to the destruction unit or exposure to plant personnel.

x. The diffusion system must work on a countercurrent basis such that the ozone is fed at the bottom of the vessel and water is fed at the top of the vessel.

xi. The depth of water in the diffusion cells of bubble diffuser contactors must be a minimum of 18 feet.

xii. All contactors must have provisions for cleaning, maintenance and drainage of the contactor. Each contactor compartment must also be equipped with an access hatchway.

xiii. Fine bubble diffusers must be fully serviceable by either cleaning or replacement.

b. Other contactors, such as horizontal or vertical sidestream venturi injection systems, may be approved by the Department provided adequate ozone transfer is achieved and the required contact times and residuals can be met and verified.

4.4.7.5 Ozone destruction unit

a. A system for treating the final off-gas from each contactor must be provided. Acceptable systems include thermal destruction and thermal/catalytic destruction units.

b. At least two units must be provided which are each capable of handling the entire gas flow.

c. Exhaust blowers must be provided in order to draw off-gas from the contactor into the destruct unit.

d. Catalysts must be protected from froth, moisture and other impurities which may harm the catalyst.

e. The catalyst and heating elements must be located where they can easily be reached for maintenance.

4.4.7.6 Piping materials must be a minimum of 316L stainless steel.

4.4.7.7 Joints and connections

a. Connections on piping used for ozone service must be welded where possible.

b. Connections with meters, valves or other equipment must be made with flanged joints with ozone resistant gaskets. Threaded fittings must not be used.

c. A positive closing butterfly valve plus a check valve must be provided in the piping between the generator and the contactor to prevent moisture reaching the generator.

4.4.7.8 Instrumentation

a. Pressure gauges must be provided at the discharge from the air compressor, at the inlet to the refrigeration dryers, at the inlet and outlet of the desiccant dryers, at the inlet to the ozone generators and contactors and at the inlet to the ozone destruction unit.

b. Each generator must have a trip which shuts down the generator when the wattage exceeds a certain preset level.

c. Dew point monitors must be provided for measuring the moisture of the feed gas from the desiccant dryers. Post-generator dew point monitors must be used where there is potential for moisture entering the ozone generator from downstream of the unit or where moisture accumulation can occur in the generator during shutdown.

d. Flow meters must be provided for measuring air flow from the desiccant dryers to each of other ozone generators, air flow to each contactor and purge air flow to the desiccant dryers.

e. Temperature gauges must be provided for the inlet and outlet of the ozone cooling water and the inlet and outlet of the ozone generator feed gas, and, if necessary, for the inlet and outlet of the ozone power supply cooling water.

f. Flow meters must be installed to monitor the flow of cooling water to the ozone generators and, if necessary, to the ozone power supply.

g. Ozone monitors must be installed to measure ozone concentration in both the feed-gas and off-gas from the contactor and in the off-gas from the destruct unit. For disinfection systems, monitors must also be provided for monitoring ozone residuals in the water. The number and location of ozone residual monitors must be such that the amount of time that the water is in contact with the ozone residual can be determined.

h. A minimum of one ambient ozone monitor must be installed in the vicinity of the contactor and a minimum of one must be installed in the vicinity of the generator. Ozone monitors must also be installed in any areas where ozone gas may accumulate. Total number of monitors must be in accordance with local, state, and federal regulations.

4.4.8 Chlorine Dioxide

4.4.8.1 Chlorine dioxide generators

Chlorine dioxide will be reviewed in detail by the Department when used for regulatory compliance either for meeting Sections 11.8, 11.10, and/or 11.25 of Regulation 11 (i.e., Surface Water Treatment Rules and/or Disinfection Byproducts Rule).

When chlorine dioxide is being used solely for aesthetic treatment (e.g., tastes and odors), the Department will perform a review of the safety aspects of the treatment and how it affects downstream compliance treatment. The design submittal in those cases will not be required to include the redundancy components (although the system may wish to consider them), disinfection efficacy, or disinfection byproduct reduction. In all cases, disinfection byproduct formation must be addressed.

a. Bench scale testing must be conducted to determine chlorine dioxide demand and decay kinetics for the specific water being treated in order to establish the correct design dose for required log inactivation compliance, oxidation reactions, and chlorite generation.

b. If chlorine dioxide is being employed for the reduction of disinfection byproducts in response to a violation, simulated distribution system testing at a minimum must be performed to assess the impact of chlorine dioxide addition on disinfection byproduct formation.

c. Chlorine dioxide generation equipment must be factory assembled pre-engineered units. Minimum yields of chlorine dioxide from the reaction of the specified chemicals are outlined in Items 4.4.8.1(d) and (e). ‘Yield’ means the ratio of chlorine dioxide generated to the theoretical stoichiometric maximum. The yield will be demonstrated by an amperometric titration analysis capable of differentiating chlorine, chlorine dioxide, chlorite, and chlorate. Analysis must be performed using the AWWA Standard Method 4500-ClO_2-E, titled "Determination of Chlorine Dioxide, Chlorine, Chlorite and Chlorate in Water." The theoretical stoichiometric maximum must be determined from the feed rates of the reacting chemicals.

d. Two chemical system minimal yield requirements:

   i. Liquid/Liquid: Hydrochloric acid and sodium chlorite systems must have a minimum yield of 80% across the proposed feed range. Unit must have a maximum production limit of 30 lb per day.

   ii. Gas/Liquid: Gaseous chlorine and sodium chlorite systems must have a minimum yield of 95% across the proposed feed range. The excess free chlorine must not exceed five percent of the theoretical stoichiometric concentration.

   iii. Gas/Solid: Gaseous chlorine and solid sodium chlorite systems must have a minimum yield of 95% across the proposed feed range.

e. Three chemical system minimal yield requirements:

   Liquid/Liquid/Liquid: Hydrochloric acid, Sodium chlorite, Sodium hypochlorite systems must have a minimum yield of 90% across the proposed feed range. The excess free chlorine must not exceed five percent of the theoretical stoichiometric concentration.

4.4.8.2 Feed and storage requirements – Refer to Section 5.4

4.4.8.3 Materials in contact with chlorine dioxide:

a. Piping components interconnecting the chlorine dioxide generator to the chemical injection point must be in accordance with the chlorine dioxide generator manufacturer requirements.

4.4.8.4 Redundancy and Unit Flow Rate:

a. Redundancy: When treatment is required for Regulation 11 compliance, at least two units must be provided. For designs that include only two units, each unit must be capable of meeting the plant design flowrate. For designs with more than two units, the unit must be capable of meeting plant design flowrate with the largest unit removed from service.

b. Unit design flow rate: The unit design flow rate will be the generation rate with the largest unit out of service.

<u>4.4.9 Ultraviolet (UV) Light for Disinfection</u>

4.4.9.1 Design considerations:

a. Redundancy: When treatment equipment is necessary for compliance with Regulation 11, a standby unit or a combination of units of sufficient size to meet design capacity must be provided to replace the largest unit when out of service. When treatment is required for Regulation 11 compliance, at least two units must be provided. For designs that include only two units, each unit must be capable of meeting the plant design flowrate. For designs with more than two units, the unit must be capable of meeting plant design flowrate with the largest unit removed from service.

b. Unit design flow rate: The unit design flow rate will be the design flowrate within the validation range with the largest unit out of service.

c. Minimum raw water quality: Sufficient raw water analysis (per Item 1.2.3) must be submitted to justify design and necessary pre-treatment. The UV influent water must meet any UV manufacturer's required standards and the BDR must summarize and compare the influent water quality to the manufacturer's requirements.

d. Design must include the following parameters:

    i. Maximum, and minimum flow rates.

    ii. Matrix of paired flow and UVT values based upon seasonal flow and UVT data.

    iii. Target organism for inactivation.

    iv. Log inactivation requirements.

    v. Operating approach.

    vi. Maximum and minimum operating pressures.

    vii. Maximum pressure at the UV reactor.

    viii. UV system redundancy.

    ix. Lamp cleaning strategy.

    x. Mercury trap/sump.

    xi. Maximum allowable headloss through the UV reactor.

e. Design dose requirements must include:

    i. The UV disinfection system must be designed to deliver the Reduction Equivalent Dose (RED) specified. To ensure the UV system can deliver the RED at the end of lamp life (EOLL), with fouled sleeves, the RED must incorporate a Combined Aging and Fouling Factor (CAF) calculated as CAF = EOLL x FF, where EOLL is the ratio of the lamp output at the end of the lamp life relative to the new lamp output, and FF is the Fouling Factor. The FF must be 0.5 for UV Systems with no sleeve wiping system, 0.75 for UV Systems with mechanical only sleeve wiping system, or 0.95 for UV Systems with an on-line combined chemical and mechanical sleeve wiping system. EOLL output must be 80% of the specified new lamp output. A higher value must be permitted only if the EOLL output has been validated by 3rd Party testing of the output at the end of the warranted lamp life.

    ii. The RED must be delivered under the maximum (design) flow and design UVT conditions, with the largest unit out of service.

f. Validation requirements:

   i. The UV Manufacturer must submit a Bioassay Validation Report for the proposed UV reactor. The bioassay testing and results must have been validated by a qualified independent third (3rd) party in full compliance with the EPA's *Ultraviolet Disinfection Guidance Manual* (a.k.a., UVDGM, Reference 18). Certify that the UV manufacturer will contact the supplier if validation requirements are adjusted, and identify all equipment and system modifications required to ensure the appropriate dosage is provided for the inactivation requirements.

   ii. Bioassay testing must evaluate reactor performance over the range of design flow rates, UVT from 70% to 98% (measured at 254 nm, 1 cm path length) and MS2 Reduction Equivalent Dose (RED) ranging from 10 to 110 mJ/cm^2, or T1 Reduction Equivalent Dose (RED) ranging from 2 to 24 mJ/cm^2. The bioassay testing must encompass the range of design and operating conditions described herein. Extrapolations to flow rates, UV Transmittance values, or UV doses outside the range actually tested, are not permitted.

   iii. Bioassay testing must also verify that the headloss generated by the proposed reactor is less than or equal to the specified limits.

4.4.9.2 Hydraulics

a. Inlet and Outlet Piping Configuration: The inlet and outlet piping to the UV reactor must result in a UV dose delivery that is equal to or greater than the UV dose delivered when the UV reactor was validated. The designer must refer to the validation report to determine that the validated inlet and outlet conditions apply to the site specific requirements, and apply one of the following options described below.

   i. Minimum of five pipe diameters of straight pipe must exist upstream of UV reactors.

   ii. Identical inlet and outlet conditions to those used during the validation must exist.

   iii. If on-site validation or custom off-site validation is planned, the inlet and outlet hydraulics must be designed according to manufacturer recommendations and to accommodate any site specific constraints.

b. UV Reactor Monitoring: Each UV reactor must be capable of UV intensity and lamp status.

c. Flow Rate Measurement and Control: A flowmeter or indicator and rate of flow controller for each reactor is required. Means for flow totalization are required for reporting out of spec water produced.

d. Head Loss and Flow Distribution: Lateral piping for each UV reactor must be sized and configured in accordance with the validated operating conditions, and maintain equal head loss through each UV reactor over the range of validated flow rates. UV reactor must not be by-passed.

e. Maximum system pressures must be evaluated to ensure that they will not exceed manufacturer's specifications. Any surge protections required to meet manufacturer's specifications must be documented.

f. Water Level Control: UV lamps in the UV reactor must be submerged at all times during operations.

g. Air Relief and Pressure Control Valves: The specific configuration of the UV reactor within a treatment plant will dictate the use of air release, air/vacuum, or combination air valves to prevent air pockets and negative pressure conditions.

h. Flow Control and Isolation Valves: Each UV reactor must be configured for isolation and removal from service while other UV reactor(s) remain in service.

i. Installation of Intermediate Booster Pumps: Booster pump system must be used if the head constraints indicate that a pump system is necessary. UV reactor will be sized accordingly.

4.4.9.3 Operating approach selection must be one of the following.

Provide operational documentation relevant to the selected approach. These approaches are outlined in detail in the UVDGM (Reference 5).

a. UV Intensity setpoint approach.

b. Calculated dose approach.

4.4.9.4 Instrumentation and control must provide:

a. UV reactor start-up and sequencing to include:

   i. UV reactor start-up.

   ii. UV reactor sequencing.

   iii. Pump cycling effects on UV reactor start-up.

b. UV equipment automation documentation.

c. UV equipment alarms and control systems interlocks.

d. UV reactor control signals including:

   i. UV lamp intensity.

   ii. UV transmittance.

   iii. Flow rate measurement.

   iv. Calculated and validated UV dose (if applicable).

   v. Operational setpoints.

   vi. Lamp age.

   vii. Lamp power, lamp status and reactor status.

   viii. UV reactor sleeve cleaning.

   ix. Ground fault interrupt and electrical lockout.

x. Alarms.

4.4.9.5 Electrical power configuration and back-up power must include:

a. Considerations for electrical power.

b. Back-up power supply.

c. Power conditioning equipment.

4.4.9.6 Elements of UV equipment

a. The UV reactor must be designed such that operating personnel at the plant can change the lamps without draining the reactor.

b. The UV reactor must be designed such that operating personnel at the plant can change UV intensity meter without draining the reactor.

c. UV lamps must be resistant to ozone.

d. UV lamp sleeves must be manufactured from fully annealed clear fused quartz tubing.

e. UV intensity sensor:

   i. UV intensity sensor must be located inside the reactor and contained within the protective quartz sleeve.

   ii. The UV intensity sensor measured output must be displayed (for UV intensity setpoint approach).

      1. Sensor(s) must meet the requirements of the EPA 815-R-06-007. Sensor(s) must filter out wavelengths below 240 nm with less than 10% coming from wavelengths greater than 300 nm.

      2. Sensors must be calibrated against one of the following standards:

         - National Physical Laboratory (NPL).
         - National Institute of Standards and Technology (NIST).
         - Deustsche Vereinigung des Gas- und Wasserfaches (DVGW).
         - Osterreichisches Normungsinstitut (ONORM).

f. Each ballast must supply power to one lamp only.

g. Control power panel

   i. Power distribution and control for each UV reactor must be through the associated control power panel.

   ii. The control power panel must house all power supplies and control hardware.

h. On-Line UV transmission monitor

   i. An on-line UV transmission monitor must be supplied (for calculated dose approach) to automatically monitor the UV transmission of the process stream (measured at 254 nm, 1 cm path length). UV transmission range must be 70% to 100%.

ii. The UV transmission monitor must include a UV lamp, UV sensor, drive system, system controller and operator interface.

i. Cleaning system

i. Each UV reactor must be equipped with an automatic on-line mechanical sleeve cleaning system.

ii. The cleaning system must provide mechanical and chemical (optional) cleaning abilities for the lamp sleeves, and mechanical cleaning abilities for the UV sensor sleeves/windows, complete with an automatically initiated and controlled cleaning cycle.

iii. The cleaning system must be fully operational while still providing validated dose requirements.

j. Spare parts

i. 20% of the UV lamps.

ii. 5% of the sleeves.

iii. One UV intensity sensor.

iv. Minimum recommended manufacturer spares.

k. Safety features

i. Each UV reactor must be equipped with a temperature switch to prevent overheating.

ii. Each UV reactor must be equipped with a water level sensor to prevent operation of the UV lamps in air.

4.4.9.7 Monitoring requirements

Design must incorporate monitoring requirements identified in the Department's UV Disinfection Acceptance letter. See Appendix H.

4.4.9.8 NSF 55 Class A validated reactors

The Department will allow the usage of NSF 55 Class A reactors at small water systems. See *NSF/ANSI 55: Ultraviolet Microbiological Water Treatment Systems* (Reference 19).

a. Design must incorporate the submittal requirements and criteria in the Department's Acceptance of NSF/ANSI Standard 55 Class "A" Ultraviolet Disinfection Equipment in Appendix I.1.

b. Additional rationale to this approach can be found in Appendix I.2 "Basis for Acceptance for ANSI/NSF Standard 55 Class 'A' Ultraviolet Disinfection Equipment for Use in Small Public Water Systems in Colorado"

4.4.10 Chloramines

Chlorine combines with ammonia to form chloramine compounds. The ammonia may be naturally occurring or may be added to the water usually after the chlorine injection point. Chloramines are a weaker disinfectant than free chlorine and typically are used to maintain a total chlorine residual in the distribution system. Chloramine formation is dependent on temperature, pH, mixing, organics, and chlorine:ammonia-nitrogen weight ratio. The relative mixture of chloramine species is dependent upon the chlorine:ammonia-nitrogen ratio. The chlorine:ammonia-nitrogen ratio should be maintained between 4.5:1 and 5:1 to reduce the concentration of free ammonia and the reduce the prevalence of dichloramine and trichloramine.

4.4.10.1 Chlorination equipment

a. The chlorination equipment must meet Item 4.4.1 requirements.

4.4.10.2 Chlorine:ammonia-nitrogen ratio

a. The BDR must identify and justify the design chlorine:ammonia-nitrogen ratio.
b. The BDR must identify the process control measures and instrumentation used to monitor and control the chlorine:ammonia-nitrogen ratio.

4.4.10.3 Feed system design

a. Chemical feed systems must meet the requirements of Part 5. Specific chemical requirements for ammonium sulfate, aqua ammonia, and anhydrous ammonia are in Section 5.4.
b. Ammonia and ammonia compounds must be stored in a separate room from any chlorine product because of potential explosive or violent reactions that could occur.
c. The feed system design must provide the following:
    i. Efficient chlorine and ammonia mixing in the bulk flow
    ii. Bulk flow reaction volume sufficient to allow chlorine:ammonia reactions to proceed
    iii. A process control sample tap located downstream of the bulk flow reaction volume.

4.4.10.4 Feed System Capacity

a. The chemical feed system must be capable of maintaining a total chlorine residual of at least 2.0 mg/L in the water once all demands are met after an effective contact time corresponding to the required amount of disinfection for a given treatment technique. This capacity must correspond to maximum flow rate coinciding with anticipated maximum chlorine/chloramine demand. The equipment must be of such design that it will operate accurately over the design dose application.

4.4.10.5 Chloramine booster system

a. Booster chlorination of chloraminated water in the distribution system can be used to reform monochloramine from the ammonia released during the decay process. Booster chloramination (adding chlorine and ammonia) may be necessary in certain situations. These treatment systems must meet all requirements in this item (Item 4.4.10).

4.4.10.6 Process Control Monitoring

a. See Item 2.9(e) for required testing equipment.

b. A monitoring and operations plan must be established for each entry point, booster chlorination station and throughout the distribution system to verify proper chloramine formation and for determination of nitrification.

4.4.10.7 Nitrification

a. Free ammonia concentration should be kept below 0.1 mg/L.

b. A nitrification control plan that includes flushing and the temporary use of a free chlorine residual should be prepared along with the triggering criteria for implementation.

4.4.10.8 Corrosion control

a. Switching from free chlorine to chloramines may increase lead solubility in water. Therefore, the submittal must evaluate the increased corrosion risk and include a corrosion control strategy. See Table A.2 in Appendix A.

b. The type of chlorine and ammonia chemicals used can affect the finished water pH and the chloride to sulfate mass ratio (CSMR). An evaluation of the corrosion control strategy is required prior to changing chemicals.

4.4.10.9 Public Water Supplier Interconnections

Connecting a water distribution system with free chlorine and a water distribution system with chloramines without proper treatment (e.g., breakpoint chlorination or chloramine formation) may result in water quality issues (e.g., taste and odor, corrosivity, disinfection byproduct, microbial growth.

a. When an interconnect is present between a free chlorine and chloramine distribution system, and the connection is designed for routine use, a booster/breakpoint chlorination or a chloramination treatment process must be provided.

b. Connecting water distribution systems that contain free chlorine and chloramines should be avoided without proper treatment except in an emergency.

<u>4.4.11 Other Disinfecting Agents</u>

See Section 4.14 for Advanced Oxidation Processes. Other disinfecting agents are considered alternative technology. Refer to Section 1.11.

<u>4.5 SOFTENING</u>

The softening process selected must be based upon the mineral qualities of the raw water and the desired finished water quality in conjunction with requirements for disposal of sludge or brine waste. Applicability of the process chosen must be demonstrated.

4.5.1 Chemical Softening Process (Lime, Lime-Soda, or Caustic Soda)

Design standards for rapid mix, flocculation and sedimentation are in Section 4.2. Consideration must be given to the following process elements and be addressed in the BDR.

4.5.1.1 When split treatment is used an accurate means of measuring and splitting the flow must be provided.

4.5.1.2 Not Used.

4.5.1.3 Chemical feed point must be fed directly into the rapid mix process.

4.5.1.4 Rapid mix detention times must be less than 30 seconds with adequate velocity gradients to keep the lime particles dispersed.

4.5.1.5 Equipment for stabilization of chemically softened water is required (see Section 4.9).

4.5.1.6 Sludge collection.

i. Mechanical sludge removal equipment must be provided in the sedimentation basin.

ii. When sludge recycle is used, sludge must be recycled to the point of rapid mix.

4.5.1.7 Residuals handling provisions must be included for proper handling and disposal of softening residuals (see Chapter 9).

4.5.1.8 The use of excess lime must not be considered an acceptable substitute for disinfection (see Section 4.4).

4.5.1.9 Plant start-up processes must be manually started following shut-down. After plant shut-down, evacuate basins, process piping, and chemical feed lines to prevent hardening.

a. Above items must be demonstrated in the Preliminary Plan of Operation (see Item 1.2.9).

4.5.2 Cation Exchange Process

Cation exchange may be used for water softening. Regenerative media must follow Section 4.6 and adsorptive media must follow Section 4.10.

4.6 REGENERATIVE MEDIA TREATMENT

This section applies to anion exchange, cation exchange, and other treatment processes where a solution or brine is used to routinely regenerate the media during the treatment process. When the media is used but not regenerated routinely onsite, then Section 4.10 (Adsorptive media) must be followed.

4.6.1 Pre-Treatment Requirements

Pre-treatment is required when the content of iron, manganese, or a combination of the two, is greater than or equal to 0.5 mg/L (see Items 4.8.1 or 4.8.3). Waters having turbidites of 5 NTU or more must not be applied directly to the media vessel. Inlet feed water quality must meet the standards as recommended by the selected media manufacturer.

4.6.2 Design

Regenerative media units are typically of the pressure type, down flow design. Automatic regeneration based on volume of water treated and water quality triggers (e.g., TDS, hardness or other parameters indicating breakthrough) must be used. A manual override must be provided on all automatic controls.

4.6.3 Design Capacity

The design capacity must conform to media manufacturer's specifications or other justification (e.g., pilot plant). Design must include an evaluation of competing ions given the raw water quality. The submittal must include:

a. The maximum operating capacity.
b. Empty bed contact time (EBCT).
c. Hydraulic loading rate.
d. Acceptable pressure drop.
e. pH control (if needed).
f. Regenerant type and consumption rate.
g. Design of service cycle and method for protection from chromatographic peaking during operation.

4.6.4 Redundancy and design flow rate

a. Redundancy: When treatment is required for Regulation 11 compliance, at least two units must be provided. For designs that include only two units, each unit must be capable of meeting the plant design flowrate at a level below the contaminant of concern's MCL. For designs with more than two units, the unit must be capable of meeting plant design flowrate with the largest unit removed from service.
b. Unit design flow rate: The unit design flow rate will be the approved loading rate with the largest unit out of service.

4.6.5 Type of Media

Media selection must be justified by manufacturer's specifications. Design must include certification that the proposed media is appropriate for treating applied water to the established water quality goals.

When the purpose of the media process is to comply with Regulation 11 (e.g., nitrate MCL), then the media must be of the specific MCL selective type or information must be provided to demonstrate effective contaminate removal. Pilot or column studies may be required.

4.6.6 Flow Rates

The rate must not exceed seven gpm/ft^2 (7 gpm/ft^2) of bed area and the backwash rate must be six to eight gpm/ft^2 (6 - 8 gpm/ft^2) of bed area.

Rate-of-flow controllers or the equivalent must be installed on the vessel influent or effluent, backwash/regeneration, and rinse water lines.

4.6.7 Freeboard

The freeboard will depend on the size and specific gravity of the media and the direction of the water flow. An appropriate amount of freeboard must be provided and justified. Adequate freeboard must be provided to accommodate the backwash flow rate of the unit. Generally, the washwater collector should be 24 inches above the top of the resin on downflow units.

4.6.8 Underdrains and Media Support

The design must include an adequate underdrain and supporting gravel system and brine distribution equipment. The bottoms, strainer systems and support for the media must conform to criteria provided for rapid rate gravity filters (see Items 4.3.1.6 and 4.3.1.7).

4.6.9 Bypass

If a portion of the water is bypassed around the units and blended with treated water, the maximum blend ratio allowable must be determined based on the highest anticipated raw water contaminant (e.g., nitrate) concentration level. If bypassing is provided, the design must also comply with Section 1.11 (blending for compliance with a MCL).

4.6.10 Cross Connection Control

Any regeneration/backwash, filter-to-waste, bed removal and replacement piping, rinse and air relief discharge pipes must be installed in such a manner as to prevent any possibility of back-siphonage per Section 11.39 of Regulation 11 (i.e., Backflow Prevention and Cross-connection Control Rule).

4.6.11 Sample Taps

When the purpose of the media is to comply with Regulation 11, sample taps must be provided for water quality monitoring. Sample taps must be located to provide for sampling of the influent, effluent and, if used, blended water. The sampling taps for the blended water must be at least 20 feet downstream from the point of blending.

4.6.12 Brine and Salt Storage Tanks

a. Salt dissolving or brine tanks and wet salt storage tanks must be covered and must be corrosion-resistant.

b. The make-up water inlet must be protected from back-siphonage by a backflow prevention method.

c. Tanks must be equipped with manholes or hatchways for access and for filling. Openings must be provided with raised curbs and watertight covers having overlapping edges similar to those required for finished water storage tanks. Each cover must be hinged on one side, and must have a locking device.

d. Overflows, where provided, must be protected with corrosion resistant screens and must terminate with either a turned downed bend having a proper free fall discharge or a self-closing flap valve.

e. The salt must be supported on graduated layers of gravel placed over a brine collection system.

f. Large brine tanks (greater than 50 gal) must be equipped with a screened drain to prevent discharge of the support gravel.

4.6.13 Brine Pump or Eductor

An eductor may be used to transfer brine from the brine tank to the media vessels. If a pump is used, a brine measuring tank or means of metering must be provided to obtain proper dilution.

4.6.14 Construction Materials

Pipes and contact materials must be resistant to the aggressiveness of salt. Plastic and red brass are acceptable materials. Steel and concrete must be coated with a non-leaching protective coating which is compatible with salt and brine.

4.6.15 Housing

Bagged salt and dry bulk salt storage must be enclosed and separated from other operating areas in order to prevent damage to equipment.

4.6.16 Preconditioning of the Media

Prior to startup of the equipment, the media must be preconditioned in accordance with manufacturer's specifications.

4.6.17 Waste Disposal

Suitable disposal must be provided for spent media and any produced treatment wastewater (see Chapter 9) including any filter-to-waste, rinse wastewater, or brine waste. Suitable disposal must be provided for brine waste (see Chapter 9).

4.6.18 Water Quality Test Equipment

If the purpose of the media is to comply with Regulation 11, then provisions must be provided for water quality monitoring

If the purpose of the treatment process is to comply with the nitrate MCL, the design must include equipment to monitor nitrate at least once per day that the water is served to the public from the treatment process.

4.7 AERATION

4.7.1 Natural Draft Aeration

Design must provide:

a. Perforations in the distribution pan 3/16 to ½ inches in diameter, spaced 1 to 3 inches on centers to maintain a six inch (6 inch) water depth.
b. For distribution of water uniformly over the top tray.
c. Discharge through a series of three or more trays with separation of trays not less than 12 inches.
d. Loading at a rate of 1 to 5 gpm/ft^2 of total tray area.
e. Trays with slotted, heavy wire (½ inch openings) mesh or perforated bottoms.
f. Construction of durable material resistant to aggressiveness of the water and dissolved gasses.
g. Protection from loss of spray water by wind carriage by enclosure with louvers sloped to the inside at an angle of approximately 45 degrees.

h. Protection from insects by a screen and cover (e.g., louver or shroud). Screens may not have openings that exceed 0.07 inches (typically 12 or 16 mesh screen).

i. Provisions for continuous disinfection feed must be provided after aeration.

4.7.2 Forced or Induced Draft Aeration

Devices must be designed to:

a. Include a blower with a weatherproof motor in a tight housing and screened enclosure.

b. Ensure adequate counter current of air through the enclosed aerator column.

c. Exhaust air to the outside atmosphere.

d. Include a down-turned air outlet and inlet with a screen and cover (e.g., louver or shroud). Screens may not have openings that exceed 0.07 inches (typically 12 or 16 mesh screen)

e. Introduce air free from obnoxious fumes, dust, and dirt.

f. Allow easy access to the aerator for maintenance and inspection of the interior.

g. Provide loading at a rate of 1 to 5 gpm/ft^2 of total tray area.

h. Ensure that the water outlet is adequately sealed to prevent unwarranted loss of air.

i. Discharge through a series of five or more trays with separation of trays not less than six inches or as approved by the Department.

j. Provide distribution of water uniformly over the top tray.

k. Be of durable material resistant to the aggressiveness of the water and dissolved gasses.

l. Provide for continuous disinfection feed after aeration.

4.7.3 Spray Aeration

Refer to Section 4.12 for spray aeration requirements in potable water storage tanks.

Design must provide:

a. A hydraulic head of between 5 - 25 feet.

b. Nozzles, with the size, number, and spacing of the nozzles being dependent on the flowrate, space, and the amount of head available.

c. Nozzle diameters in the range of 1 to 1.5 inches to minimize clogging.

d. An enclosed basin to contain the spray. Any openings for ventilation, etc. must be protected with a screen and cover (e.g., louver or shroud). Screens may not have openings that exceed 0.07 inches (typically 12 or 16 mesh screen)

e. For continuous disinfection feed after aeration.

4.7.4 Pressure Aeration

Pressure aeration may be used for oxidation purposes only. This process is not acceptable for removal of dissolved gasses. Filters following pressure aeration must have adequate exhaust devices for release of air. Pressure aeration devices must be designed to:

a. Give thorough mixing of compressed air with water being treated.

b. Provide screened and filtered air, free of obnoxious fumes, dust, dirt and other contaminants.

4.7.5 Packed Tower Aeration (PTA)

Generally, PTA is feasible for compounds with a Henry's Constant greater than 100 atm mol/mol at 120C, but not normally feasible for removing compounds with a Henry's Constant less than 10. For values between 10 and 100, PTA may be feasible but should be evaluated using pilot studies. Values for Henry's Constant must be evaluated in the BDR considering effects of temperature within the anticipated temperature range during treatment.

4.7.5.1 Process Design

a. The applicant must provide justification for the design parameters selected (e.g., height and diameter of unit, air to water ratio, packing depth, surface loading rate).

b. The ratio of the packing height to column diameter must be at least 7:1 for the pilot unit and at least 10:1 for the full scale tower. The type and size of the packing used in the full scale unit must be the same as that used in the pilot work.

c. The minimum volumetric air to water ratio at peak water flow must be 25:1 and the maximum should be 80:1.

d. Disinfection capability must be provided prior to and after PTA.

4.7.5.2 Materials of Construction

a. The tower must be constructed of stainless steel, concrete, aluminum, fiberglass or plastic. Uncoated carbon steel is not recommended because of corrosion. Towers constructed of light-weight materials should be provided with adequate support to prevent damage from wind.

b. Packing materials must be resistant to the aggressiveness of the water, dissolved gasses and cleaning materials and must be suitable for contact with potable water.

4.7.5.3 Water Flow System

a. Water must be distributed uniformly at the top of the tower using spray nozzles or orifice-type distributor trays that prevent short circuiting.

b. A mist eliminator must be provided above the water distributor system.

c. A side wiper redistribution ring must be provided at least every 10 feet in order to prevent water channeling along the tower wall and short circuiting.

d. Sample taps must be provided in the influent and effluent piping.

e. The effluent sump, if provided, must have easy access for cleaning purposes and be equipped with a drain valve. The drain must not be connected directly to any storm or sanitary sewer.

f. A blow-off line must be provided in the effluent piping to allow for discharge of water/chemicals used to clean the tower.

g. The design must prevent freezing of the influent riser and effluent piping when the unit is not operating. If piping is buried, it must be maintained under positive pressure.

h. The water flow to each tower must be metered.

i. An overflow line must be provided which discharges 12 to 14 inches above a splash pad or drainage inlet. Proper drainage must be provided to prevent flooding of the area.

j. Means must be provided to prevent flooding of the air blower.

4.7.5.4 Air Flow System

a. The air intake and the outlet vent must be downturned and protected with a screen and cover (e.g., louver or shroud) to prevent contamination from extraneous matter. Screens may not have openings that exceed 0.07 inches (typically 12 or 16 mesh screen).

b. An air flow meter must be provided on the influent air line or an alternative method to determine the air flow must be provided.

c. A positive air flow sensing device and a pressure gauge must be installed on the air influent line. The positive air flow sensing device must be a part of an automatic control system which will turn off the influent water if positive air flow is not detected. The pressure gauge will serve as an indicator of fouling buildup.

d. A backup motor for the air blower must be readily available.

4.7.5.5 Other Features That Must Be Provided

a. A sufficient number of access ports with a minimum diameter of 24 inches to facilitate inspection, media replacement, media cleaning and maintenance of the interior.

b. A method of cleaning the packing material when fouling may occur.

c. Tower effluent collection and pumping wells constructed to standards of Chapter 7 of these criteria.

d. An acceptable alternative supply must be available during periods of maintenance and operation interruptions. No bypass must be provided unless specifically approved by the Department.

e. Disinfection application points both ahead of and after the tower to control biological growth.

f. Adequate packing support to allow free flow of water and to prevent deformation with deep packing heights.

g. Adequate foundation to support the tower and lateral support to prevent overturning due to wind loading.

h. An access ladder with safety cage for inspection of the aerator including the exhaust port and de-mister.

i. Electrical interconnection between blower, disinfectant feeder and well pump.

4.7.6 Other Methods of Aeration

Other methods of aeration may be used if applicable to the treatment needs. Such methods include but are not restricted to spraying, diffused air, cascades and mechanical aeration. The treatment processes must be designed to meet the particular needs of the water to be treated and are subject to the approval of the Department.

4.7.7 Protection of Aerators

All aerators except those discharging to lime softening or clarification plants must be protected from contamination by birds, insects, wind borne debris, rainfall and water draining off the exterior of the aerator.

4.8 IRON AND MANGANESE CONTROL

Control of dissolved iron and dissolved manganese, as used herein, refers solely to treatment processes designed specifically for the purpose of either oxidizing and subsequently removing the constituents or sequestering the constituents to remain in the dissolved state. The selection of one or more treatment processes must meet specific local conditions as determined by engineering investigations, including chemical analyses of representative samples of water to be treated, and receive the approval of the Department. Water quality data must be collected in accordance with Item 1.2.3 in order to justify the treatment process selected.

4.8.1 Removal by Oxidation, Detention and Filtration

4.8.1.1 Protecting groundwater from contamination during treatment

For groundwater installations the design must protect the water throughout the treatment process from outside contamination. Groundwater treatment basins are considered protected water storage in Chapter 7. The water during the oxidation, detention, and filtration processes must not be uncovered and must be protected from external contamination.

4.8.1.2 Detention

a. A minimum detention time of 30 minutes must be provided following aeration to ensure that the oxidation reactions are as complete as possible. The reaction tank/detention basin must be designed to prevent short circuiting.

b. Provisions for sedimentation and sludge removal must be made when solids production may adversely impact downstream processes. Sedimentation basins must conform to Item 4.2.4.

4.8.1.3 Filtration

Filters must be provided and must conform to Section 4.3.

4.8.2 Removal by the Lime-Soda Softening Process

See Item 4.5.1.

4.8.3 Removal by Manganese Coated Media Filtration

This process consists of a continuous or batch feed of an oxidant to the influent of a manganese coated media filter.

a. The design must consider the reaction kinetics given the oxidant used, water temperature, residence time in the filter, and raw water characteristics.

b. Filters must conform to Section 4.3.

4.8.4 Removal by Ion Exchange

Pre-treatment is required when the content of iron, manganese, or a combination of the two, is greater than or equal to 1.0 mg/L. See Section 4.6 or Section 4.10.

4.8.5 Biological Removal

Biofiltration to remove manganese and/or iron requires on-site piloting to establish effectiveness. The final filter design must be based on the on-site pilot plant studies and must comply with all applicable portions of Item 4.3.7.

4.8.6 Sequestration by Polyphosphates

This process must not be used when iron, manganese or combination thereof exceeds 1.0 mg/L. The total phosphate applied must not exceed 10 mg/L as PO_4 and must not exceed the ASNI/NSF 60 specified maximum dose. Possible adverse effects on corrosion must be addressed when phosphate addition is proposed for iron sequestering – water quality measurements and associated calculations must be provided. Appendix K can be used as a reference for required information, even if optimal corrosion control treatment (OCCT) under Section 11.26 of Regulation 11 is not being installed.

a. Feed equipment must conform to the requirements of Chapter 5.

b. Polyphosphates must not be applied ahead of iron and manganese removal treatment. The point of application must be prior to any aeration, oxidation or disinfection if no iron or manganese removal treatment is provided.

c. Polyphosphates must not be used in public water systems with lead service lines.

4.8.7 Sequestration by Sodium Silicates

Sodium silicate sequestration of iron is appropriate only for groundwater supplies prior to air contact. On-site pilot tests are required to determine the suitability of sodium silicate for the particular water and the minimum feed needed. Rapid oxidation of the metal ions such as by chlorine or chlorine dioxide must accompany or closely precede the sodium silicate addition.

a. Sodium silicate addition must not be used on waters containing greater than 2 mg/L of iron, manganese or combination thereof.

b. The amount of silicate added must be limited to 20 mg/L as SiO_2 and must not exceed the ASNI/NSF 60 specified maximum dose. The amount of added and naturally occurring silicate must not exceed 60 mg/L as SiO_2.

c. Feed equipment must conform to the requirements of Chapter 5.

d. Sodium silicate must not be applied ahead of iron or manganese removal treatment.

4.9 STABILIZATION AND CORROSION CONTROL TREATMENT

Water that is unstable due either to natural causes or to subsequent treatment must be stabilized. In this section, "stabilization" refers to the prevention of corrosion in drinking water systems by modifying the water chemistry to make it less corrosive and to encourage formation of passivating films on the contacting surface. This is typically accomplished through pH and/or alkalinity adjustment or through the addition of a corrosion inhibitor. Most corrosion control treatment techniques will also be beneficial for reducing corrosion of lead, copper, iron, steel and galvanized pipe.

If the treatment processes are installed as "optimal corrosion control treatment" under Section 11.26 of Regulation 11 (i.e., Lead and Copper Rule) then all design criteria in Section 4.9 must be met. When treatment processes are installed for stabilization, durability of the distribution system or water quality aesthetics (i.e., not for compliance with Section 11.26 of Regulation 11), then the design does not have to conform to the requirements of Section 4.9 since the treatment is not specifically for compliance.

Corrosion control impacts of projects and subsequent requirements are outlined in Item 1.2.10 and must accompany all designs related to the following technologies.

4.9.1 Carbon Dioxide Addition for pH adjustment

Carbon dioxide addition may be applicable for corrosion control to lower the pH without impacting alkalinity.

a. Recarbonation basins must have:
   i. A theoretical detention time of twenty minutes (20 minutes).
   ii. Two compartments, with a depth that will provide a diffuser submergence of not less than 7.5 feet nor greater than recommended by the manufacturer. The two compartments must be:
      1. A mixing compartment with a minimum detention time of three minutes (3 minutes).
      2. A reaction compartment.

b. Where liquid carbon dioxide is used, adequate precautions must be taken to prevent carbon dioxide from entering the plant from the recarbonation process.

c. Recarbonation tanks must be located outside or if located inside, the tanks must be sealed and vented to the outside.

d. The design of the recarbonation basin must allow for draining the basin and removing sludge.

4.9.2 Acid Addition

Feed equipment must conform to Chapter 5.

4.9.3 Phosphates

The feeding of orthophosphates and blended phosphates may be applicable for corrosion control or stabilization. Polyphosphates are not a corrosion inhibitor and must not be used for corrosion control. If a phosphate inhibitor is the designated optimal corrosion control treatment (OCCT) under Section 11.26 of Regulation 11 then the design must meet all Item 4.9.3 criteria.

Phosphates may also be used for sequestering iron and manganese - See Section 4.8.

a. Orthophosphate and blend phosphates

Orthophosphate acts as a corrosion inhibitor by forming a protective film on the interior of pipes. This film protects the pipe material from the corrosive effects of water, which reduces or eliminates the potential for lead and copper leaching into the water. Phosphates containing zinc will help protect cement and cement mortar-lined pipes at low alkalinity/hardness/pH conditions.

Blended phosphates contain some proportion of orthophosphate and polyphosphate. The orthophosphate portion is beneficial for corrosion control while the polyphosphate sequesters hardness, iron, or manganese. It is possible that blended phosphates can provide both sequestration of metals and reduce metals release. The orthophosphate to polyphosphate ratio is very important and should be optimized to assure sufficient orthophosphate residual to control the lead or copper release.

b. Phosphate selection justification

If a phosphate inhibitor is the designated optimal corrosion control treatment (OCCT) under Section 11.26 of Regulation 11 then the submittal must include a justification for the selected phosphate chemical. If blended phosphates are used as OCCT then the submittal must include documentation from the chemical supplier indicating: the percentage of orthophosphate, percentage of polyphosphate, and the basis of the blend selection.

c. Phosphate systems design:

i. Chemical feed equipment must conform to Chapter 5.

ii. Chemical feed system must be capable of maintaining an orthophosphate residual of at least 1.0 mg/L as P (3.0 mg/L as PO4) throughout the distribution system.

iii. Should be designed to operate within the optimum pH range and alkalinity concentration.

iv. Stock phosphate solution must be kept covered and disinfected by carrying approximately 10 mg/L free chlorine residual unless the phosphate is not able to support bacterial growth and the phosphate is being fed from the covered shipping container.

v. Must have testing equipment that meets Section 2.9 including an orthophosphate residual meter.

The preliminary plan of operation (required in Item 1.2.9) must include a start-up plan addressing the planned initial passivation dose and duration (if used) and the long-term maintenance dose.

4.9.4 "Split Treatment"

Under some conditions, a lime-softening water treatment plant can be designed using "split treatment" in which raw water is blended with lime-softened water to partially stabilize the water prior to secondary clarification and filtration.

4.9.5 pH/alkalinity treatment

pH/alkalinity adjustment includes adding a base or similar chemical to the water to increase pH to a level where the practical lead or copper solubility lowers, adequate buffer intensity exists, acids are neutralized, and less soluble metal compounds are formed on the pipes. Treatment must be designed to produce and maintain water of the optimum pH range and alkalinity concentration within the distribution system.

If a pH/alkalinity adjustment is the designated optimal corrosion control treatment (OCCT) under Section 11.26 of Regulation 11 then the design must meet all Item 4.9.3 criteria. Chemical feed equipment must conform to Chapter 5.

a. Chemicals

i. Caustic soda

Caustic soda (sodium or potassium hydroxide) will increase the pH with minimal effect on alkalinity and no impact on dissolved inorganic carbon (DIC). It can be difficult to stabilize pH in low-alkalinity water through caustic soda addition.

ii. Soda ash

Soda ash (sodium or potassium carbonate) will increase the alkalinity, DIC, and moderately increase the pH. Soda ash is relatively safe to handle compared to caustic soda.

iii. Lime

Lime (calcium hydroxide) will increase the pH, alkalinity, and hardness with no impact on DIC. A stable pH is very difficult to achieve when using lime on water having low alkalinity. Some types of lime can cause an increase in turbidity.

iv. Sodium bicarbonate

Sodium bicarbonate substantially increases the alkalinity and DIC, while minimally increasing the pH. It will not increase the pH above 8.3.

v. Calcite contactor. See Item 4.9.10.

b. Simultaneous compliance

Alkalinity and pH can have secondary impacts that limit the use of caustic soda, soda ash, lime and sodium bicarbonate. The following secondary impacts must be evaluated:

i. Optimal pH for all other processes, particularly disinfection. The submittal must include a disinfection log inactivation calculation when pH/alkalinity adjustment is used at surface water and ground water under the direct influence of surface water plants.

ii. Calcium carbonate precipitation pH. At a minimum, a saturation pH must be estimated.

iii. Oxidation of iron and manganese. At a minimum, the BDR must address if oxidation impacts are expected.

iv. Disinfection byproducts (DBP) formation (trihalomethanes). At a minimum, the BDR must address if DBP impacts are expected.

c. Alkalinity/pH Adjustment system design:

i. Chemical feed equipment must conform to Chapter 5.

ii. Chemical feed systems must be capable of providing a stable pH. A stable pH is considered 0.4 s.u. range at the entry point. A trim loop (i.e., feedback loop) may be required to maintain a 0.4 s.u. range.

iii. Must have testing equipment that meets Section 2.9 including a field pH and alkalinity meter.

iv. Design must produce treated water with an alkalinity of at least 20 mg/L as $CaCO3$.

4.9.6 Carbon Dioxide Reduction by Aeration

The carbon dioxide content of aggressive water may be reduced by aeration. Aeration devices must conform to Section 4.7.

4.9.7 Other Treatment

Other treatment for controlling corrosive waters by the use of calcium hydroxide, sodium hydroxide, sodium silicate and sodium bicarbonate may be used where necessary. Any proprietary compound must receive the specific approval of the Department before use and be ANSI/NSF 60 certified. Chemical feeders must be as required in Chapter 5.

4.9.8 Chloride to sulfate mass ratio (CSMR)

Using or changing to chloride-base coagulant, utilizing anion exchange treatment, and runoff from road salt can increase the lead solubility. The CSMR is calculated by the entry point chloride concentration divided by the entry point sulfate results. The CSMR value of the water can be an indicator of potential lead release. CSMR needs to be addressed if the CSMR is being increased.

4.9.9 Not Used

4.9.10 Calcite Contactors

4.9.10.1 Feed Water Quality

a. Calcite contactor influent (i.e., feed water) must contain: calcium <20 mg/L as Ca, alkalinity <60 mg/L as $CaCO_3$, DIC <10 mg/L as C, Fe <0.2 mg/L, Mn <0.05 mg/L, and pH <7. Water quality adjustment prior to the calcite contactor is allowable to meet these water quality parameters. Feed waters with natural organic matter >2 mg/L TOC must be pilot or bench tested to ensure that organic deposits will not interfere with the dissolution of calcite media over time.

b. When the calcite contactor is a package system provided by a manufacturer, the feed water quality must meet the minimum water quality standards recommended by the manufacturer.

4.9.10.2 Design

a. The units may be of pressure or gravity type; either an upflow or downflow design.

b. Downflow contactors must include provisions for automatic backwashing. Automatic backwashing based on volume of water treated must be used. A manual override must be provided on all automatic controls.

c. The design empty bed contact time (EBCT) must be determined based on the specific feed water chemistry, operating temperature, and finished water goals with a minimum of 5 minutes provided for all contactors.

d. If a portion of the water is bypassed around the units and blended with treated water, the maximum blend ratio allowable must be determined based on the range of anticipated feed water quality based either on 4 quarters of water quality data (one sample per calendar quarter per Item 1.2.3), or water quality modeling.

e. Design must include a certification that the proposed calcite is appropriate for treating applied water to the established water quality goals.

4.9.10.3 Redundancy and design flow rate

a. Redundancy: When treatment is required for Regulation 11 compliance, at least two units must be provided. For designs that include only two units, each unit must be capable of meeting the plant design flowrate at a level below the contaminant of concern's MCL. For designs with more than two units, the unit must be capable of meeting plant design flowrate with the largest unit removed from service.

b. Unit design flow rate: The unit design flow rate will be the approved loading rate with the largest unit out of service.

4.9.10.4 Calcite Media

a. Calcite composition must be the following:

   i. $CaCO_3$: 95% minimum.

   ii. MgCO3: 3.0% maximum.

   iii. Fe 0.05% maximum.

   iv. Acid solubility <2.0%.

b. Characteristics

   i. Specific gravity of 2.7.

   ii. Size distribution 0.1% greater than 1.1 mm and 10% smaller than 0.4 mm.

   iii. Moisture < 0.2%.

   iv. Uniformity coefficient between 1.5 and 2.5.

   v. Less than 2% fines (<200 mesh).

4.9.10.5 Calcite Depth

a. The minimum calcite depth must be 24-inches.

b. For calcite contactors treating greater than 1 MGD, the design must include a system to pre-wash calcite particles to remove fines. To maintain a consistent depth of calcite in the contactor the design must include either a continuous calcite feed system or a means to measure usage and maintain calcite depth.

4.9.10.6 Flow Rates

The loading rate must not exceed 10 gpm/ft^2 of bed area. For downward flow contactors, a typical backwash rate is between 8 – 12 gpm/ft^2 and must not exceed 20 gpm/ft^2 of bed area. For upflow contactors, a pre-rinse rate must not be less than 10 gpm/ft2. Rate-of-flow controllers or the equivalent must be installed for the above purposes.

4.9.10.7 Freeboard

An appropriate amount of freeboard must be provided and justified and will depend upon the direction of water flow and media characteristics. In downflow contactors, freeboard must accommodate a minimum 35% bed expansion.

4.9.10.8 Miscellaneous Appurtenances

a. The system must be designed to include an adequate under drain (downflow) and supporting gravel system. The bottoms, strainer systems and support for the calcite media must conform to criteria provided for rapid rate gravity filters (see Items 4.3.1.6 and 4.3.1.7).

b. For upflow contactors, each contactor must include an internal top screen to prevent calcite from blowing out of the contactor.

c. When a bypass is installed, totalizing meters must be installed on the bypass line and on either the contactor feed or return line. The bypass line must have a shutoff valve and should have an automatic proportioning or regulating device.

4.9.10.9 Cross Connection Control

Backwash, rinse and air relief discharge pipes must be installed in such a manner as to prevent any possibility of back-siphonage per Section 11.39 of Regulation 11: (i.e., Backflow Prevention and Cross-connection Control Rule).

4.9.10.10 Calcite Storage

Bagged calcite and dry calcite storage must be enclosed to limit adsorption of moisture.

4.9.10.11 Backwash Waste Recycle/Disposal

a. Depending on location within the treatment process, backwash recycle/disposal must be specified in the BDR.

b. Suitable disposal must be provided for waste backwash water (See Chapter 9).

4.10 ADSORPTIVE MEDIA

This section applies to activated alumina, sacrificial ion exchange media, granular activated carbon, and other treatment processes where the media is used to adsorb contaminants and then the media is disposed of or regenerated off site rather than regenerated in-situ. When the media is regenerated routinely onsite then Section 4.6 Regenerative Media treatment must be followed.

4.10.1 Pre-Treatment Requirements

Pre-treatment is required when the water entering the adsorptive media treatment process has a content of iron, manganese, or a combination of the two, is greater than or equal to 0.5 mg/L (see Items 4.8.1 or 4.8.3). Waters having turbidites of 5 NTU or more must not be applied directly to the media vessel. Inlet feed water must meet the minimum water quality standards as recommended by a specific media manufacturer.

4.10.2 Design

Adsorptive media units are typically of the pressure type, down flow design.

4.10.3 Design Capacity

The design capacity must conform to the media manufacturer's specifications or other justification (e.g., pilot plant, column test). Design must include certification that the proposed media is appropriate for treating applied water to the established water quality goals. Design must include an evaluation of competing constituents given the influent water quality. This design submittal must include:

a. The maximum operating capacity.

b. Minimum empty bed contact time (EBCT).

    i. When used to comply with the Direct Potable Reuse Rule - minimum 15 minutes total empty bed contact time (EBCT) with one contactor out of service.

c. Hydraulic loading rate.

d. Acceptable pressure drop.

e. pH control (if needed).

f. Break-through curve.

g. Estimated time of media replacement.

h. If treatment is used seasonally then shut down and start up procedures and any necessary design provisions (e.g., chemical addition for bed fluidization) must be provided.

i. When used to comply with the Direct Potable Reuse Rule – a written plan must be included to explain how capacity will be maintained (EBCT) while media replacement occurs (e.g. plant capacity will be lowered, additional filters will be installed for redundancy, etc).

4.10.4 Redundancy and design flow rate

a. Redundancy: When treatment is required for Regulation 11 compliance, at least two units must be provided. For designs that include only two units, each unit must be capable of meeting the plant design flowrate at a level below the contaminant of concern's MCL. For designs with more than two units, the unit must be capable of meeting plant design flowrate with the largest unit removed from service.

b. Unit design flow rate: The unit design flow rate will be the approved loading rate with the largest unit out of service.

4.10.5 Type of Media

Media selection must be justified by manufacturer's specifications. Design must include certification that the proposed media is appropriate for treating applied water to the established water quality goals.

When the purpose of the media is to comply with Regulation 11 (e.g., nitrate MCL), then the media must be of the specific MCL selective type or information must be provided to demonstrate effective contaminate removal. Pilot or column studies may be required.

Granular activated carbon must meet the latest version of AWWA B604, *Standard for Granular Activated Carbon* (GAC).

4.10.6 Flow Rates

The rate must not exceed seven gpm/ft^2 (7 gpm/ft^2) of bed area. If backwash is used, then the backwash rate must be 6 to 8 gpm/ft^2 of bed area. Higher backwash rates may be allowed based on media manufacturer recommendations. Rate-of-flow controllers or the equivalent must be installed for the above purposes.

a. When used to comply with the Direct Potable Reuse Rule – the design flow rates must be justified. Considerations must include the following: a detailed discussion of how EBCT will be maintained, how flow will be split across contactors, how flow will be verified/measured, whether filter-to-waste will be used, and how backwash rates will be chosen if applicable.

4.10.7 Freeboard

The freeboard will depend on the size and specific gravity of the media and the direction of the water flow. An appropriate amount of freeboard must be provided and justified. If backwash is used, then adequate freeboard must be provided to accommodate the backwash flow rate of the unit. The freeboard will depend on the media.

4.10.8 Bypass

If a portion of the water is bypassed around the units and blended with treated water, the maximum blend ratio allowable must be determined based on the highest anticipated raw water contaminant (e.g., nitrate) concentration level.If bypassing is provided, the design must also comply with Section 1.11 (blending for compliance with a MCL).

a. When used to comply with the Direct Potable Reuse Rule – bypasses around GAC will not be approved and must not be installed.

4.10.9 Underdrains and Media Support

The design system must be designed to include an adequate under drain and supporting gravel system and backwash distribution equipment. The bottoms, strainer systems and support for the media must conform to criteria provided for rapid rate gravity filters (see Items 4.3.1.6 and 4.3.1.7).

The system must be designed to include an adequate under drain and support for the media. If an open bed, he bottoms, strainer systems and support for the media must conform to criteria provided for rapid rate gravity filters (see Items 4.3.1.6 and 4.3.1.7).

4.10.10 Cross Connection Control

Any backwash, filter-to-waste, bed removal and replacement piping, rinse and air relief discharge pipes must be installed in such a manner as to prevent any possibility of back-siphonage per Section 11.39 of Regulation 11 (i.e., Backflow Prevention and Cross-connection Control Rule).

4.10.11 Preconditioning of the Media

The BDR must indicate the media pre-conditionitioning protocol. Prior to startup of the equipment, the media must be preconditioned in accordance with manufacturer's specifications.

4.10.12 Waste Disposal

Suitable disposal must be indicated in the BDR and provided for spent media and any generated wastewater (see Chapter 9) including any filter-to-waste or rinse wastewater.

4.10.13 Water Quality Test Equipment

When the purpose of the media is to comply with Regulation 11, provisions must be provided for water quality monitoring.

If the purpose of the treatment process is to comply with the nitrate MCL, the design must include equipment to monitor nitrate at least once per day that the water is served to the public from the treatment process.

4.10.14 Sample taps

When the purpose of the regenerative media is to comply with Regulation 11, sample taps must be provided for water quality monitoring. Sample taps must be located to provide for sampling of the influent, effluent and, if used, blended water. The sampling taps for the blended water must be at least 20 feet downstream from the point of blending.

4.11 BLENDING FOR COMPLIANCE WITH AN MCL

4.11.1 Water Quality

In addition to the requirements of Item 1.2.3, the BDR must provide sufficient water quality data of the water being used for blending as well as the source water being treated with blending to justify blending calculations given possible seasonal variations. Discussion of the maximum measured level of the contaminant of concern in the source and the blending water must be included.

4.11.2 Flow

a. Design must identify methods of determining accurate flow rates of the blending water, source water, and 'treated' or blended water.

b. Adequate mixing of waters prior to entry point must be provided and justified.

4.11.3 Operational Protocol

a. BDR must summarize the operational protocols used to ensure adequate blending occurs during times of elevated contaminant levels. The protocols must include:

    i. Frequency of water quality sampling and monitors used for process controls.

    ii. Procedures for identifying operational triggers for both the beginning of blending as well as the cessation of blending activities.

    iii. Calibration of flow meters and verification of adequate mixing.

4.12 STORAGE TANK TREATMENT SYSTEMS – MIXING, AERATION, ETC.

Only certain tank mixing systems require approval by the Department. The items below outline minimum requirements for tank mixing/aeration systems and when the Department expects these to be submitted as treatment. If a supplier has had, or is imminently going to have any violation of Section 11.25 of Regulation 11 (i.e., Disinfection Byproducts Rule), then tank mixing or aeration systems that are installed must be approved by the Department. Otherwise, Item 4.12.1 applies but does not require approval from the Department.

4.12.1 Tank Mixing Systems - General

Any mixing or aeration system must not eliminate the detectable chlorine residual within the storage tank. Equipment must meet the requirements of Chapter 2.

4.12.2 Complying with a disinfection byproducts violation with Tank Treatment

The design submittal must demonstrate the following:

a. Conformance with Item 4.12.1 above

b. Historical data and/or modeling calculations supporting that proposed treatment will adequately address DBP violations. If there is limited data to demonstrate compliance with DBPs then the Department may require the installation be a demonstration scale project.

c. In addition, aeration systems must:

    i. Verify with bench scale data or model calculations that chlorine residual will be maintained within the storage tank with aeration system in place

    ii. Operational plan must be developed to ensure operation and verification of the system occurs on a regular basis

4.13 POINT OF USE (POU) AND POINT OF ENTRY (POE) DEVICES

The federal register and the safe drinking water act allow for point of use or point of entry (POU/POE) devices to be used at small systems for compliance with a variety of contaminants. Each appropriate treatment technology is listed by the EPA as Small System Compliance Technologies (SSCT) for specific contaminants. Based upon the federal requirements, POU/POE systems are considered treatment and must receive approval by the Department. Due to the special nature of the POU/POE systems, Appendix J contains a modified BDR and construction application outlining information that must be submitted to and considered by the Department.

The design submittal for POU/POE systems must demonstrate that:

a. The proposed treatment device is listed as a SSCT by the EPA. This list can be found on the EPA website (www.epa.gov). EPA reference material includes:

- *Point-of-Use or Point-of Entry Treatment Options for Small Drinking Water Systems*, EPA 815-R-06-010. April 2006 (Reference 20).
- *Cost Evaluation of Point-Of-Use and Point-of-Entry Treatment Units for Small Systems: Cost Estimating Tool and User Guide*, EPA 815-B-07-001. April 2007 (Reference 21).
- Website "Help for Small Systems in Complying with Drinking Water Regulations". Available at: https://www.epa.gov/dwcapacity/help-small-systems-complying-drinking-water-regulations

b. Appropriate feed water quality data has been gathered to justify the device's use – the water quality parameters will depend on the type of device selected and the manufacturer's limits on raw water quality but typically include alkalinity, hardness, dissolved iron, and dissolved manganese content of the water.

c. Each device proposed has an acceptable third party verification for the targeted contaminant (e.g. reverse osmosis devices must be ANSI/NSF 58).

d. Microbiological safety issues are addressed when activated carbon is employed. An example could be filter change-out at prescribed intervals to avoid re-growth of organisms.

e. Each device will be equipped with a warning device that detects when the treatment has failed (e.g. a conductivity meter on a RO filtration unit).

   i. The device can either initiate a warning light or shut down the unit, but the submittal must specify which action will occur.

   ii. A shut off device measuring the number of gallons treated is not sufficient and will not be approved.

f. When employed by a supplier of water, pilot testing for POU/POE systems (as referenced by the EPA) must be approved by the Department.

   i. For the purposes of POU/POE installations and as referenced by the EPA, pilot testing means installation of devices at a subset of locations (e.g. a few homes) in order to demonstrate the reliability of the treatment to remove the regulated contaminant. The Department will evaluate these pilot installations as demonstration-scale evaluations as discussed in Section 1.7 because they provide potable water to the public.

   ii. Suppliers typically will submit for POU/POE approval with a pilot plan included. The Department will grant conditional approval while the pilot plan is executed, and then the system will prepare a final report for review and final approval of the POU/POE installation by the Department.

   iii. For pilot testing, the system must submit an operational plan to discuss the length of the pilot test, what parameters will be tested during the pilot, and how items a-e above are being met.

4.14 Advanced Oxidation Processes

Direct Potable Reuse (DPR) Rule will require advanced oxidation. Advanced oxidation process (AOP) is defined in Regulation 11 as follows:

> "ADVANCED OXIDATION PROCESS" means a set of chemical treatment processes

whereby oxidation of organic contaminants occurs on a molecular level through reactions with hydroxyl radicals or similarly aggressive radical oxidant species. The process breaks down recalcitrant organic molecules into smaller oxidized organic fragments.

4.14.1 General Design Criteria

The AOP must be designed to achieve the identified contaminant destruction performance under all expected operating conditions. Sizing and dosing requirements for the AOP system must address the following factors in the BDR:

a. Target Chemical - Some organic contaminants are easier to degrade than others (i.e., require a higher concentration of radical species and longer contact time with the radicals), which is similar to chlorine CT or UV dose required for disinfection of different pathogens. In addition, contaminants degrade through different processes that may be associated with the AOP. For example, with a UV-initiated AOP, some contaminants, such as NDMA, may degrade directly from exposure to UV light (direct photolysis) while others, such as 1,4-dioxane, degrade only from exposure to radical species (indirect photolysis or advanced oxidation). Thus, the primary design criteria for a new system should include a list of target contaminants.(1,4 Dioxane or justified alternatives)
    i. Required Degradation - In conjunction with the identified target contaminants, the desired degradation or log reduction of these contaminants should be identified.
b. Radical Scavenging - Hydroxyl and other radicals are non-specific on the molecules with which they react, and some constituents have a high affinity for reactions with these radicals. These radical scavengers include carbonate, bicarbonate, organic carbon, free and combined chlorine species, and other common water constituents. The radical scavenging potential in the background water matrix should be quantified through the piloting process. The expected average and worst-case radical scavenging conditions that will be associated with the installation should be delineated and quantified.
c. pH - The treated water pH range (through the AOP) should be identified to help select the most appropriate AOP process, to quantify background radical scavengers, to assess the potential for disinfection byproducts, and to develop the operating considerations of the AOP.
d. DBP Formation Precursors Potential - Prior to the installation of an AOP, the background water matrix should be reviewed for any precursors that could result in the formation of disinfection byproducts that could impact the water at the ultimate discharge location.

4.14.2 Ozone-based AOP

For Ozone-based AOP, See Item 4.4.7 (operated at specific conditions). The following criteria must also be addressed:

a. Ozone-based AOP includes the application of ozone as part of the DPR treatment process with the intent to create hydroxyl radicals for chemical removal. Ozone-based AOP must have the capability of adding an additional oxidant (e.g., hydrogen peroxide). Note: through site-specific pilot work, sufficient data can justify that an oxidant feed is not necessary with ozone.

b. Ozone-based AOP should be designed and operated to achieve a minimum ozone to TOC ratio of 0.5 (after being corrected for nitrite) at all times.

c. Pilot operations must provide justification for the design dose and proposed operating boundaries with chemical removal data. If hydrogen peroxide is used as the oxidant, refer to Section 5.4 for design criteria.

d. Note: pathogen inactivation cannot be verified when peroxide is applied prior to ozone residual monitoring.

e. Ozone produces disinfection byproducts when applied at doses needed to meet chemical oxidation needs. Piloting must include an analysis of disinfection byproducts including at least NDMA and bromate formation along with a mitigation strategy.

f. Design of the ozone system is consistent with Item 4.4.7 except considerations noted for DPR systems.

4.14.3 Ultraviolet (UV) Light-based AOP

For Ultraviolet light-based AOP (UVAOP), See Item 4.4.9 (operated at specific conditions - typically with H2O2 or UV/Cl feed). The following criteria must also be addressed:

a. UVAOP includes the application of a dose of ultraviolet light exceeding 276 mJ/cm2 in the presence of an oxidant for chemical removal. (note: typical UV doses for AOP far exceed this)

b. An oxidant is required for UVAOP systems. Justification from pilot testing (chemical removal data) is required for the selected oxidant, the design dose, and the proposed operating boundaries. If hydrogen peroxide is used as the oxidant, refer to Section 5.4 for design criteria specific to hydrogen peroxide.

c. UV Transmittance (for UVAOP) - Similar to UV disinfection, the ability for UV light to pass through the water column defines the amount of energy that should be input for a given treatment goal. The UV transmittance range of the site-specific water should be determined.

d. Fouling Potential (for UVAOP) - As with UV disinfection, the fouling of lamp sleeves lessens the amount of source UV energy that passes into the water column. For UV-initiated AOPs, the water matrix constituents that could contribute to sleeve fouling should be evaluated, especially if medium-pressure lamps are considered; these lamps operate at higher temperatures, which can accelerate fouling.

e. Turbidity (for UVAOP) - Particles within the water matrix can reflect/block UV light. Thus, the influent water should have turbidities lower than approximately 1 to 3 Nephelometric Turbidity Unit (NTU) so as not to significantly impact treatment effectiveness.

f. Design of the UVAOP system is consistent with Item 4.4.9 except considerations noted for DPR systems.

4.14.4 Residual Oxidant Quenching

Several advanced oxidation processes result in residual oxidant, such as hydrogen peroxide or ozone, that must be quenched prior to downstream processes. Several options exist for residual oxidant quenching, including chlorine, sodium bisulfite, sodium thiosulfate, sodium sulfite, or granular activated carbon. Either an option must be selected with the design of the AOP or justification must be provided that oxidant quenching won't be required.

a. The design should take into account performance, operations, monitoring, and costs.

4.14.5 Control and Monitoring

Control of an AOP system requires monitoring of chemical and/or the UV dose being delivered, supplemental chemical concentrations and feed rates, and the effective quenching of any chemical residual downstream of the process.

a. Sufficient instrumentation must be identified in the design and then be installed to ensure proper monitoring and control.

b. The performance of the residual quenching system must be monitored and controlled using downstream grab samples or online continuous instrumentation for measurements of the residual concentration (hydrogen peroxide or ozone), ORP, and/or free chlorine residual.

CHAPTER 5
CHEMICAL APPLICATION

5.0 GENERAL

All chemicals used to treat water ultimately meant for human consumption must be approved.

5.0.1 Plans and Specifications

Plans and specifications must be submitted for review and approval, as provided for in Chapter 1, and must include:

a. Descriptions of feed equipment, including maximum and minimum feed ranges (e.g., gallons per hour of chemical fed).

b. Location of feeders, piping layout and points of application.

c. Storage and handling facilities.

d. Operating and control procedures including proposed application rates.

e. Descriptions of monitoring equipment.

f. System design including all tanks (with capacities, drains, overflows, and vents), feeders, transfer pumps, connecting piping, valves, points of application, backflow prevention devices, air gaps, secondary containment, and safety eyewashes and showers as applicable.

5.0.2 Chemical Application

Chemicals must be applied to the water at such points and by such means as to:

a. Assure satisfactory dispersion of the chemicals in the bulk process flow with adequate reaction time depending on chemical applied. Mixing must be upstream of any reaction vessel (e.g., log inactivation contact time).

b. Provide maximum flexibility of operation through various points of application, when appropriate.

c. Prevent backflow or back-siphonage between multiple points of feed through common manifolds.

5.0.3 General Equipment Design

General equipment design must be such that:

a. Feeders will be able to supply, at all times, the necessary amounts of chemicals at an accurate rate, throughout the range of feed.

b. Chemical-contact materials and surfaces are resistant to the aggressiveness of the chemical solution.

c. Corrosive chemicals are introduced in such a manner as to minimize potential for corrosion.

d. Chemicals that are incompatible are not stored or handled together and are also not applied to the water in such a manner as to cause an adverse reaction.

e. All chemicals are conducted from the feeder to the point of application in separate conduits.

5.0.4 Chemical Information

For each chemical the information submitted must include:

a. Documentation that the chemical is ANSI/NSF Standard 60 approved.
    - Note: ANSI/NSF 60 certifications may not exist for certain gaseous chemicals such as gas chlorine or anhydrous ammonia.
b. Specifications and SDS sheets for the chemical to be used.
c. Purpose of the chemical.
d. Proposed minimum non-zero, average and maximum dosages (and supporting calculations), solution strength or purity (as applicable), and specific gravity or bulk density.
e. Method for independent calculation of amount fed daily - for systems treating with only sodium hypochlorite or treating bulk flows of less than 50 gallons per minute (gpm), independent calculation of amount fed daily is not necessary.

5.1 FEED EQUIPMENT

5.1.1 Feeder Redundancy

a. Where a chemical feed pump is necessary for Regulation 11 compliance (e.g., chlorination, coagulation for surface water treatment rule compliance, pH adjustment for lead and copper compliance), then a standby unit or a combination of units of sufficient size to meet capacity must be provided to replace the largest unit when out of service, and the Department may require that more than one be installed.
    - Treatment plants with a design flow of less than 20 gpm may include a discussion of how spare parts or pumps will be made available by the operator in responsible charge or be available for purchase and installation in less than 72 hours.
b. A separate feeder must be used for each chemical applied.

5.1.2 Control

a. Feeders may be manually or automatically controlled. Automatic controls must be designed so as to allow override by manual controls.
b. Chemical feed rates must be proportional to the flow stream being dosed.
    - Treatment plants with a design flow of less than 20 gpm with a relatively consistent flowrate (e.g., vertical well with a constant speed submersible pump) are exempt from this requirement (Item 5.1.2(b)).
c. Chemical feeders must be controlled to automatically start and stop based on start and stop of process flow.
    - Treatment plants with a design flow of less than 20 gpm with a relatively consistent flowrate (e.g., vertical well with a constant speed submersible pump) are exempt from this requirement (Item 5.1.2(c)).
d. A means to measure the flow stream being dosed must be provided in order to determine chemical feed rates.

- Treatment plants with a design flow of less than 20 gpm with a relatively consistent flowrate (e.g., vertical well with a constant speed submersible pump) are exempt from this requirement (Item 5.1.2(d)).

e. Provisions must be made for measuring the quantities of chemicals used.

f. Weighing scales must be provided for weighing cylinders at all plants utilizing chlorine and ammonia gas.

5.1.3 Dry Chemical Feeders

Dry chemical feeders must:

a. Measure chemicals volumetrically or gravimetrically.

b. Provide adequate solution/slurry water and agitation of the chemical at the point of placing in solution/slurry.

c. Enclose chemicals to prevent emission of dust to the operating room.

5.1.4 Positive Displacement Solution Feed Pumps

a. Pumps must be capable of operating at the required maximum rate against the maximum head conditions found at the point of injection.

b. Calibration tubes or mass flow monitors which allow for direct physical measurement of actual feed rates must be provided.

- Treatment plants with a design flow of less than 20 gpm are exempt from this requirement (Item 5.1.4 (b)) unless the chemical feed system is optimal corrosion control treatment for compliance with Section 11.26 of Regulation 11.

c. A pressure relief valve must be provided on the pump discharge line unless not recommended by the pump manufacturer.

d. Discharge pipe must be designed to remain full when the pump stops to ensure accurate feed rates on pump re-start.

5.1.5 Liquid Chemical Feeders - Siphon Control

Liquid chemical feeders must be such that chemical solutions cannot be siphoned or overfed into the finished water by one of the following:

a. Assuring discharge at a point of positive pressure.

b. Providing vacuum relief.

c. Providing a suitable air gap, or anti-siphon device.

d. Providing other suitable means or combinations as necessary.

e. Peristaltic pump design.

5.1.6 Cross-Connection Control

Cross-connection control must be provided to assure that:

a. The service water lines discharging to liquid chemical storage tanks must be properly protected from backflow as required by the Department.

b. No direct connection may exist between any sewer and a drain or overflow from the liquid chemical feeder, liquid storage chamber or tank by providing that all drains terminate at least six inches or two pipe diameters, whichever is greater, above the overflow rim of a receiving sump, conduit or waste receptacle.

c. For SW/GWDUI treatment plants under Section 11.8 of Regulation 11: If a chemical will be fed both upstream and downstream of the compliance filter then separate feeders must be provided such that all unfiltered water feed points are fed from one feeder, and that all filtered water feed points are fed from another feeder.

5.1.7 Chemical Feed Equipment Location

Chemical feed equipment must be located in a separate room wherever hazards and dust problems may exist. Separate rooms are required for powder activated carbon and chlorine gas feed systems. Bulk storage tanks of chemicals that can react together must be contained in separate bulk storage containment areas.

5.1.8 In-Plant Water (note: see Section 2.11 For house potable water)

In-plant water (i.e. process water, chemical carrier water) must be:

a. Sized to meet water plant demands.
b. Provided with means for measurement when preparing specific solution concentrations by dilution.
c. Properly treated for hardness, when necessary.
d. Properly protected against backflow.
e. Obtained from the finished water (i.e. entry point) line.
    - In groundwater systems, certain applications may allow for using raw water as in-plant water supply. The department will approve such uses case-by-case.
    - Deviations can be granted for certain chemical feed systems using raw or partially treated water as carrier water (e.g., powder activated carbon in the floc basin).

5.1.9 Storage of Chemicals

a. Space requirements:
    i. BDR must indicate why the proposed amount of chemical storage was chosen (e.g., number of days of chemical supply during peak flow, typical truck volume).
    ii. Dry storage conditions must be provided.
    iii. A minimum storage volume of 1.5 truckloads must be provided where purchase is by truck load lots.

5.1.10 Liquid Storage Tanks

a. Storage tanks and pipelines for liquid chemicals must be specified and labeled for use with individual chemicals and not used for multiple chemicals. Offloading areas must be clearly labeled to prevent accidental cross-contamination. Water system must provide locking mechanisms or other standard protocols to prevent cross contamination.
b. Storage tanks must be compatible with the type of chemical being stored.

c. A means which is consistent with the nature of the chemical stored must be provided in a liquid storage tank to maintain a uniform chemical strength. Continuous agitation must be provided to maintain slurries in suspension.

d. A means to assure continuity of chemical supply while servicing a liquid storage tank must be provided.

e. Means must be provided to measure the liquid level in the liquid storage tank; visible liquid level in translucent tanks is acceptable.

   - For tanks less than or equal to 55 gallons a dipstick or visual level measurement through the hatch is acceptable.

f. Liquid storage tanks must be kept covered. Large liquid storage tanks with access openings must have such openings curbed and fitted with overhanging covers.

g. Subsurface locations for liquid storage tanks must:

   i. Be free from sources of possible contamination.

   ii. Assure positive drainage away from the area for ground waters, accumulated water, chemical spills and overflows.

   iii. If hazardous, be approved by the Underground Storage Tank Program (UST) of the Department.

h. Liquid storage tanks must be vented, but not through vents in common with other chemicals or day tanks. Acid storage tanks must be vented to the outside atmosphere. Outside vents must be configured in such a manner as to prevent chimney effect (horizontal vs. vertical).

   - Tanks less than or equal to 55 gallons are exempt from this requirement (Item 5.1.10(h)).

i. Each liquid storage tank must be provided with a valved drain.

   - Tanks less than or equal to 55 gallons are exempt from this requirement (Item 5.1.10(i)).

j. Overflow pipes, when provided, must:

   i. Be turned downward, with the end screened on outdoor installations. Screens may not have openings that exceed 0.07 inches (typically 12 or 16 mesh screen)

   ii. Have a free fall discharge.

   iii. Be located where visible to operations staff.

k. Liquid storage tanks must have secondary containment provided so that chemicals from equipment failure, spillage or accidental drainage are prevented from entering the water in conduits, treatment or storage basins. Secondary containment volumes must be able to hold the volume of the largest storage tank. Piping must be designed to minimize or contain chemical spills in the event of pipe ruptures. Secondary containment can be common provided it serves compatible chemicals.

   - Recommended but not required on tanks less than or equal to 55 gallons as long as there is no path to the potable water (e.g., a clearwell access hatch) and not storing acids or strong bases. In those cases, storage for acids and strong bases must always be designed with a suitable containment tub regardless of size.

5.1.11 Day Tanks

a. Day tanks are not required for chemical feed systems.
b. Day tanks must meet all the requirements of Item 5.1.10, except that shipping containers do not require overflow pipes and drains.
c. Day tanks must be sized to hold a 20-30 hour supply at expected peak flow.
d. Day tanks must be scale-mounted, or have a calibrated gauge painted or mounted on the side if liquid level can be observed in a gauge tube or through translucent sidewalls of the tank. In opaque tanks, a gauge rod may be used.
e. Hand pumps may be provided for transfer from a shipping container. Appropriate safety measures must be employed. A tip rack may be used to permit withdrawal into a bucket from a spigot. Where motor-driven transfer pumps are provided, a liquid level limit switch must be provided.
f. A means which is consistent with the nature of the chemical solution must be provided to maintain uniform chemical strength in a day tank. Continuous agitation must be provided to maintain slurries in suspension.
g. Tanks and tank refilling line entry points must be clearly labeled with the name of the chemical contained.
h. Filling of day tanks must not be automated.

5.1.12 Feed Lines

a. Must be installed within a conduit when buried.
b. Must be protected from freezing.
c. Must be designed consistent with scale-forming or solids depositing properties of the water, chemical, solution or mixtures conveyed.

5.1.13 Mixing - Injector/diffuser

The design must have adequate mixing prior to subsequent treatment (e.g., disinfection contact volume). The design must include a mechanism to facilitate chemical mixing at the chemical injection point such as an injector, static mixer, or diffuser. The solution injector/diffusers must be compatible with the point of application to provide a rapid and thorough mixing with the water being treated.

If used on pipes 4-inches or larger with no downstream mixer, injectors must have the ability to be inserted in a minimum of one-third (1/3) of a pipeline diameter for quill injection or full diameter for multi-port injection systems.

5.1.14 Housing

When venting to the outside from feeders, storage facilities and equipment exhaust must discharge separately to the outside atmosphere above grade and remote from air intakes.

5.2 NOT USED

5.3 SAFETY

5.3.1 Ventilation

Special provisions must be made for ventilation of all chemical feed and storage. Refer to all applicable local, state, and federal codes, industry standards, and manufacturer requirements.

- Suppliers serving less than 500 population feeding only sodium hypochlorite are exempt from this requirement (Item 5.3.1).

5.3.2 Not Used

5.3.3 Chlorine/Ammonia Gas Leak Detection

Where pressurized chlorine or ammonia gas is present, continuous chlorine or ammonia leak detection equipment is required and must be equipped with both an audible alarm and a warning light visible from outside the chlorine and ammonia rooms.

5.3.4 Other Protective Equipment

An appropriate deluge shower and eye washing device or station must be installed where chemicals are used or stored.

- Suppliers serving less than 500 population feeding only sodium hypochlorite are exempt from this requirement (Item 5.3.4).

5.3.5 Ozone Safety

a. The maximum allowable ozone concentration in the air to which workers may be exposed must not exceed 0.1 ppm (by volume).

b. Emergency exhaust fans must be provided in the rooms containing the ozone generators to remove ozone gas if leakage occurs in accordance with local, state, and federal regulations.

5.3.6 Hydrogen Peroxide Safety

Where concentrated hydrogen peroxide is present, continuous hydrogen peroxide leak detection is required and must be equipped with both an audible alarm and a warning light visible from outside the hydrogen peroxide room.

5.4 SPECIFIC CHEMICALS

5.4.1 Chlorine Gas

a. Both the chlorine gas feed and storage rooms must include an exterior wind sock that will be visible to first responders.

b. Chlorine feed and storage rooms must be climate controlled. Cylinders and gas lines must be protected from temperatures above that of the feed equipment.

c. Chlorine gas feed and storage must be enclosed and separated from other operating areas. Both the feed and storage rooms must be constructed so as to meet the following requirements:

    i. An inspection window must be installed in an interior wall.

    ii. All openings between the rooms and the remainder of the plant must be sealed.

iii. Doors must have an inspection window and open outward only to the building exterior.

iv. A ventilating exhaust fan is required when the room is occupied.

v. The ventilating exhaust fan must take suction near the floor and as great a distance as is practical from the door and air inlet. The exterior point of discharge must be located outside of the building away from air inlets to any rooms, structures, designated operator access, or walkway areas.

vi. Air inlets with corrosion resistant louvers must be installed near the ceiling.

vii. Separate switches for the ventilating exhaust fan and for the lights must be located outside and at the inspection window. A signal light indicating ventilating fan operation must be provided at each entrance.

viii. Vents from chlorinator and storage areas must include a non-metallic corrosion resistant screen and discharge to the outside atmosphere.

ix. Floor drains are not allowed.

x. Plants with storage capacities in excess of 2,000 lbs must be equipped with scrubbing equipment capable of neutralizing the contents of the single largest container.

d. Chlorine gas feed systems must be of the vacuum type and include the following:

i. Vacuum regulators installed on all individual 150 pound cylinders in service.

ii. In-plant water (Item 5.1.8) to injectors/eductors must be of adequate amount and pressure to operate feed equipment within the needed chlorine dosage range for the proposed system.

e. Pressurized or vacuum chlorine feed lines must not carry chlorine gas beyond the chlorinator rooms.

f. Full and empty cylinders and containers of chlorine gas must meet the following requirements:

i. Housed in areas specifically designed for chlorine storage.

ii. Restrained in position with a corrosion-resistant restraint system that is 2/3 height of the cylinder.

iii. Protected from direct sunlight and climate controlled.

g. Automatic switch-over

i. Automatic switch-over of chlorine cylinders must be provided to assure continuous disinfection.

h. Eductor

i. Each eductor must be selected for the point of application with particular attention given to the quantity of chlorine to be added, the minimum injector water flow, the total discharge minimum back pressure, the minimum injector operating pressure, and the size of the blended solution line. Pressure gauges for measuring positive water pressure and vacuum at the inlet and outlet of each eductor should be provided.

5.4.2 Acids and Caustics

a. Acids and caustics must be kept in closed corrosion-resistant shipping containers or bulk liquid storage tanks.

b. Acids and caustics must not be handled in open vessels.

c. Acids and caustics must not be stored together.

5.4.3 Sodium Chlorite

Provisions must be made for proper storage and handling of sodium chlorite to eliminate any danger of fire or explosion associated with its powerful oxidizing nature. The necessary special provisions must be made for all sodium chlorite feed and storage requirements. Refer to all applicable local, state, and federal codes and industry standards.

a. Storage

i. Sodium chlorite must be stored by itself in a separate room and preferably stored in an outside building detached from the water treatment plant. It must be stored away from organic materials due to the extreme fire hazard.

ii. The storage structures must be constructed of noncombustible materials.

iii. Water must be available to keep the sodium chlorite area cool enough to prevent heat induced explosive decomposition of the sodium chlorite.

b. Feeders

i. Positive displacement or eductor feed systems (including filters) must be provided in accordance with the manufacturer's recommendations.

ii. Tubing for conveying sodium chlorite or chlorine dioxide solutions must be Type 1 PVC, polyethylene or materials recommended by the manufacturer.

iii. Chemical feeders may be installed in chlorine rooms if sufficient space is provided or in separate rooms meeting the requirements of Item 5.4.1.

iv. Feed lines must be installed in a manner to prevent formation of gas pockets and must terminate below the lowest operating level at the discharge point.

v. Check valves must be provided to prevent the backflow of chlorine into the sodium chlorite line.

5.4.4 Hypochlorite

a. Storage

i. Sodium hypochlorite must be stored in the original shipping containers or in sodium hypochlorite compatible bulk liquid storage tanks.

ii. Storage containers or tanks must be located out of direct sunlight in a cool area and must be vented to the outside of the building.

- Treatment plants with a design flow of less than 50 gpm or with sodium hypochlorite storage tanks less than or equal to 55 gallons, are not required to meet the outside venting portion of Item 5.4.4(a)(ii).

iii. Where dilution is required, raw groundwater, process water, deionized, or softened water must be used.

iv. Where calcium hypochlorite is used, solid calcium hypochlorite must be diluted into a chemical feed solution in a batch style tank.

b. Feeders

i. Positive displacement pumps with hypochlorite compatible materials for wetted surfaces must be used.

- Treatment plants with a design flow of less than 50 gpm are exempt from this requirement (Item 5.4.4 (b)(i)).

ii. To avoid air locking in suction lift applications, small diameter suction lines must be used with foot valves and degassing pump heads.

iii. Flooded suction applications must be designed with pipe work arranged to ease escape of gas bubbles.

iv. Calibration tubes or mass flow monitors which allow for direct physical checking of actual feed rates must be provided.

- Treatment plants with a design flow of less than 50 gpm are exempt from this requirement (Item 5.4.4 (b)(iv)).

v. Injectors must be removable for regular cleaning while the system remains in operation.

c. On Site Generation

i. Brine Conditioning:

1. Salt storage must be discussed in BDR.
2. Water quality must be pretreated to meet the requirements of the generator manufacturer.
3. Brine make-up system must be discussed in BDR.

ii. Generator must have hydrogen detectors and temperature controls.

iii. Storage: Refer to Item 5.4.4(a).

iv. Feed Systems: Refer to Item 5.4.4(b).

5.4.5 Ammonia

5.4.5.1 Ammonium Sulfate

Ammonium sulfate can be supplied as a liquid solution or solid. Mixing, feed, and storage must be enclosed and separated from other operating areas. The ammonium sulfate room must be equipped as in Item 5.1.10.

5.4.5.2 Aqua Ammonia (Ammonium Hydroxide)

Aqua ammonia feed pumps and storage must be enclosed and separated from other operating areas. The aqua ammonia room must be equipped as in Item 5.4.1 with the following changes:

a. Corrosion resistant, closed, unpressurized tank must be used for bulk liquid storage and day tanks, vented through scrubber system to outside the building.

b. The liquid storage tank(s) must be designed to avoid conditions where temperature increases cause the ammonia vapor pressure over the aqua ammonia to exceed atmospheric pressure. Such provisions must include either:

    i. Refrigeration or other means of external cooling.

    ii. Dilution and mixing of the contents with water without opening the bulk liquid storage tank.

c. The piping system materials must be compatible. The aqua ammonia feed systems must be capable of pressure relief within the closed system.

d. If carrier water is used, the carrier stream must be softened.

5.4.5.3 Anhydrous Ammonia

a. Anhydrous ammonia and storage feed systems (including climate control) must be enclosed and separated from other work areas and constructed of corrosion resistant materials.

b. Pressurized ammonia feed lines must be restricted to the ammonia storage room / area.

c. An emergency air exhaust system, as in Item 5.4.1(c) but with an elevated intake, must be provided in the ammonia storage room.

d. Leak detection systems must be provided in ammonia areas.

e. Vacuum breaker/regulator provisions must be provided.

f. When carrier water systems are used, softened water must be provided.

g. The ammonia injector must use a vacuum eductor, when applied directly.

h. Plants with storage capacities in excess of 2,000 lbs must be equipped with scrubbing equipment capable of neutralizing the contents of the single largest container.

5.4.6 Potassium Permanganate

When potassium permanganate is being dissolved into a bulk solution in a tank, mechanical mixers must be provided.

5.4.7 Fluoride

a. Storage
    i. Compounds must be stored in covered or unopened shipping containers and must be stored inside a building.
    ii. Unsealed storage units for fluorosilicic acid must be vented to the atmosphere at a point outside any building. The vents to atmosphere must be provided with a non-corrodible screen. Screens may not have openings that exceed 0.07 inches (typically 12 or 16 mesh screen).

b. Chemical feed equipment and methods
    i. At least two diaphragm operated anti-siphon devices must be provided on all fluoride saturator or fluorosilicic acid feed systems.
        1. One diaphragm operated anti-siphon device must be located on the discharge side of the feed pump.
        2. A second diaphragm operated anti-siphon device must be located at the point of application unless a suitable air gap is provided.
    ii. Fluoride compound must not be added before lime-soda softening or ion exchange softening.
    iii. The point of application if into a horizontal pipe must be in the lower half of the pipe, preferably at a 45 degree angle from the bottom of the pipe and protrude into the pipe one third (1/3) of the pipe diameter.
    iv. Water used for sodium fluoride dissolution must be softened if hardness exceeds 75 mg/L as calcium carbonate.
    v. Saturators must be of the upflow type and be provided with a meter and backflow protection on the makeup water line.

c. Protective equipment

    Deluge showers and eye wash devices must be provided at all fluorosilicic acid installations in accordance with applicable local codes.

d. Dust control (dry feeders)
    i. Provision must be made for the transfer of dry fluoride compounds from shipping containers to storage bins or hoppers in such a way as to minimize the quantity of fluoride dust which may enter the room in which the equipment is installed.
    ii. The enclosure must be provided with an exhaust fan and dust filter which places the hopper under a negative pressure.
    iii. Air exhausted from fluoride handling equipment must discharge through a dust filter to the outside atmosphere of the building.

5.4.8 Powdered Activated Carbon

a. Activated carbon must not be applied near the point of chlorine or other oxidant application.

b. Continuous agitation or re-suspension equipment must be provided to keep the carbon from depositing in the slurry storage tank.

c. Provision must be made for dust control including ventilation of the room to the outside atmosphere.

d. Powdered activated carbon must be handled as a potentially combustible material and is required to be stored in an isolated room, compartment, or area.

5.4.9 Copper Sulfate and Other Algae Control Compounds

Feeding of copper sulfate or other algae control chemicals in an engineered chemical feed system requires approval from the Department. Seasonal application of algae control chemicals is not covered in the scope of this document. The Department recommends consultation with the appropriate regulatory agencies (e.g., Fish and Wildlife or Water agencies or the Department of Natural Resources) before making applications to public waters.

If engineered chemical feed systems are installed, calculations must be provided in the BDR demonstrating the copper does not exceed 1.0 mg/L.

5.4.10 Hydrogen peroxide

Special consideration must be given to hydrogen peroxide chemical feed systems.

a. Feed Equipment

    i. Feed equipment must be resistant to the oxidizing nature of hydrogen peroxide and the heat generated when combined with water. Stainless steel feed lines must be used and justification must be provided for pump selection.

    ii. Redundant pumps must be installed.

    iii. Cross connection control must be addressed in the chemical storage and feed system.

b. Storage

    Storage facilities must be constructed of chemical resistant materials specifically designed to withstand hydrogen peroxide. Adequate secondary containment is required.

c. Safety

    i. Feed system must conform with Item 5.3.6

    ii. A procedure must be included in the operations plan for safe plant shutdown in the event of a peroxide leak.

CHAPTER 6
PUMPING FACILITIES

6.0 GENERAL

Pumping facilities must be designed to maintain the sanitary quality of pumped water. Inaccessible installations must be avoided. Where subsurface pits are unavoidable due to freezing or other constraints, they must have active, powered ventilation and drain to daylight with a drain line large enough to carry peak instantaneous flow.

6.1 LOCATION

The pumping station must be so located that the proposed site will meet the requirements for sanitary protection of water quality, hydraulics of the system and protection against interruption of service by fire, flood or any other hazard.

6.1.1 Site Protection

The station must:

a. Not be subject to flooding.

b. Be readily accessible at all times unless permitted to be out of service for the period of inaccessibility.

c. Be graded around the station to direct surface drainage away from the station.

d. Be protected to prevent vandalism and entrance by animals or unauthorized persons.

6.2 PUMPING STATIONS

Pumping stations must:

a. Have adequate space for the safe servicing and access of all equipment.

b. Be of durable construction, fire and weather resistant and with outward-opening doors in accordance with relevant state or local codes.

c. Have underground structures waterproofed.

d. Have all floors drained in such a manner that the quality of the potable water will not be endangered. All floors must slope to a suitable drain.

e. Provide a suitable outlet for drainage without allowing discharge across the floor, including pump packing glands, vacuum air relief valves, etc.

f. If proposed in the BDR, have adequate space for the installation of additional units.

6.2.1 Suction Wet Well

Suction wet wells must:

a. Meet the requirements of Chapter 7 as protected water storage.

b. Have floors sloped and/or a sump or similar geometry to permit removal of water and settled solids.

c. Be covered or otherwise protected against contamination.

d. Have two pumping compartments or other means (e.g., sufficient upstream and downstream storage, portable bypass pumping) to allow the suction well to be taken out of service for inspection, maintenance, or repair.

e. Have adequate volume to provide sufficient storage to prevent overflow.

f. Have a level monitoring device.

    i. For pump stations that are designed to operate automatically, the level monitoring device must control pump start and stop, track wetwell levels, and alarm operators of a high level condition prior to an overflow condition.

g. Have pipes in wetwell capable of conveying overflow at flow rates equal to flow entering wetwell or controls capable of stopping flow into wetwell upon a high level condition.

h. If containing potable water, the suction wet well must not have common wall construction with basins containing sanitary sewer or water of lesser quality.

6.2.2 Equipment Servicing

Pump stations must be provided with:

a. Crane-ways, hoist beams, eyebolts, or other adequate facilities for servicing or removal of pumps, motors or other heavy or bulky equipment.

b. Openings in floors, roofs or wherever else needed for removal of heavy or bulky equipment.

c. Adequate access to facilitate maintenance or removal of equipment from the building.

6.2.3 Stairways and Ladders

Stairways or ladders must:

a. Be provided between all floors, and in pits or compartments which are intended to be entered.

b. Must conform to the requirements of the Uniform Building Code, or relevant state and/or local codes.

c. Must be provided with adequate safety equipment as required by Occupational Safety and Health Administration guidelines.

6.2.4 Heating

Provisions must be made for adequate heating for:

a. The comfort of the operator.

b. The safe and efficient operation of the equipment.

- In pump houses/stations not occupied by personnel, only enough heat must be provided to prevent freezing of equipment and to allow proper operation of equipment and treatment processes.

6.2.5 Ventilation

Adequate ventilation must be provided for all pumping stations for operator comfort/safety and dissipation of excess heat from the equipment. Forced ventilation in compliance with relevant state and/or local codes must be provided for all occupied floor areas.

6.2.6 Dehumidification

Dehumidification must be provided in areas where excess moisture could cause hazards for operator safety or damage to equipment.

6.2.7 Lighting

Pump stations must be adequately lighted throughout to deter vandalism and facilitate maintenance. All electrical work must conform to the requirements of the National Electrical Code or to relevant state and/or local codes.

6.2.8 Sanitary and Other Conveniences

All pumping stations that are manned for extended periods should be provided with potable water, lavatory and toilet facilities as allowed by state and /or local codes. Plumbing must be so installed as to prevent contamination of a public water supply. Wastes must be discharged in accordance with Chapter 9.

6.3 PUMPS

At least two pumping units must be provided for all pumping systems. With any one pump out of service, the remaining pump or pumps must be capable of providing the maximum pumping demand of the system. The pumping units must:

a. Have capacity to supply the peak demand against the required distribution system pressure without overloading.
b. Be served by control equipment in accordance with Item 6.6.5 that has proper heater and/or ventilation and overload protection for the air temperature encountered.
c. Be sized to accommodate initial and future operating conditions as outlined in the BDR.
d. When used with a wet well, have sufficient capacity to maintain wet well water surface levels below design maximum high water (alarm) levels.
e. Be driven by prime movers able to meet the maximum horsepower condition of the pumps and de-rated for the installation altitude, if necessary.
f. Avoid pump suction cavitation by having a flooded-suction or having a net positive suction head available ($NPSH_A$), as calculated at the pump suction connection, greater than the net positive suction head required ($NPSH_R$) for the pump. For vertical and submersible pump types, have a minimum operating level above the pump suction greater than the minimum submergence and adequate spacing or inlet structure designs (based on Hydraulic Institute Standards) for all operating flows.

6.3.1 Suction Lift

Suction lift must:

a. Be avoided, if possible.
b. Be documented to be within NPSH requirements, preferably less than 15 feet.
    i. If suction lift is necessary, provision must be made for priming the pumps.

6.3.2 Pump Priming

Prime water must not be of lesser sanitary quality than that of the water being pumped. Means must be provided to prevent either backpressure or backsiphonage backflow. When an air-operated ejector is used, the screened intake must draw clean air from a point at least 10 feet above the ground or other source of possible contamination, unless the air is filtered by an apparatus . Vacuum priming may be used.

6.3.3 Submersible Pumps

a. Pump arrangement in a wet well must conform to pump manufacturer's recommendations for pump spacing and minimum submergence to accommodate motor cooling with consideration of satisfactory hydraulic operation with adjacent pump(s) operating at the same time.
b. Connection to the discharge piping must be capable of being operated without requiring personnel to enter or drain the wetwell.
c. Pump removal must be possible without requiring operating personnel to enter or drain the wetwell.

6.3.4 Pumps Installed In "Dry-Pit" Configuration

Suitable pump support and management of vibration at all pump operating conditions must be provided.

6.4 DISTRIBUTION BOOSTER PUMPS

Distribution booster pumps must be located or controlled so that:

a. They will not produce negative pressure in their suction lines.
b. Pumps installed in the distribution system must maintain inlet pressure as required in Item 8.2.1 under all operating conditions (exclusive of pumps connected to transmission piping).
c. Systems designed to operate in an automatic mode have automatic shutoff or a low pressure controller to maintain at least 20 psi (140 kPa) in the suction line under all operating conditions, unless otherwise acceptable to the Department. Pumps taking suction from ground storage tanks and designed to operate in an automatic mode must be equipped with automatic shutoffs or low pressure controllers as recommended by the pump manufacturer.
d. Automatic control devices must have a range between the start and cutoff pressure which will prevent excessive cycling.

6.4.1 Individual Residential Booster Pumps

Private booster pumps for any individual residential service from the public water supply main must only be permitted as allowed by local agencies having jurisdiction. Where allowed, private booster pumps must meet the requirements above.

6.5 AUTOMATIC CONTROLLED STATIONS

All automatically controlled stations must be provided with telemetry or other automatic signaling apparatus which will report when the station is out of service or has a self-activated alarm condition. Automatic controlled stations must have provisions for manual operations.

6.6 APPURTENANCES

6.6.1 Valves

Each pump must have an isolation valve on the intake and discharge side of the pump to permit satisfactory operation, maintenance and repair of the equipment. If foot valves are necessary, they must have a net valve area of at least 2 ½ times the area of the suction pipe and they must be screened. Each pump must have a positive-acting check valve or a pump control valve on the discharge side between the pump and the shut-off valve.

6.6.2 Piping

In general, piping must:

a. Be designed so that the friction losses will be minimized.

b. Not be subject to contamination.

c. Have watertight packing and jointing materials that meet the standards of AWWA and the Department.

d. Be provided with suitable restraints where necessary.

e. Be designed such that each pump has an individual suction line or that the lines must be so manifolded that they will insure similar hydraulic and operating conditions.

f. Gaskets containing lead must not be used. Repairs to lead-joint pipe must be made using alternative methods. Manufacturer approved transition joints must be used between dissimilar piping materials.

g. Pressure tested and leakage tested in accordance with the appropriate AWWA Standards.

h. If conveying potable water, must be disinfected in accordance with AWWA Standard C651.

6.6.3 Gauges and Meters

Each pump must have:

a. A standard pressure gauge on its discharge line.

b. A compound gauge on its suction line.

c. Pressure gauges on the common discharge pipeline header that has a method of recording the measured pressure.

d. A flow rate indicator and totalizing meter at the station, and a method of recording both the instantaneous flow and the total water pumped.

6.6.4 Shaft Seal Water

Shaft seal water must not be supplied with water of a lesser sanitary quality than that of the water being pumped. Where pumps are sealed with potable water and are pumping water of lesser sanitary quality, the seal must:

a. Be provided with either an approved reduced pressure principle backflow preventer or a break tank open to atmospheric pressure.

b. Where a break tank is provided, have an air gap of at least six inches or two pipe diameters, whichever is greater, between the feeder line and the flood rim of the tank.

6.6.5 Controls

Pumps, their prime movers and accessories, must be controlled in such a manner that they will operate at rated capacity without overload. Where two or more pumps are installed, provisions must be made for alternating duty pump operations. Equipment must be provided or other arrangements made to prevent surge pressures from activating controls which switch on pumps or activate other equipment outside the normal design cycle of operation.

6.6.6 Standby Power

If loss of primary power results in the inability to meet minimum service conditions specified in Item 8.2.1, a power supply must be provided from a standby or auxiliary source. If standby power is provided by onsite generators or engines, the fuel storage and fuel line must be designed to protect the water supply from contamination. A minimum of 24 hours of operation capacity is required.

Carbon monoxide detectors must be provided when generators are housed within pump stations.

6.6.7 Water Pre-Lubrication

When automatic pre-lubrication of pump bearings is necessary and an auxiliary power supply is provided, design must assure that pre-lubrication is provided when auxiliary power is in use, or that bearings can be lubricated manually before the pump is started

6.6.8 Oil or Grease Lubrication

All lubricants which come into contact with the potable water or which can contact potable water must be listed in ANSI/NSF Standard 60, H1, 3H, or H3.

6.6.9 Air and Vacuum Release/Relief Valves

Air release/relief or air vacuum valves must be utilized at critical locations on the pump station piping to allow large quantities of air at pump start-up or small quantities of air that is entrained in the fluid being conveyed or as a result of pump operation from exiting the piping system. Isolation valves must be provided on air release or air vacuum valves to allow for maintenance or replacement.

6.6.10 Drain Valves

Drain valves such as ball valve or stop cock must be installed on suction and/or discharge piping to facilitate maintenance of pumps, valves, and associated piping.

CHAPTER 7
PROTECTED WATER STORAGE

7.0 GENERAL

The materials and designs used for protected water storage tanks must provide stability and durability as well as protect the quality of the stored water.

For the purposes of the Design Criteria, protected water storage is considered:

- For groundwater systems: any tanks or treatment processes storing untreated or partially treated groundwater. This includes recycling or backwash storage tanks if any portion of the water will be sent back through groundwater treatment process.
- For surface water or GWUDI systems: any tanks downstream of the compliance filter. This includes backwash storage tanks.
- All public water systems: any tanks or clearwells downstream of disinfection and/or entry point. This includes clearwells, distribution system tanks, pump station wet wells, and any tanks storing finished water as defined by Regulation 11.

Finished or treated water must not be stored in a storage tank with a common wall, either vertically or horizontally, to an untreated, partially treated water storage tank, or backwash storage tank.

Water storage tanks must follow the current AWWA and ACI standards concerning tanks, standpipes, and elevated tanks wherever they are applicable. Other materials of construction are acceptable when properly designed to meet the requirements of Chapter 7.

7.0.1 Sizing

Storage tanks must have sufficient capacity, as determined from engineering studies, to meet domestic demands, and where fire protection is provided, fire flow demands.

a. The minimum storage capacity (or equivalent capacity) for systems not providing fire protection must be equal to the average daily consumption. This requirement may be reduced when the source and treatment facilities have sufficient capacity with standby power to supplement peak demands of the system.
    - Non-community systems are exempt from this requirement (Item 7.0.1(a)).

b. Excessive storage capacity should be avoided to prevent potential water quality deterioration problems.

c. Fire flow requirements established by the appropriate state Insurance Services Office should be satisfied if reasonably possible where fire protection is provided.

7.0.2 Location of Protected Water Storage Tanks

Storage tanks have location considerations beyond the Section 2.4 requirements.

a. The lowest elevation of the floor and sump floor of ground level storage tanks must be placed above the 100-year flood elevation or the highest flood of record, whichever is higher, and at least two feet above the groundwater table unless an underdrain system is installed.

b. For buried storage tanks: sewers, drains, standing water, and similar potential sources of contamination must be kept at least 50 feet from the water storage tank.

    i. Gravity sewers constructed of water main quality pipe, pressure tested in place without leakage, may be used at distances greater than 20 feet but less than 50 feet.

c. Water storage tanks may be buried, ground level, or elevated. All construction joints must be properly sealed with waterstops to prevent infiltration.

d. For buried storage tanks: If the bottom of a storage reservoir structure is below the groundwater table, hydrostatic uplift forces must be addressed and calculations provided.

<u>7.0.3 Protection from Contamination</u>

All protected water storage tanks must be designed to exclude birds, animals and insects. The installation of appurtenances, such as antenna, must be done in a manner that ensures no damage to the tank, coatings or water quality, or corrects any damage that occurs.

<u>7.0.4 Security</u>

Protected water storage tanks must be protected. See the security requirements in Item 1.2.11.

<u>7.0.5 Drains</u>

a. All protected water storage tanks must have a separate drain pipeline. Alternatively the tank design may request a deviation under Section 1.4 to justify an alternative way to drain the tank.

    - Tanks less than 11,000 gallons are exempt from this requirement (Item 7.0.5(a)).

b. Water storage tanks must not use the outlet pipe as a drain.

    - Tanks less than 11,000 gallons are exempt from this requirement (Item 7.0.5(b)).

c. Not used.

d. Drains on water storage tanks must not be connected to sanitary sewer.

e. The drain may connect to a storm water manhole provided there is a vertical separation of twice the diameter of the drain pipe or at least two feet between the bottom of the drain valve pipe and the top of storm sewer connection pipe.

f. Drains to daylight must be equipped with an automatic drainage gate (i.e. flap gate) or duckbill type check valve to prevent backsiphonage. Drains should not be covered with screen. Drains that discharge to daylight must have an air gap above any backwater level at the discharge point (e.g., high water line of discharge pond). Drains must have provisions to prevent erosion, such as rip rap, and grading to prevent pooling.

g. The design must provide for draining the water storage tank for cleaning or maintenance without causing disruptions to the distribution system.

- Non-community water systems are exempt from this requirement (Item 7.0.5(g)).

h. Subsurface discharge of drains (e.g., french drains for subsurface disposal) are not allowed.

7.0.6 Stored Water Age

a. All water storage tanks must have adequate controls to provide tank turnover to maintain protected water quality. Control design must facilitate turnover of water in the protected water storage to minimize stagnation and/or stored water age. Demonstration of “adequate” may require a control narrative showing how turnover will occur.

   i. Use of the overflow as a control mechanism is not acceptable.

      - Tanks less than 11,000 gallons are exempt from this requirement (Item 7.0.6(a)(i)).

b. Distribution system storage facilities should be designed to eliminate short-circuiting and stratification and achieve adequate mixing. If used, consideration should be given to mixing systems to avoid stagnation and freezing.

c. Designs with a single inlet/outlet pipe should be avoided unless a mixing system is present.

d. Consideration should be given to piping configurations that are reflective of the storage tank geometry and promote mixing of the protected water storage tank contents.

e. The protected water tank design must consider all factors that affect water quality and freezing.

7.0.7 Overflow

a. All water storage tanks must be provided with an overflow.

   - Tanks less than 11,000 gallons are exempt from this requirement (Item 7.0.7(a)).

b. Not used.

c. Overflows must not be connected directly to a sanitary sewer.

d. The overflow may be connected to a storm water manhole if there is vertical separation of twice the diameter of the overflow pipe or maximum of two feet between the bottom of the overflow drain pipe pipe and the top of storm sewer connection pipe. The overflow line must be equipped with an automatic drainage gate or duckbill type check valve to prevent backsiphonage and protect the tank from contaminants such as insects, rodents, birds, etc. When an internal overflow pipe is used on elevated tanks, it must be located in the access tube.

e. Overflow lines to daylight must be equipped with an automatic drainage gate (a.k.a., flap valve), check valve or equivalent protection to prevent backsiphonage and protect the tank from contaminants such as insects, rodents, birds, etc. The automatic drainage gate, check valve or equivalent protection must be installed so that it is fully closed when there are no pipe flows. Overflow lines that discharge to daylight must have an air gap above any backwater level at the discharge point (e.g., high water line of discharge pond). Overflow discharge points must have provisions to prevent erosion, such as rip rap, and grading to prevent pooling.

- Tanks less than 11,000 gallons may have overflow outlets covered with a non-corrodible screen rather than an automatic drainage gate or check valve. Screens may not have openings that exceed 0.07 inches (typically 12 or 16 mesh). This is not the preferred overflow design since the screen could clog and cause structural damage to the storage tank or blow off during an overflow event. The screen must be installed within the overflow pipe at a location that is not susceptible to vandalism but allows for overflow to be operational during overflow events. The screen with the smallest openings must be accessible for replacement and must be the outermost screen.

f. The overflow structure, overflow pipe diameter and pipe slope must be designed to permit the discharge of water in excess of the maximum inflow rate. Overflow calculations are required by Item 1.2.5(c).

g. The top of the overflow must be a minimum of 1-foot below the lowest point of the roof structure.

- Tanks less than 11,000 gallons are exempt from this requirement (Item 7.0.7(g)).

<u>7.0.8 Access</u>

Protected water storage tanks must be designed with reasonably convenient access to the interior for cleaning and maintenance. Water storage tanks must have at least one access opening above the waterline at each water compartment. Multiple access openings are recommended.

a. Above grade water storage tanks

i. All water storage tanks must have at least one access opening to allow for routine inspections and, if applicable, inspections required under Section 11.28 of Regulation 11 (i.e., Storage Tank Rule). The access opening must be designed to protect the tank from contaminants such as: surface water, stormwater runoff, insects, rodents, and birds.

ii. At least one of the access openings must be framed at least four inches above the surface of the roof at the opening.

- Tanks less than 11,000 gallons are not required to have an access opening with a minimum 4-inch frame.

iii. Access hatches located outdoors or exposed to the elements must be fitted with a solid, water and insect tight, gasketed cover which overlaps the framed opening and extends down around the frame, must be hinged on one side, and must have a locking device.

- Tanks less than 11,000 gallons are not required to have an overlapping cover but must have solid, water and insect tight, gasketed cover.

iv. Access hatches located indoors must be fitted with a solid, water and insect tight, gasketed cover to prevent contamination. The cover does not need to have an overlapping frame if superstructure (aka roof) is present to divert potential contamination sources. If present, hatch drainlines cannot drain into the protected water storage.

v. All other access openings must be bolted and gasketed.

b. Buried water storage tanks

i. All water storage tanks must have at least one access opening to allow for routine inspections and, if applicable, inspections required under Section 11.28 of Regulation 11 (a.k.a. the Storage Tank Rule). The access opening must be designed to protect the tank from contaminants such as: surface water, stormwater runoff, insects, rodents, and birds.

ii. Each access opening must be elevated at least 24 inches above the top of the tank or ground surface, whichever is higher.

iii. Each access opening must be fitted with a solid, water and insect tight gasketed cover which overlaps a framed opening and extends down around the frame. The frame must be at least four inches high. Each cover must be hinged on one side and have a locking device. Hatch drainlines cannot drain into the protected water storage.

- Tanks less than 11,000 gallons are not required to have an overlapping cover but must have solid, water and insect tight, gasketed cover.

iv. All other access openings must be bolted and gasketed.

<u>7.0.9 Vents</u>

a. All finished water storage tanks must be vented.

b. Water storage tanks must not use the overflow pipe as the vent.

- Tanks less than 11,000 gallons may use a combined vent and overflow line. Tank designs with a combined vent and overflow line must have a screen installed which meets the requirements in the bullet under Item 7.0.7(e).

c. Open construction between the sidewall and roof is not permissible.

d. The vent area must be designed for the maximum water storage tank flow rates. Venting calculations are required by Item 1.2.5(c). Vent calculations must be provided and demonstrate vent sizing methodology including assumed free area and calculate head loss, etc. The default screen free surface area of 40% is required unless integrated pressure/vacuum release is provided in accordance with Item 7.0.9(e)(iv).

e. Vents must be designed to protect the tank from contaminants such as: surface water, stormwater runoff, insects, rodents, birds, etc. All openings must be protected by a non-corrodible screen. Screens may not have openings that exceed 0.07 inches (typically 12 or 16 mesh screen). The screen must be installed within the vent at a location least susceptible to vandalism. The screen must be accessible for replacement.

f. Vents must be designed for unobstructed air flow into and out of the vent. Vents must open downward. Down turned vents can be candy cane, mushroom style, or where no portion of the vent screen is visible from a horizontal position (e.g. vent in the side of a hatch assembly with louver protecting the vent). Any vent cover must overlap so that no horizontal pathway exists. Candy cane or downturned vents are allowed to have a visible screen (i.e. not covered) below the bottom of the vent opening as long as no direct horizontal pathway exists between the vent opening and the tank. When a mushroom type vent is used, the minimum opening distance must be measured from the lowest point on the vent cap to allow for air flow to enter the screened area. Integral vents on tanks (e.g., threaded cap on a polyethylene tank access lid) that do not have downturned screening are not allowed outdoors.

i. For ground level or buried tanks, the vent elevation from the top of the roof or ground surface must be justified in the BDR however all vent openings must be a minimum of 24-inches above the top of the roof or ground surface. The design must consider site conditions and provide justification including the annual snow depth. Snow depth sources may include the *Colorado Design Snowloads by the Structural Engineers Association of Colorado, ASCE Minimum Design Loads and Associated Criteria for Buildings and Other Structures* (Reference 22), or local knowledge. Unless snow depth data is provided to prove otherwise, average accumulated snow depths for locating the height of the vent opening must be as follows, based on site elevation above mean sea level (MSL):

   a. Below 6,500 feet MSL, accumulated snow depth must be assumed as 24 inches.

   b. Between 6,500 - 8,500 feet MSL, accumulated snow depth must be assumed as 36 inches.

   c. Above 8,500 feet MSL, accumulated snow depth must be assumed as 72 inches.

ii. For elevated tanks, the vent elevation from the top of the roof must be a minimum of 24-inches above the top of the roof. The elevated tank must be designed to remove snow via tank geometry and therefore snow build up clogging vents is not anticipated to be a concern.

iii. For water hauler tanks (see Section 7.4), all vent openings must be a minimum of 6-inches above the top of the tank.

iv. For tanks inside buildings, all vent openings must be at or above the highest point in the tank. Vent screens are required inside buildings.

g. Tank designs may, but are not required to, include a vent with integrated pressure and/or vacuum release mechanisms. AWWA Standards recommend vents with integrated pressure and/or vacuum release mechanisms for steel tanks but they also may be used on other types of tanks. When used, vents with integrated pressure and/or vacuum release mechanisms must be designed to be normally closed to prevent contamination from entering the tank. Any integrated pressure and/or vacuum release vent design must include: a gasket on all mechanism interfaces (e.g., doors, plates – i.e., no metal to metal seals when the pressure and/or vacuum release mechanism (door/plate) is closed), 4 mesh screen covering any openings to/from the integrated pressure and/or vacuum release mechanism to prevent the mechanism from being inadvertently held open (i.e., when the pressure and/or vacuum release mechanism is open, there is 4 mesh screen protecting the opening), and appropriate screen (see Item 7.0.9(e)(i)) on all main vent openings (i.e., the permanent vent openings).

7.0.10 Roof and Sidewall

a. Water storage tank walls must be watertight with no openings except properly constructed pipe penetrations and manways.
b. Water storage tank roofs, including the wall to roof joint, must be watertight with no openings except: properly constructed vents, access openings, equipment openings, pipe penetrations, pump mountings, or control ports. Particular attention must be given to the sealing of roof structures which are not integral to the tank body.
c. Pipe penetrations through water storage tank walls or roof must be watertight. Pipe penetrations must be detailed with sufficient flexibility to accommodate differential movement between the pipe and the tank. For steel water storage tanks, pipe penetrations through the roof or wall must be welded when possible.
d. Openings in the water storage tank roof that are designed to accommodate control apparatus or pump columns must be curbed and sleeved with proper additional shielding to prevent contamination from surface or floor drainage.
e. Valve stems and similar projections that pass through the roof or top of the water storage tank, for valves and controls located inside the water storage tank, must be watertight.
f. Water storage tank roofs must be sloped to facilitate drainage. Downspout and/or drain pipes must not enter or pass through the protected water storage tank. Parapets, or similar construction which would tend to hold water and snow on the roof, will not be approved unless adequate waterproofing and drainage are provided.
g. Concrete water storage tank roofs with an earthen cover must be sloped to facilitate drainage. Consideration should be given to installation of an impermeable membrane roof covering. All cracks in the concrete storage tank roof must be repaired prior to placing soil on the roof.
    i. Pre-cast concrete roof structures with roof joints are not acceptable.

7.0.11 Construction Materials

Water storage tanks construction materials must conform to Section 2.21. Porous materials, including wood and concrete block, are not suitable for potable water storage applications and must not be used.

7.0.12 Safety

Safety must be considered in the water storage tank design. The design must conform to pertinent laws and regulations of the area where the water storage tank is constructed. The Department expects that the tank design be consistent with any relevant OSHA standard.

a. All water storage tanks must have safety provisions that allow for routine inspections and, if applicable, inspections required under Section 11.28 of Regulation 11 (i.e., Storage Tank Rule). The design must allow access to: vents, roof hatches, overflow lines, inlet, outlets, etc.

b. Ladders, ladder guards, balcony railings, stairs, and safely located entrance hatches must be provided where applicable. Access to roof hatches and vents must be provided. When a fixed ladder is used, with no lockable ladder guard, the bottom must be located at least 12 feet above ground . When a fixed ladder is used, with a lockable guard, the ladder may go to the ground.

c. Confined space entry requirements must be considered for all water tanks.

d. Elevated tanks with riser pipes over eight inches in diameter must have protective bars over the riser openings inside the tank.

e. Elevated tanks must have railings or handholds where persons must transfer from the access tube to the water compartment. Fall protection is expected to be provided.

7.0.13 Freezing

a. Protected water storage tanks and their appurtenances, especially the riser pipes, overflows, and vents, must be designed to prevent freezing which will interfere with proper functioning. Over-sizing venting capacity is recommended to prevent freezing issues.

b. If a water circulation system is used, it is recommended that the circulation pipe be located separately from the inlet pipe. Circulation systems must conform with Section 4.12.

7.0.14 Internal Catwalk

Catwalks located in protected water storage tanks must have a solid floor with sealed raised edges, designed to prevent contamination from shoe scrapings and dirt.

7.0.15 Silt Stop

Outlet pipes on water storage tanks must be designed to prevent sediment from entering the distribution system. The outlet must have a minimum four inch (4-inch) high silt stop.

- Tanks less than 11,000 gallons are exempt from this requirement (Item 7.0.15).

7.0.16 Grading

The area surrounding a ground-level or buried water storage tank must be graded in a manner that will prevent surface water from standing within 50 feet of the tank.

7.0.17 Painting and/or Cathodic Protection

Proper protection must be given to metal surfaces by a protective coating. Cathodic protection systems may be used in conjunction with a protective coating system.

a. Protective coating systems must meet Section 2.21. In addition, storage tanks interior coatings must be applied, cured, and used in a manner consistent with the ANSI/NSF approval and manufacturer recommendations.

b. Coating systems must meet the requirements of AWWA D102 “Coatings Steel Water Storage Tanks”.

c. Cathodic protection must be designed and installed by competent technical personnel. The system must be designed to resist freezing of the water inside the tank and be adequately maintained.

7.0.18 Disinfection

Protected water storage must be disinfected in accordance with AWWA Standard C652 and Section 2.15.

7.0.19 Provisions for Sampling

Smooth-nosed sampling tap or taps should be provided to facilitate collection of water samples for both bacteriological and chemical analyses. If installed, sample taps should be easily accessible and protected against freezing.

7.0.20 Pressure Relief Valve

Tank designs may, but are not required to, include a pressure relief valve. When used, pressure relief valves must be designed to be normally closed to prevent contamination from entering the tank. Any pressure relief valve design must include: a gasket on all mechanism interfaces (e.g., doors, plates – i.e., no metal to metal seals when the pressure and/or vacuum release mechanism (door/plate) is closed), 4 mesh screen covering any openings to/from to prevent the mechanism from being inadvertently held open (i.e., when the mechanism is open, there is 4 mesh screen protecting the opening), and appropriate screen (see Item 7.0.9(e)) on all main openings (i.e., the permanent vent openings).

7.1 TREATMENT PLANT STORAGE

The applicable design standards of Section 7.0 must be followed for treatment plant storage.

7.1.1 Filter Washwater Tanks

Filter washwater tanks must be sized, in conjunction with available pump units and finished water storage, to provide the backwash water required by Item 4.3.1. Consideration must be given to the backwashing of several filters in rapid succession.

7.1.2 Clearwells (Storage tanks used for disinfection contact volume)

Clearwells are storage tanks used for disinfection contact volume and must meet Item 4.4.3 in addition to the Chapter 7 requirements.

7.1.3 Adjacent Storage

Finished or treated water must not be stored or conveyed in a compartment adjacent to untreated or partially treated water when the two compartments are separated by a single, common wall.

7.1.4 Other Treatment Plant Storage Tanks

Other treatment plant storage tanks/basins such as detention basins, backwash reclaim tanks, receiving basins and pump wet-wells for finished water must be designed as protected water storage structures if the destination of the water contained within is meant for a location in the process that will not receive full treatment.

7.2 HYDROPNEUMATIC TANK SYSTEMS

Hydropneumatic (pressure) tanks, when provided as the only water storage, are acceptable only in non-community water systems serving less than 500 people. Hydropneumatic tank storage is not recommended for fire protection purposes. Pressure tanks must meet ASME code requirements or an equivalent requirement of state and local laws and regulations for the construction and installation of unfired pressure vessels. Non-ASME, factory-built hydropneumatic tanks may be allowed if approved by the Department.

7.2.1 Location

a. The tank must be located above normal ground surface and be completely housed.

b. Hydropneumatic tanks must be located downstream of chlorine disinfection

7.2.2 System Sizing

a. The capacity of the wells and pumps in a hydropneumatic system must be at least ten times the average daily consumption rate.

b. The gross volume of the hydropneumatic tank, in gallons, should be at least ten times the capacity of the largest pump, rated in gallons per minute. For example, a 250 gpm pump should have a minimum 2,500 gallon pressure tank, unless other measures (e.g., variable speed drives in conjunction with the pump motors) are provided to meet the maximum demand.

c. Sizing of hydropneumatic storage tanks must consider the need for disinfectant contact time. Hydropneumatic tanks with a common inlet and outlet may not be used for disinfectant contact time due to short-circuiting.

7.2.3 Piping

The hydropneumatic tank(s) must have isolation valves and bypass piping to permit easy removal and operation of the system while the tank is being repaired or painted. Banks of two or more hydropneumatic tanks must have piping configurations to minimize differential headloss between tanks and encourage similar hydraulics to produce tank turnover.

7.2.4 Appurtenances

Air- water interface and bladder, bag or diaphragm tanks:

a. Each tank must have an isolation valve, a drain, and control equipment consisting of a pressure gauge, automatic or manual air blow-off, dedicated means for adding clean air (air water interface only - oil less air compressors are required), and pressure operated start-stop controls for the pumps.

b. A pressure relief valve must be installed and be capable of handling the full pumpage rate of flow at the pressure vessel design limit. Smaller tanks (120 gallons or less) may not require a pressure relief valve as long as the pressure is less than rated capacity of the tank.

c. In addition, air-water interface tanks must have a water sight glass, and access manhole. Where practical, the access manhole should be 24 inches in diameter.

7.3 DISTRIBUTION SYSTEM STORAGE

The applicable design standards of Section 7.0 must be followed for distribution system storage.

7.3.1 Not Used

7.3.2 Drainage See 7.0.5

7.3.3 Level Controls

Adequate controls must be provided to maintain levels in distribution system finished water storage tanks.

Level indicating devices must be provided, accessible at a central location.

a. Pumps should be controlled from tank levels with the signal transmitted by telemetry equipment when any appreciable head loss occurs in the distribution system between the entry point and the storage structure.

b. Altitude valves or equivalent controls may be required for secondary and subsequent structures on the system.

c. Overflow and low-level warnings or alarms must be provided and able to notify water system staff.

    - Tanks less than 11,000 gallons are exempt from this requirement (Item 7.3.3(c))

7.4 WATER HAULER TANKS

Water Hauler Tanks and companies that operate them are considered public water systems and suppliers of water when they meet the appropriate definitions within the Regulation 11. Water hauler tanks are considered protected storage tanks for purposes of the application of Design Criteria regardless of where the hauled water is introduced into the process. For example, if finished drinking water is hauled but added to a tank that it used for disinfection contact time, while this is before the entry point all criteria still apply for review and approval.

7.4.1 Acceptable Materials

a. Water hauler tanks must only be used for potable water.

b. Tank and hose materials must meet Section 2.21.

c. The hauler truck must have enclosed containers for storing hoses during transport. Each hauler tank must have a dedicated hose to prevent contamination. Equipment storage must have a locking device to prevent tampering.

d. A dedicated pump must be used if a pump is necessary for emptying the tank (food grade lubricants, clean). The pump must be enclosed or sealed while not in use.

7.4.2 Drain and Fill Lines

No drain on a water hauler tank may be directly connected to a sewer or storm drain. The use of air gap devices must be specified on drain and fill lines.

7.4.3 Vents

Water hauler tanks must be vented. Open construction between the sidewall and roof is not permissible. Vents must meet the requirements of Item 7.0.9.

7.4.4 Disinfection

Finished water storage must be disinfected in accordance with AWWA Standard C652 and Section 2.15.

7.4.5 Provisions for Sampling

Smooth-nosed sampling tap or taps should be provided to facilitate collection of water samples for both bacteriological and chemical analyses. If installed, sample taps should be easily accessible and protected against freezing.

7.4.6 Access

Water hauler tanks must be designed with convenient access to the tank interior for cleaning and maintenance. Water hauler tanks must have at least one access opening above the waterline at each water compartment.

a. The access opening must be designed to protect the tank from contaminants such as: surface water, stormwater runoff, insects, rodents, and birds.
b. The access openings must be framed at least four inches above the surface of the roof at the opening.
c. Access hatches must be fitted with a solid, water and insect tight, gasketed cover which overlaps the frame opening and extends down around the frame to fit tight, must be hinged on one side and have a locking device.
    - Tanks less than 11,000 gallons are not required to have an overlapping cover but must have solid, water and insect tight, gasketed cover.

7.4.7 Backflow prevention

To prevent contamination of water during delivery, an acceptable backflow prevention assembly (e.g., reduced pressure zone assembly (RPZ)) or method (e.g., airgap (AG)) between the receiving water tank and the haul tank delivery hose/pipe must be provided.

CHAPTER 8
DISTRIBUTION SYSTEM PIPING AND APPURTENANCES

8.0 GENERAL

Water distribution systems must be designed to maintain treated water quality. Special consideration should be given to distribution main sizing, providing for design of multidirectional flow, adequate valving for distribution system control, and provisions for adequate flushing. Systems should be designed to maximize turnover and to minimize residence times while delivering acceptable pressures and flows. In this chapter the term "water main" means untreated groundwater, partially treated groundwater, and finished potable water mains.

8.1 MATERIALS

8.1.1 Standards for Material Selection

a. All materials including pipe, fittings, valves and fire hydrants and those used for the rehabilitation of water mains must conform to the latest standards issued by the ASTM, AWWA and ANSI/NSF, where such standards exist, and be acceptable to the Department.

b. In the absence of such standards, materials meeting applicable product standards and acceptable to the Department may be selected.

c. Special attention must be given to selecting pipe materials which will protect against both internal and external pipe corrosion.

d. Pipes and pipe fittings must not contain more than 0.25% lead.

e. All materials used for the rehabilitation of water mains must meet Section 2.21.

8.1.2 Permeation by Organic Compounds

Where distribution systems are installed in areas of groundwater contaminated by organic compounds, materials which do not allow permeation of the organic compounds must be used for all portions of the system including, pipe, joint materials, hydrant leads, and service connections.

8.1.3 Reused Materials

Water mains and appurtenances which have been used previously for conveying potable water may be reused provided they comply with all applicable sections of this Chapter and have been restored practically to their original condition.

8.1.4 Joints

Packing and jointing materials used in the joints of pipe must meet the standards of AWWA and the Department. Pipe with mechanical joints or slip-on joints with rubber gaskets is preferred. Gaskets containing lead must not be used. Manufacturer approved transition joints must be used between dissimilar piping materials.

8.2 SYSTEM DESIGN

8.2.1 Pressure

All water mains, including those not designed to provide fire protection, must be sized after a hydraulic analysis based on flow demands and pressure requirements. The system must be designed to maintain a minimum pressure of 20 psi (140 kPa) at ground level at all points in the distribution system under all conditions of flow. The normal working pressure in the distribution system must be at least 35 psi (240 kPa) and should be approximately 60 to 80 psi (410 - 550 kPa). Near storage tanks, the water main pressure maybe less than the required pressures stated above. The Department expects water systems to mitigate the low pressure around storage tanks and to minimize the amount of distribution main impacted.

8.2.2 Diameter

The minimum size of water main which provides for fire protection and serving fire hydrants must be six-inch diameter. Larger size mains will be required if necessary to allow the withdrawal of the required fire flow while maintaining the minimum residual pressure specified in Item 8.2.1.

The minimum size of water main in the distribution system where fire protection is not to be provided must be a minimum of three (3) inch diameter. Any departure from minimum requirements must be justified by hydraulic analysis and future water use, and can be considered only in special circumstances.

8.2.3 Fire Protection

When fire protection is to be provided, system design should be such that fire flows and facilities are in accordance with the requirements of the appropriate regulatory authority (e.g. Insurance Services Office, ISO).

8.2.4 Dead Ends

a. Dead ends must be minimized by making appropriate tie-ins whenever practical, in order to provide increased reliability of service and reduce head loss.

b. Dead end mains must be equipped with a means to provide adequate flushing. Flushing devices should be sized to provide flows which will give a velocity of at least 2.5 feet per second in the water main being flushed. They may be provided with a fire hydrant if flow and pressure are sufficient. Flushing devices must not be directly connected to any sewer.

8.3 VALVES

A sufficient number of valves must be provided on water mains to minimize inconvenience and sanitary hazards during repairs. Valves must be located at not more than 600 foot intervals in developed areas. Where blocks exceed 600 feet in length or when two or more hydrants are connected to the same main, additional valves are required. Where systems serve widely scattered customers and where future development is not expected, the valve spacing should not exceed one mile.

8.4 HYDRANTS

8.4.1 Locations and Spacing

a. Fire hydrants should be provided at each street intersection and at intermediate points between intersections as recommended by the agency having jurisdiction.

b. Water mains not designed to carry fire-flows must not have fire hydrants connected to them. It is recommended that flushing devices be provided on these systems. Flushing devices should be sized to provide flows which will give a velocity of at least 2.5 feet per second in the water main being flushed. No flushing device must be directly connected to any sewer.

8.4.2 Valves and Nozzles

Fire hydrants should have a bottom valve size of at least five inches, one 4-½ inch pumper nozzle and two 2-½ inch nozzles.

8.4.3 Hydrant Leads

The hydrant lead must be a minimum of 6-inches in diameter. Auxiliary valves must be installed on all hydrant leads.

8.4.4 Hydrant Drainage

Hydrants must include one or more drain valves that work automatically with the main valve to drain the barrel when the main valve is in the closed position. Drain tubes must be large enough for the barrel to drain within a reasonable amount of time. A gravel pocket or dry well must be provided unless the natural soils will provide adequate drainage.

8.5 AIR RELIEF VALVES

8.5.1 Air Release/Relief Valves

Air release/relief valves may be required to be installed at high points in water mains where air can accumulate and no provisions exist to remove air via hydrants or service lines. Automatic air release/relief valves must not be used in situations where flooding may occur unless equipped with an inflow preventer conforming to AWWA C514.

8.5.2 Air Release/Relief Valve Piping

a. Air release/relief valves installed below grade must be installed in chambers, pits or manholes. An air relief pipe must be installed to vent air to the atmosphere. The open end of an air relief pipe from automatic valves must be extended to at least one foot above grade or above typical snow depth, whichever is greater, and must be designed to prevent infiltration of rain and insects. However, there may be situations where the design engineer and/or the supplier of the water determines it is not practical or desired to extend the open end of an air relief pipe to at least one foot above grade or above typical snow depth, whichever is greater (e.g., vault in a parking area, water getting trapped in the vent pipe, etc.). In these situations, the design engineer and/or the supplier of the water may provide other solutions that they consider to provide equivalent protection to the potable water. These solutions may include one or more of the following: 1) provide a screened drain in the bottom of the chamber, pit, manhole or vault that discharges to the ground surface or outside atmosphere; 2) provide an automatic sump pump with floats in the vault that discharges to the ground surface or outside atmosphere when activated; 3) provide a water level monitoring or leak detection system in the vault that notifies the supplier that water is accumulating in the vault and must be removed (pumped or vacuumed out); 4) provide an inspection program whereby the supplier of water routinely inspects the vault for indications of water accumulating in the vault and records the result of each inspection (if inspections indicate that water is accumulating in the vault, then a different solution must be implemented), 5) equip the air release/relief piping with an inflow preventer conforming to AWWA C514.

b. Discharge piping from air relief valves must not connect directly to any storm drain, storm sewer, or sanitary sewer.

8.6 VALVE, METER, AND BLOW-OFF CHAMBERS

Wherever possible, chambers, pits or manholes containing valves, blow-offs, meters, or other such appurtenances to a distribution system, must not be located in areas subject to flooding or in areas of high groundwater. Such chambers or pits should drain to the ground surface, or to absorption pits underground. The chambers, pits and manholes must not connect directly to any storm drain or sanitary sewer. Blow-offs must not connect directly to any storm drain or sanitary sewer.

8.7 INSTALLATION OF WATER MAINS

8.7.1 Standards

Specifications must incorporate the provisions of the AWWA standards and/or manufacturer's recommended installation procedures.

8.7.2 Bedding

Continuous and uniform bedding must be provided in the trench for all buried pipe. Granular backfill material must be tamped in layers around the pipe and to a sufficient height above the pipe to adequately support and protect the pipe. Stones found in the trench must be removed for a depth of at least six inches below the bottom of the pipe. Alternatively, pipe may be bedded using controlled low strength material (e.g., flowable fill) to provide equivalent support for the pipe as granular backfill.

8.7.3 Cover

Water mains must be covered with sufficient earth or other insulation to prevent freezing.

8.7.4 Blocking

All tees, bends, plugs and hydrants must be provided with reaction blocking, tie rods or joints designed to prevent movement.

8.7.5 Anchoring of Fusible Pipe

Additional restraint may be necessary on fusible pipe at the connection to appurtenances or transitions to different pipe materials to prevent separation of joints. The restraint may be provided in the form of an anchor ring encased in concrete or other methods as approved by the Department.

8.7.6 Pressure and Leakage Testing

Installed pipe must be pressure tested and leakage tested in accordance with the appropriate AWWA Standards.

8.7.7 Disinfection

New, cleaned and repaired water mains must be disinfected in accordance with AWWA Standard C651. The specifications must include detailed procedures for the adequate flushing, disinfection, and microbiological testing of all water mains. Method of disposal of chlorinated water must be specified. In an emergency or unusual situation, the disinfection procedure must be discussed with the Department.

8.7.8 External Corrosion

If soils are found to be aggressive, the water main must be protected by encasement in polyethylene, the provision of cathodic protection (in very severe instances), or the use of corrosion resistant water main materials.

8.7.9 Separation from Other Utilities

Water mains should be installed to ensure adequate separation from other utilities such as electrical, telecommunications, and natural gas lines for the ease of rehabilitation, maintenance, and repair of the water main.

8.8 SEPARATION DISTANCES FROM CONTAMINATION SOURCES

8.8.1 General

The following factors should be considered in providing adequate separation:

a. Materials and type of joints for water, sewer (sanitary and storm), raw surface water, reclaimed water, and liquid petroleum pipes.

b. Soil conditions.

c. Service and branch connections into the water and sewer pipes.

d. Compensating variations in the horizontal and vertical separations.

e. Space for repair and alterations of water and sewer pipes.

f. Off-setting of water pipes around sewer manholes.

8.8.2 Parallel Installation

a. Water mains must be laid at least 10 feet horizontally from any existing or proposed non-potable pipe or source such as gravity sanitary or storm sewer, raw surface water pipes, reclaimed water pipes, liquid petroleum pipes, septic tank, or subsoil treatment system. The distance must be measured edge to edge.

8.8.3 Crossings

a. Water mains crossing a non-potable pipe (e.g., gravity sanitary or storm sewers, raw surface water pipes, reclaimed water pipes, and liquid petroleum pipes) must be laid to provide a minimum vertical distance of 18 inches between the outside of the water main and the outside of the non-potable pipe (e.g., gravity sanitary or storm sewer, raw surface water pipe, reclaimed water pipe, and liquid petroleum pipe). This must be the case where the water main is either above or below the sewer with preference to the water main being located above the non-potable pipe.

b. At crossings, one full length of water pipe must be located so both joints will be as far from the non-potable pipe as possible. Special structural support for the water and non-potable pipe may be required.

8.8.4 Exception

When it is impossible to obtain the minimum 10 foot horizontal separation distance of Item 8.8.2, the following methods of installation may be used:

a. Exceptions to the horizontal separation distance are allowed, provided that the water main is laid in a separate trench or on an undisturbed earth shelf located on the “uphill” side of the non-potable pipe at such an elevation that the bottom of the water main is at least 18 inches above the top of the non-potable pipe. The non-potable pipe materials must be water works grade 150 psi (1.0 Mpa) pressure rated pipe meeting AWWA standards or similar and must be pressure tested to ensure water tightness.

b. The design engineer (i.e., Colorado registered professional engineer) may deviate from the minimum 10 foot horizontal separation distance and the exception listed above if the design engineer provides a similar solution that can be justified to provide equivalent protection to the water from contamination.

When it is impossible to obtain the minimum 18 inch vertical separation distance of Item 8.8.3, the following methods of installation may be used:

c. If the non-potable pipe will cross less than 18 inches above or under the water main, either the water main or sewer pipe must be installed with secondary containment. Acceptable options include a pipe casing extending no less than 9-feet each side of the crossing. The pipe casing must be of watertight material with no joints. The casing pipe materials may be steel, ductile iron, fiberglass, fiberglass reinforced polymer mortar (FRPM), or polyvinylchloride (PVC) with suitable carrier pipe supports and casing pipe end seals. The design must include a means to support the non-potable pipe to prevent settlement and permit maintenance of the water main without damage to the non-potable pipe or water main. Alternatively, concrete or controlled low strength material (e.g., flowable fill) encasement of either pipe extending no less than 10-feet each side of the crossing may be used. Crossings involving jointless pipe such as HDPE, fusible PVC or welded steel do not require installation of secondary containment.

d. The design engineer (i.e., Colorado registered professional engineer) may deviate from the minimum 18 inch vertical separation distance and the exception listed above if the design engineer provides a similar solution that they consider to provide equivalent protection to the water from contamination.

8.8.5 Not Used

8.8.6 Sewer Manholes

Water pipes must not pass through or come in contact with any part of a sewer manhole. Water mains should be located at least 10 feet from sewer manholes.

8.8.7 Separation of Water Mains from Other Sources of Contamination

Design engineers should exercise caution when locating water mains at or near certain sites such as wastewater treatment plants or industrial complexes. On site waste disposal facilities including absorption fields must be located and avoided. The engineer must contact the Department to establish specific design requirements for locating water mains near any source of contamination.

8.9 SURFACE WATER CROSSINGS

Surface water crossings, whether over or under water, present special problems. The Department should be consulted before final plans are prepared.

8.9.1 Above-Water Crossings

The pipe must be adequately supported and anchored, protected from vandalism, damage and freezing, and accessible for repair or replacement.

8.9.2 Underwater Crossings

A minimum cover of five feet must be provided over the pipe unless otherwise approved by the Department. When crossing water courses which are greater than 15 feet in width, the following must be provided:

a. The pipe must be of special construction, having flexible, restrained or welded watertight joints.

b. Valves must be provided at both ends of water crossings so that the section can be isolated for testing or repair; the valves must be easily accessible, and not subject to flooding.

c. Permanent taps or other provisions to allow insertion of a small meter to determine leakage and obtain water samples on each side of the valve closest to the supply source.

8.10 CROSS-CONNECTIONS AND INTERCONNECTIONS

8.10.1 Cross-Connections

There must be no connection between the distribution system and any pipes, pumps, hydrants, or tanks whereby unsafe water or other contaminating materials may be discharged or drawn into the system. Each water utility must have a program conforming to Section 11.39 of Regulation 11 (i.e., Backflow Prevention and Cross-connection Control Rule).

8.10.2 Cooling Water

Neither steam condensate, cooling water from engine jackets, nor water used in conjunction with heat exchange devices must be returned to the potable water supply.

8.10.3 Interconnections

The approval of the Department must be obtained for interconnections between potable water supplies. Consideration should be given to differences in water quality.

8.11 WATER SERVICES AND PLUMBING

8.11.1 Plumbing

Water services and plumbing must conform to the applicable local and/or state plumbing codes. Refer to Section 2.21 for information regarding material requirements.

8.11.2 Booster Pumps

Booster pumps must be designed in accordance with Chapter 6.

8.12 SERVICE METERS

Each domestic service connection should be individually metered.

8.13 WATER LOADING STATIONS

Water loading stations present special problems since the fill line may be used for filling both potable water vessels and other tanks or contaminated vessels. To prevent contamination of both the public supply and potable water vessels being filled, the following principles must be met in the design of water loading stations:

a. There must be no backflow to the public water supply.

b. The piping arrangement must prevent contaminant being transferred from a hauling vessel to others subsequently using the station.

c. Filling hoses attached to the station must not be contaminated by contact with the ground.

Acceptable Water Loading Station
See Section 8.13

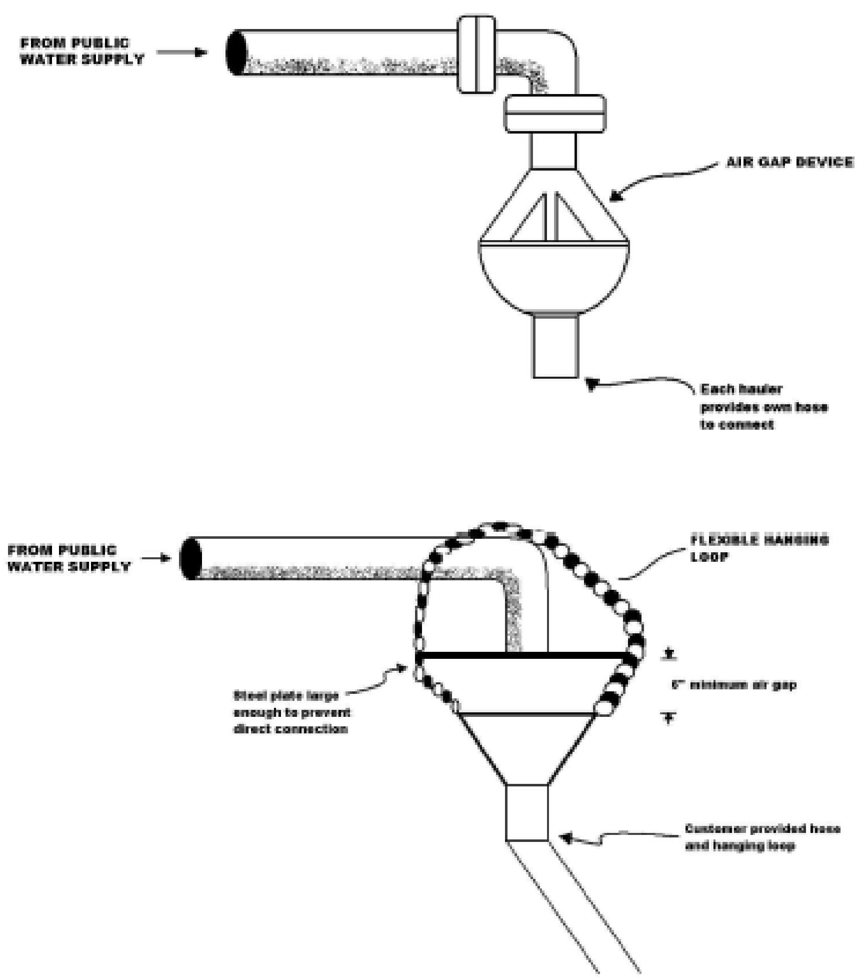

Figure 8.1 Acceptable water loading stations

CHAPTER 9
WASTE RESIDUALS

9.0 GENERAL

All residual waste discharges and waste disposal must be in accordance with all federal, state and/or local laws and ordinances. The requirements outlined herein must, therefore, be considered minimum requirements as federal, state, and/or local water pollution control authorities have more stringent requirements.

For all projects, the BDR must include an evaluation and plan that includes a discussion of residuals management, including as applicable:

a. Expected waste stream generation quantities and anticipated physical and chemical characteristics for both wastewater discharges and waste materials.

b. Calculations, filter run time assumptions, wash water assumptions, pilot study data, or other information to estimate capacity of designed waste material handling units (e.g., pipes, pumps, containers, basins, storage volumes). For example, capacity to maintain reliable water plant operation capable of containing the volume of wash water produced based on the schedule for filter cleaning.

c. Design for appropriate process waste concentrations based on proposed water treatment percent solids unless higher concentrations are documented with full-scale operational data or pilot study results.

d. Adequate capacity to store and process the waste materials under maximum and minimum flow conditions. BDR must include a summary of operating considerations for those designs where capacity is dependent on specific operating scenarios and must identify operating plan(s) or standard operating procedures (SOPs) that will be developed.

e. Redundant waste handling systems (e.g., two pumping units, containers, basins) or other methods providing operating flexibility to conduct waste system maintenance without impacting the ability to produce treated water (e.g., parallel units).

f. If waste handling includes storage in open units located outside the water treatment plant that are exempt from or are not classified as an impoundment under Section 9 (Waste Impoundment) of the *Colorado Regulations Pertaining to Solid Waste Disposal Sites and Facilities 6 CCR 1007-2* (Reference 23) (e.g., backwash ponds with recycle exempted as water treatment process units) the design must provide:

    i. Documentation that the waste handling units will be accessible and protected from physical damage during the 100-year flood (e.g., floodplain as designated by FEMA or other local flood mapping management agency) so the drinking water treatment facility can continue to function.

    ii. Methods to divert storm water or snowmelt runoff around the unit.

    iii. Methods to dissipate flow velocity at unit inlet.

    iv. Freeboard of at least 2 feet from the normal design water surface elevation to the crest of the embankment.

    v. Side slopes must be constructed at a ratio of 3 horizontal to 1 vertical unless a geotechnical investigation indicates that a flatter slope is required to attain slope stability and prevent slope sloughing. Steeper side slopes may be allowed on a case-by-case basis when documented with a slope stability analysis.

vi. Corner configurations must be rounded to mitigate the accumulation of floating solids and scum in the corners of the cells. The degree of rounding will be dependent upon the basin depth and overall pond dimensions.

vii. Yard piping and flow controls.

  a. All yard piping must be capable of conveying design flow rates in accordance with appropriate hydraulic design criteria.

  b. Yard piping must be arranged such that any given impoundment can be bypassed for maintenance and adjustment of hydraulic loading.

  c. Level control structures will be provided to maintain consistent and adjustable water surface elevations in each impoundment.

viii. Influent flow measurement and recording facilities must be provided.

ix. Inlet piping must discharge into each cell near the bottom to preclude erosion of the side slope and cell bottom. At the point of discharge, an erosion-resistant surface (e.g., cast-in-place concrete, grouted rock or grouted waste concrete riprap, multiple layers of synthetic liner material) must be provided to preclude any erosion around the discharge point.

x. Erosion control must be accomplished to preserve the original design and constructed side slope and bottom configurations of the ponds. Erosion control must be accomplished with erosion-resistant material including, but not necessarily limited to, impervious membrane material, suitably sized rock riprap, suitably sized reclaimed concrete pieces, or cast-in-place concrete. Native grass and/or other vegetation on the treatment cell side slopes will not be deemed a suitable permanent erosion protection.

xi. Detailed on-site geotechnical investigations, field permeability and analysis and laboratory permeability and geotechnical evaluations may be required to confirm the suitability of on-site, native soil materials, with or without soil amendments, to demonstrate the seepage from the impoundment does not exceed 1 X 10^6 cm/sec. In lieu of seepage control as described above, an appropriate synthetic geomembrane material may be proposed. The membrane material must have the following minimum thicknesses to best assure longevity and assurance of seepage control with material properties consistent with the referenced standards from the Geosynthetic Research Institute (GRI).

- Reinforced linear low density polyethylene (LLDPE-R): 45 mils (GRI-GM25).
- Reinforced polypropylene (fPP-R): 45 mils (GRI-GM-18).
- High density polyethylene (HDPE): 60 mils (GRI-GM13).
- Linear low density polyethylene (LLDPE): 60 mils (GRI-GM17).
- Reinforced chlorosulfonated polyethylene (CSPE-R): 45 mils (GRI-GM28).
- Reinforced composite polyethylene (RCPE): 40 mils (GRI-GM30).
- Ethylene propylene diene monomer (EPDM): 45 mils (GRI-GM21).

xii. Documentation of appropriate depth for maximum and minimum design operating conditions to ensure the ability to produce treated water.

xiii. Volume of at least 10 times the total quantity of wash water discharged during a 24-hour period (unless lower volumes are documented with full-scale operational data or pilot study results).

xiv. Weir overflow device at an outlet with a weir length equal to or greater than unit depth.

g. If recycling of decant water is anticipated, provide adjustable decant methods and adjustable decant return rates, and recycle to the raw water side of the treatment process. Maximum design recycle rate must be less than 10 percent of the instantaneous raw water flow rate entering the water treatment plant.

h. A discussion of the method(s) used to convey, remove, and handle waste sludge and anticipated method of final sludge disposal.

Design approval will not be provided if appropriate waste handling is not described, including identification of anticipated discharge or impoundment permits, if needed. Provisions must be made for proper disposal or discharge of all anticipated water treatment facility wastes such as sanitary and laboratory wastes, clarification sludge, softening sludge, iron sludge, filter backwash water, backwash sludge, and brines (including softener, ion exchange regeneration wastes, and membrane wastes). Pilot studies may be warranted to determine waste handling and management strategies.

Discharge of treated potable water from distribution overflow pipes/outlets does not require a discharge permit from the Department if the provisions in the “Low Risk Discharge Guidance: Discharges of Potable Water, Clean Water Policy WQP27” (Reference 24) are followed. In locating sewer lines and waste disposal facilities, consideration must be given to preventing potential contamination of the water supply. Appropriate backflow prevention measures must be provided on waste discharge piping as needed to protect the public water supply.

9.1 SANITARY WASTE

The sanitary waste from water treatment plants, pumping stations, and other waterworks installations must receive treatment. Waste from these facilities must be discharged directly to a sanitary sewer system, when available and feasible, or to an adequate on-site waste treatment facility approved by the appropriate Department. The appropriate federal, state, and local officials must be notified when designing treatment facilities to ensure that the intended sanitary waste system can accept the anticipated wastes.

9.2. TREATMENT WASTE DISCHARGES

Treatment process waste discharges vary in quantity and in chemical characteristics depending on the treatment process and the chemical characteristics of the water being treated. Requirements for proper discharge management similarly vary by the wastewater discharge, the amount of pretreatment (e.g., dewatering, holding/flow equalization), and the type of discharge (e.g., to sanitary sewer, to surface water, to groundwater, to an impoundment). Potential requirements to be considered in the waste disposal and discharge evaluation and plan are described in this section.

9.2.1 Discharges to Sanitary Sewer

Discharge of drinking water treatment process wastes to a sanitary sewer is an industrial discharge subject to acceptance, possibly through a pretreatment permit, by the respective domestic wastewater treatment facility. For designs expecting sanitary sewer discharge of industrial wastes, the BDR must include acceptance of the industrial wastewater by the domestic wastewater treatment facility and any pretreatment processes necessary for the discharge (e.g., flow equalization, chemical pretreatment, filtering) with a management plan for associated pretreatment wastes, if any. For a domestic wastewater treatment facility without an EPA-approved pretreatment program, the industrial discharge may need to receive a pretreatment permit from the Water Quality Control Division (WQCD) Permits Section in accordance with *Regulation No. 63 Pretreatment Regulations* 5 CCR 1002-63 (Reference 25). Information regarding surface discharge permits is available at: https://cdphe.colorado.gov/water-quality-permits.

9.2.2 Discharges to Surface Water

The WQCD remains the sole regulatory authority over discharges to surface water. Discharge to surface water from: 1) a treatment facility, 2) an intermediate waste impoundment (as clarified below), or 3) from an unlined impoundment that is hydraulically connected with an adjacent creek/stream, requires a discharge permit from the Permits Section of the WQCD. Information regarding surface discharge permits is available at: https://cdphe.colorado.gov/water-quality-permits.

Discharges from an intermediate impoundment vary depending on design intent at the particular facility. Discharges to surface water that are anticipated during normal operations (e.g., expected, regular, periodic, seasonal) require a discharge permit. For impoundments that have design provisions for an emergency overflow during an extreme event (e.g., a high level spillway, extremely rare precipitation events) but are designed to not have a planned discharge to surface water, a discharge permit is not required. An overflow from this type of impoundment, if any, would be expected to be handled as a spill or unauthorized discharge with State notification at the time of the discharge. Please note that these requirements are related to the discharge to surface water from the impoundments. Impoundment requirements are discussed further in Item 9.2.4 below.

9.2.3 Discharges to Groundwater

Industrial (i.e., non-domestic) waste discharge to groundwater through an on-site wastewater treatment system distribution field or an injection well are subject to regulation by the U.S. Environmental Protection Agency under the Underground Injection Control (UIC) program. Additional information is available at the EPA Region 8 UIC website at: http://www.epa.gov/region8/water/uic/classv.html.

9.2.4 Discharges to Impoundments

Industrial waste impoundments, including sludge drying beds and sludge drying pads, and some water treatment backwash ponds, are subject to regulation by the Hazardous Materials Waste Management Division (HMWMD) of CDPHE under Section 9 (Waste Impoundment) of the *Colorado Regulations Pertaining to Solid Waste Disposal Sites and Facilities 6 CCR 1007-2* (Reference 23). The Section 9 regulations require water treatment systems managing waste impoundments to be evaluated to determine the appropriate design and permitting requirements for the impoundment.

If an impoundment is subject to the Section 9 regulations, residual discharge and handling must be evaluated in accordance with the Section 9 regulations.

Additional information is available at: https://cdphe.colorado.gov/swregs, select “Regulations Pertaining to Solid Waste Sites and Facilities: 6 CCR 1007-2 Part 1”.

If an impoundment is exempt from or not classified as an impoundment under the Section 9 regulations, see Item 9.0(f) above regarding the impoundment design.

9.2.5 Beneficial Reuse

Beneficial reuse of water treatment sludges is subject to regulation by the HMWMD of CDPHE under Section 8 (Recycling and Beneficial Use) of the Colorado Regulations Pertaining to Solid Waste Disposal Sites and Facilities 6 CCR 1007-2 and *Regulations Pertaining to the Beneficial Use of Water Treatment Sludge and Fees Applicable to the Beneficial Use of Sludges*," 5 CCR 1003-7 (Reference 26). Beneficial reuse of industrial waste materials other than sludges is subject to regulation under Section 8 (Recycling and Beneficial Use) of the *Colorado Regulations Pertaining to Solid Waste Disposal Sites and Facilities* 6 CCR 1007-2.

Additional information is available at: https://cdphe.colorado.gov/swregs, select "Regulations Pertaining to Solid Waste Sites and Facilities: 6 CCR 1007-2 Part 1".

9.2.6 Land Application

Land application of industrial wastes, including process wastewater, is subject to regulation by the HMWMD as beneficial reuse (see Item 9.2.5 above) when the application rate is less than the evapotranspiration rate. Land application regulated by HMWMD does not require a discharge permit through WQCD. Land application at a rate greater than the evapotranspiration rate requires a discharge permit from the Permits Section of the WQCD. Information regarding surface discharge permits is available at: https://cdphe.colorado.gov/water-quality-permits.

9.2.7 Radioactive Materials

Drinking water treatment processes may remove and/or concentrate radioactive elements directly (e.g., lower element concentration) or indirectly (e.g., iron filtration which removes precipitated iron and a portion of radium from the drinking water prior to distribution). Residuals from these treatment processes likely contain radioactive constituents, including precipitated iron that may also include radium. In these situations, the equipment (e.g., filters, impoundments) may also contain Technologically Enhanced Naturally Occurring Radioactive Materials (TENORM) and the system or their contractors may need licensure by the CDPHE's Radiation Management Program of the HMWMD to ensure the treatment and waste handling is conducted in accordance with the pertinent regulations.

Additional information regarding TENORM is available at: https://cdphe.colorado.gov/tenorm-reg-dev. If licensure is needed, Radiation Program information is available at: https://cdphe.colorado.gov/radioactive-materials-licensing.

9.2.8 Potable Water Discharges

Some potable water discharges (e.g., discharges from potable water monitoring devices, discharges of potable water) are allowed under the WQCD permits section low risk discharge policy (Reference 24). Discharge applicability is limited and the low risk discharge guidance must be followed.

Information regarding low risk discharge policy and associated low risk guidance are available at: https://cdphe.colorado.gov/clean-water-policies.

REFERENCES

1. Great Lakes – Upper Mississippi River Board of State and Provincial Public Health and Environmental Managers, *Recommended Standards for Water Works, 2018 Edition – Policies for the Review and Approval of Plans and Specifications for Public Water Supplies*. 2018. Document also referred to as the *10-States Standards*, https://www.health.state.mn.us/communities/environment/water/tenstates/standards.html

2. Colorado Department of Public Health and Environment (CDPHE), Water Quality Control Commission, *Regulation No. 11: Colorado Primary Drinking Water Regulations* (5CCR 1002 – 11) a.k.a. Regulation 11, Effective date September 30, 2020.

3. CDPHE Water Quality Control Division, Safe Drinking Water Program, Drinking Water Program Policy DW-011. *New Public Water System Capacity Planning Manual (NPWSCPM)*; June 2016.

4. Colorado Department of Regulatory Agencies, State Board of Licensure for Architects, Professional Engineers, and Professional Land Surveyors, *4 CCR 730-1 Architects, Professional Engineers, and Professional Land Surveyors Rules and Regulations*. Effective date October 30, 2021.

5. CDPHE Water Quality Control Division, Safe Drinking Water Program, "Policy 4 Guidance: Guidance on Proper Operations of Water Treatment Processes for the Control of Microbiological Contaminants." June 2019.

6. Colorado Water and Wastewater Facility Operators Certification Board. *Regulation 100: Water and Wastewater Facility Operators Certification Requirements*. Effective date May 2021.

7. U.S. Environmental Protection Agency, *EPA Guidance Manual for Compliance with the Surface Water Treatment Rules: Turbidity Provisions*. EPA 815-R-20-004. June 2020. https://www.epa.gov/sites/default/files/2020-06/documents/swtr_turbidity_gm_final_508.pdf

8. CDPHE Water Quality Control Division, Safe Drinking Water Program Policy DW-003 "Safe Drinking Water Program Policy DW-003, Determination of GWUDI of Surface Water". March, 2012.

9. Colorado Department of Natural Resources Division of Water Resources, Board of Examiners of Water Well Construction and Pump Installation Contractors, 2 CCR 402-2 *Rules and Regulations for Water Well Construction, Pump Installation, Cistern Installation, and Monitoring and Observation Hole/Well Construction*. Effective date July 1. 2018.

10. CDPHE Water Quality Control Division, Safe Drinking Water Program Policy DW-004 "Safe Drinking Water Program Policy DW-004, Surface Water Treatment Rule Performance Assessment, Proper Operation, and Fostering Improved Operations", October, 2010.

11. U.S. Environmental Protection Agency, *Membrane Filtration Guidance Manual* (MFGM), EPA 815-R-06-009, November, 2005.

12. U.S. Environmental Protection Agency, *Disinfection Profiling and Benchmarking Technical Guidance Manual*. EPA 815-R-20-003. June 2020.

13. CDPHE Water Quality Control Division, *Baffling Factor Guidance Manual Determining Disinfection Capability and Baffling Factors for Various Types of Tanks at Small Public Water Systems*. March 2014.

14. CDPHE Water Quality Control Division, *Technical Guidance Manual on Computational Fluid Dynamics Modeling of Chlorine Contact Basins - Determining Baffling Factors Through the Use of CFD Modeling*, March 2021.

15. U.S. Environmental Protection Agency, *Guidance Manual for Compliance with the Filtration and Disinfection Requirements for Public Water Systems Using Surface Water Sources*. EPA 68-01-6989. March 1991.

16. American Water Works Association Research Foundation, *Improving Clearwell Design for CT Compliance*. 1999.

17. California State Water Resources Control Board, Division of Drinking Water *Chlorine Contact Chamber Design and Flow Evaluation*. Version 1.24. 2019.

18. U.S. Environmental Protection Agency, *Ultraviolet Disinfection Guidance Manual (UVDGM) for the Final Long Term 2 Enhanced Surface Water Treatment Rule*,EPA 815-R-06-007. November, 2006.

19. ANSI/NSF International. *NSF/ANSI 55: Ultraviolet Microbiological Water Treatment Systems*.

20. U.S. Environmental Protection Agency, *Point-of-Use or Point-of Entry Treatment Options for Small Drinking Water Systems*, EPA 815-R-06-010. April 2006.

21. U.S. Environmental Protection Agency, *Cost Evaluation of Point-Of-Use and Point-of-Entry Treatment Units for Small Systems: Cost Estimating Tool and User Guide*, EPA 815-B-07-001. April 2007

22. Structural Engineers Association of Colorado (SEAC) Snow Load Committee. *Colorado Design Snowloads by the Structural Engineers Association of Colorado, ASCE Minimum Design Loads and Associated Criteria for Buildings and Other Structures (ASCE 7). April 2016.*

23. CDPHE Hazardous Materials and Waste Management Division, *Colorado Regulations Pertaining to Solid Waste Disposal Sites and Facilities 6 CCR 1007-2. Effective date January 14, 2022.*

24. CDPHE Water Quality Control Division, Clean Water Program, Water Quality Permits Policy WQP-27. “Low Risk Discharges”; June 2008.

25. CDPHE, Water Quality Control Commission, *Regulation No. 63: Pretreatment Regulations* (5CCR 1002 – 63), Effective date May March 1, 2017.

26. CDPHE Hazardous Materials and Waste Management Division, *Beneficial Use of Water Treatment Sludge and Fees Applicable to The Beneficial Uses of Sludges 5 CCR 1003-7. Effective date September 28, 2006.*

APPENDIX A
DESIGN REVIEW FIGURE AND MATRIX

The design submittal and review process are described in Chapter 1. Figure A.1 depicts a graphical representation of the process. Table A.1 Design Review Matrix specifies which types of projects need which type of review. Table A.2 Impacts to Corrosivity specify additional activities that will be required related to corrosion control.

APPENDIX B
DESIGN SUBMITTAL TEMPLATE

The Department has created a template for design approval including all the required elements of the BDR, plans, and specifications. Please follow the link to view the template in Microsoft Word.

APPENDIX C
PILOT AND DEMONSTRATION SCALE TEMPLATES

All demonstration scale projects must be approved by the Department. The Department recommends that pilot scale projects receive our comments to ensure the right information is being included. Please follow the link to view the Pilot / Demonstration Scale application in Microsoft Word.

APPENDIX D
ALTERNATIVE TECHNOLOGY APPLICATION

All alternative technologies must submit an application to the Department. Please follow the link to view the template in Microsoft Word.

APPENDIX E
ANSI/NSF 61 REQUIRED MATERIALS

This appendix (as referenced in Section 2.21) is intended to be an informational resource. Materials requiring ANSI/NSF 61 certification include but are not limited to:

FILTER TYPES/MEDIA

Anthracite

Granular Activated Carbon

Sand

Gravel

Greensand (Pyrolusite)

Calcite

Filter Membranes

Bags

Cartridges

Plastic filter housings

Diatomaceous earth

PROCESS EQUIPMENT (non-metallic)

Sludge collection systems

Under-drain systems

Flocculation equipment

PROTECTIVE MATERIALS

Coatings, Liners (including tank and pipe coatings/liners)

JOINING AND SEALING MATERIALS

Solvent cements

Concrete curing compounds

Concrete form release agents

Glues

Caulking

Welding materials

Gaskets

Lubricating oils

Greases

PIPES AND RELATED PRODUCTS

Plastic Pipes and Fittings made from non-exempt materials (Section 2.21)

Plastic Tanks (for water storage) made from non-exempt materials (Section 2.21)

POTENTIAL LEAD CONTAINING APPURTENANCES

Water meters

Tapping saddles

Corp stops

Brass, copper or bronze materials

OTHER

Plastic Settling tubes/curtains

Plastic Baffling materials

Fiberglass components

Carbon fiber components

APPENDIX F
ACCEPTED ALTERNATIVE TECHNOLOGIES

All alternative technologies must be accepted by the Department prior to use in Colorado. The Department’s web page contains a summary of all the accepted alternative technologies and the individual acceptance letters.

APPENDIX G
NATURAL FILTRATION FOR COMPLIANCE WITH THE SWTR

The Department's position on utilizing natural filtration for compliance with the SWTR can be found here.

APPENDIX H
UV ACCEPTANCE LETTER (2011) WITH MONITORING

The Department's position on appropriate UV monitoring and control can be found here.

APPENDIX I
NSF 55A (UV) ACCEPTANCE

Appendix I.1:The Department's position on appropriate NSF55A acceptance can be found here.

Appendix I.2: The Department's justification for allowing NSF 55A reactors can be found here.

APPENDIX J
APPLICATION FOR USE OF POU/POE SYSTEMS FOR REGULATION 11 COMPLIANCE

The Department's application form for use of POU or POE devices to comply with a regulated MCL under Regulation 11 can be found here.

APPENDIX K
OPTIMAL CORROSION CONTROL TREATMENT (OCCT)

The OCCT process is for systems implementing OCCT in response to an action level exceedance (ALE) or requesting to make modifications to an existing OCCT in accordance with Regulation 11, Section 11.26(3) and 11.26(8).

Appendix K.1: The Department's OCCT recommendation form for most small/medium suppliers. The required form can be found here.

Appendix K.2: The Department's minimum requirement for corrosion control studies can be found here.

APPENDIX L
PARTICULATE REMOVAL STUDY

The following protocol is acceptable for demonstrating particle sizes in advance of utilization of cartridge or bag filtration:

Purpose: This particle size analysis procedure is intended to demonstrate the potential efficacy of one micron absolute bag or cartridge filters towards achieving compliance turbidities of 1.49 NTU or less. The particulate analysis size study must take samples weekly for a for minimum 2 month minimum period during the critical or most challenging period (e.g., run-off, lake turnover) for the filtration process.

The Department requires results from a 1 µm filter at least, but recognizes the value of other sizes as well. The system may want to investigate how well prefilters before the compliance filter will remove turbidity by testing membrane filters with larger micron pore sizes that match the prefilters of interest (e.g., 5 and 10 µm).

Materials:

- Turbidimeter (Hach 2100P or equivalent)
- 4 sample cells for turbidimeter (cell)
- Silicone infused cloth or Kimwipes
- Membrane filters, absolute pore sizes 1 µm and 0.45 µm (design basis: Whatman Nuclepore), optional roughing pre-filters (e.g., 10 µm, 5 µm)
- Reusable syringe membrane filter holder or housing (filter holder)
- Syringe (20 ml or larger)
- Particle free rinse water (deionized or distilled; if not available, bottled water)
- Approximately 20-30 mL of sample to be analyzed (sample)

Data Collection Procedure:

<u>Sample Preparation and Unfiltered Turbidity</u>

Note: Ensure that the turbidimeter has been properly calibrated prior to starting the particle analysis data collection procedure.

1. Rinse out turbidimeter cells with particle free rinse water.
2. Pour raw water sample to be analyzed into 2 separate cells. Fill both cells to fill line.
3. Using silicone cloth or Kimwipe, completely clean all sides and bottom of both cells.
4. Insert cells into turbidimeter, one at a time, and read the turbidity. Enter both turbidity results (sample A and sample B) into the data spreadsheet under "Unfiltered" (see example spreadsheet provided below in Table 1).

<u>Filter turbidity sampling steps</u>

5. Remove the plunger from the syringe.
6. Install a filter (e.g., 1 µm filter) into the filter holder and screw into the outer housing of the syringe.
7. Pour unfiltered sample into the syringe and replace the plunger.
8. Compressing the plunger, filter the sample through the filter (e.g., 1 µm filter) into a clean/rinsed cell (sample A).
   Note: if the syringe is too small to contain the full volume of the cell, filter the sample into the clean/rinsed cell in two batches.
9. Repeat steps 7-8 for the second sample cell (sample B).
10. Using silicone cloth or Kimwipe, complete clean all sides and bottom of both cells.

11. Insert cells into turbidimeter, one at a time, and read the turbidity. Enter both turbidity results (sample A and sample B) into the data spreadsheet under “1 µm Filter” or “Roughing __ µm filter” (see example spreadsheet provided below in Table 1).
12. Clean/ rinse out the two recently emptied cells with particle free water.
13. If applicable, repeat steps 5-12, using other filter sizes.

Table 1 Particle analysis turbidity data example spreadsheet

Date	**Sample**	Unfiltered	Roughing __ µm filter**	1 µm filter	0.45 µm filter
Week 1	Sample A				
	Sample B				
Week 2	Sample A				
	Sample B				
Week 3	Sample A				
	Sample B				
Week 4	Sample A				
	Sample B				
Week 5	Sample A				
	Sample B				
Week 6	Sample A				
	Sample B				
Week 7	Sample A				
	Sample B				
Week 8	Sample A				
	Sample B				

** Roughing filter optional

Data Analysis Procedure:
If the average turbidity in the 1 µm filter effluent is greater than 1.49 NTU then the treatment technique may not be appropriate.

APPENDIX M
NOTES AND JUSTIFICATION FOR SPECIFIC UPDATES TO THE DESIGN CRITERIA

2022 Update Project (written May 4, 2022):

APPROACH

The current version of the Design Criteria was last updated in 2017. The Department had committed to perform updates at least every 4-5 years. In the fall of 2021, the Department began a project to update the Design Criteria based known issues related to corrosion control, storage tank rule impacts, treatment chapter improvements, and the potential impact of direct potable reuse (DPR).

Like the 2013 and 2017 efforts, the Department convened a concentrated group of stakeholders to work on the criteria. There were four external workgroups: Corrosion Control, Storage Tanks, Treatment, and Direct Potable Reuse. Generally, the overall structure of this document remained the same between 2013, 2017, and 2022 including section headings and names. The following describes the goals and justifications of each workgroup.

Corrosion Control:

The corrosion control workgroup updated Section 4.9 of Chapter 4 treatment to clarify and expand design criteria requirements for optimal corrosion control treatment processes such as pH/alkalinity adjustment and inhibitor addition. The workgroup also updated Appendix A, Table A.2 to include additional project types, desktop corrosion evaluation, and immersion coupon requirements. The workgroup also decided to develop an appendix (Appendix K.2) to outline corrosion control study expectations.

Storage Tanks:

The storage tank workgroup focused on updating Chapter 7. One significant change was to change the terminology and chapter title from finished water storage to protected water storage to align with Section 11.28 of Regulation 11 (i.e., Storage Tank Rule). The workgroup also clarified requirements for vents, overflows, drains, etc. based on experience from the Storage Tank Rule. Additionally, the water hauler tanks section was revised to align with the department's water hauler operational handbook.

Treatment:

The treatment workgroup focused on updating Chapter 4 to clarifying existing treatment process requirements and adding requirements for treatment processes not in the 2017 version. Design criteria for chloramines, regenerative media (generalized from the previous ion change sections), and adsorptive media were developed.

Direct Potable Reuse:

The direct potable reuse stakeholder project was occurring concurrently to the design criteria update project. During that stakeholder effort, advanced treatment technologies were identified that would be eventually required by the proposed DPR regulations. Furthermore, several utilities have installed such advanced technologies in Colorado voluntarily to address contaminants of emerging concern proactively. Therefore, the department transferred some of the technical design specifications of the advanced treatment technologies into Policy 5 with stakeholder input. Specifically, for this revision of Policy 5, the department focused on creating a section for Advanced Oxidation (proposed to be defined in Regulation 11) and concurrent UV light/hydrogen peroxide addition. The department also made minor updates to the granular activated carbon and ozone sections.

2017 Update Project (written October 1, 2017):

APPROACH

The current version of the Design Criteria was last updated in September of 2013. At that time, the Department committed to make minor updates and edits periodically as well as attempt to perform updates at least every 4-5 years. In the spring of 2017, the Department began a project to update the Design Criteria based upon known issues with corrosion control and design reviews which were a result of corrosion issues. The project stemmed from the Department evaluating its own corrosion control practices after the crisis that occurred in Flint, Michigan in 2014-2016.

Like the 2013 effort, the Department convened a concentrated group of stakeholders to work on the criteria. There were only 4 external workgroups: Corrosion Control, Storage Tanks, Surface Water, and Materials in Contact with Potable Water (ANSI/NSF 61). The primary driver for the Design Criteria update is the updates required for corrosion control treatment, but in addition the Department is taking the opportunity to update sections which are known to have issues and need to be re-evaluated.

The structure of this document remained the same between 2013 and 2017 including section headings and names. The overall philosophy from 2013 was adhered to. The following describes the goals and justifications of each workgroup.

Corrosion Control:

While the EPA published comprehensive guidance in 2016, many decisions about evaluating corrosion control are left to the primacy agencies. Therefore, the Department, with the aid of a large and committed workgroup of consulting engineers, water operators, and utility professionals developed table A.2 within Appendix A to interpret the requirements of Section 11.26(8) of Regulation 11. Also, the workgroup developed Appendix K in order to define the requirements for a supplier of water to submit an optimum corrosion control treatment (OCCT) recommendation or to modify an OCCT. While there are no new requirements being introduced with respect to regulations, the new sections of the Basis of Design Report, Appendix A, and Appendix K will allow water suppliers to understand the submittal requirements relating to corrosion control.

Storage Tanks:

Language and ambiguous requirements were updated throughout the chapter. Requirements for overflows and vents were updated extensively.

One specific change was with regard to the screening requirements on vents, which had been 24 mesh for at least 40 years. The Department’s workgroup researched why the screen size was set to 24 mesh. References to 24 mesh was discovered in the 1968 10 States Standards. The workgroup also had information that the mesh size on vents may have been meant to exclude mosquitos from storage tanks. Based upon references and research, the smallest mosquitos (insects of concern in Colorado) measure approximately 0.125 inches. http://www.nationalgeographic.com/animals/invertebrates/group/mosquitoes/

The workgroup then considered mesh sizes from references. It appears that even 12 mesh would have openings approximately 0.06 inches (1/2 of the size of the smallest mosquitos). That said, as long as the openings are less than 0.07 inches the Department considers this protective of public health. (Ref.:

http://www.espimetals.com/index.php/faq/334-understanding-mesh-sizes)

Surface Water:

The primary focus of the surface water group was to better define raw water data collection requirements for systems installing new surface water treatment. In Colorado, a disproportional amount of surface water treatment violations are occurring at very small systems who have installed a filtration system like bags or cartridges that are incapable of effectively removing turbidity. The Department will require systems to collect more data to ensure the chosen treatment is appropriate for the raw water quality.

After a supplier of water collects raw water quality, should the raw water quality be out of required specifications, additional treatment may be needed. The criteria also outline acceptable methods for testing the water at a system to discern whether out of spec water will be treated effectively by the technology of choice. The group also elected to clarify the requirements for granular activated carbon treatment and provide further information on justifying baffling factors.

Materials in Contact with Potable Water (ANSI/NSF 61):

The Department understands that many other states have a requirement for all materials in contact with the potable water be ANSI/NSF standard 61 certified. For many years (at least since 1997) the DCPWS document has also required ANSI/NSF 61. Recently, the Department began to re-assess this requirement on small systems due to the burdensome cost this requirement imposes.

The Department queried agencies that test products for ANSI/NSF 61 compliance for data that demonstrates a health risk. Understanding that testing has now been occurring for decades, it is logical that data should be available demonstrating that contaminants have been detected at unacceptable levels as a result of product testing. The department and members of the workgroup asked the different organizations to share any data demonstrating that there is a threat to public health. The test organizations refused to provide any data that demonstrated an adequate health risk. Therefore, the Department is choosing to relax the ANSI/NSF 61 requirement based on known materials that have been widely used throughout waterworks and do not appear to have threats of leaching harmful materials.

2013 Update Project:

OVERVIEW

The current version of the Design Criteria was last updated in March, 1997. In 2007, the Department began a project to update the Design Criteria. After significant effort by both the Department and stakeholders, the effort was placed on hold due to significant workload and resource limitation issues. While workload and resource constraints still persist, the dynamic nature of treatment technologies and the changes in engineering practice necessitated that the Department update the Design Criteria. Due to changes in the organization of the Department and general engineering practice, the Department will largely abandon the previous revision of the Design Criteria in favor of a more succinct process to update the Design Criteria and facilitate a system where they can be updated on a regular interval.

APPROACH

A group of stakeholders from the professional engineering community participated in 10 different workgroups to develop the criteria: the criteria were reviewed by the Department, workgroup leaders, and the stakeholders. After the effective date, modifications to keep this document current may be made by the Department as necessary (e.g., address changes in the titles or numbering of referenced policies and/or regulations, website links). These minor revisions will be made by the Department and notification provided to interested parties via the quarterly AquaTalk publication, email notifications, water utility council announcements, and other means. Generally, the goal will be to perform a major technical review and update of the criteria through a formal stakeholder process. This stakeholder process is expected to be more routine than the 2012/2013 effort based on a shorter timeframe between updates rather than the most recent 15 years.

GENERAL PHILOSOPHY

As of the 2013, there are over 2050 regulated public water systems in Colorado. Most of these systems are classified as small; with many serving less than 500 people per day. Because the Department regulates so many small systems, many of the designs reviewed by the Department are for facilities without the benefit of large amounts of site-specific data available at larger facilities.

Therefore, the Design Criteria are intended to serve two main purposes:

1. Codify a set of standards that establishes **minimum** requirements for the design of new waterworks to protect the **reliability and quality** of the finished water capable of complying with the *Regulation No. 11: Colorado Primary Drinking Water* Regulations (Regulation 11);

2. Summarize and characterize nationally-recognized industry best **minimum** practices for designing waterworks given that many designs occur without substantial site-specific data.

To resolve historic misunderstandings of the terms modification, variance, deviation, alternative filtration, new technology, and to set a common new approach, the Department has replaced the former terms with new terms such as: **substantial modification, site-specific deviation** and **alternative technology**. Although there is some overlap between historic and new terms, entities are encouraged to read the sections regarding the new terms.

ACKNOWLEDGEMENTS

The chapter structure of this document and much of the content is based upon the "Recommended Standards for Water Works, 2012 Edition" (found at http://10statesstandards.com/waterrev2012.pdf). These are referred to as the "10 States Standards" commonly. These standards are published by the Great Lakes – Upper Mississippi River Board of State and Provincial Public Health and Environmental Managers. However, beyond the chapter structure, much of the content has been drafted or modified to meet the needs of the State of Colorado. The Department would like to thank the board for permission to utilize these standards as a guide for development.

A special thank you to the many participants in the workgroups and the workgroup leaders:

List of Workgroup Leaders: Tyson Ingels, P.E.; Donene Dillow; Melanie Criswell, P.E.; Brian Daw, P.E.; Patrick O'Brien, P.E.; Garth Rygh; Kit Badger, P.E.; David Kurz, P.E.; and Hope Dalton.