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TITLE: **STATE OF COLORADO DESIGN CRITERIA FOR DOMESTIC WASTEWATER TREATMENT WORKS**	APPROVED BY	DATE
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STATE OF COLORADO
DESIGN CRITERIA
FOR
DOMESTIC WASTEWATER TREATMENT WORKS

Effective Date: September 15, 2012

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PREFACE

Overview

The *Design Criteria Considered in the Review of Wastewater Treatment Facilities* are used by the State of Colorado in the review of domestic wastewater treatment works (including appurtenances). Prior to this revision, these criteria were encompassed in Water Quality Control Commission (WQCC) Policy 96-1. The current version of Policy 96-1 was last updated in May 2002, with an expiration date of 2007. In 2007, the expiration date of the policy was extended to May 31, 2008 by the WQCC with an understanding that the policy would shift from the WQCC to the Water Quality Control Division (Division) upon its next revision. Due to significant workload and resource issues within the Division since early in 2007, revision work for Policy 96-1 was placed on hold.

Although Division workload and resources continue to be an issue, the dynamic nature of wastewater treatment technologies and the rate of change of practice necessitated a revision to Policy 96-1 at this time. In addition to a significant update of the associated administrative and technical content of the criteria, this revision also includes a change to the number of the policy as it is now a Division policy.

Approach

A large group of stakeholders from the professional engineering community participated in nine workgroups to develop the technical criteria which then went through additional reviews by the workgroup leaders and the stakeholders. Colorado-specific information was revised for administrative aspects of the criteria, consistent with the current version of the Water Quality Control Commission's "Regulation No. 22, Site Location and Design Approval Regulations for Domestic Wastewater Treatment Works" (Regulation No. 22).

Modifications to keep this document current may be made by the Division 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 Division and notification provided to interested parties via the monthly Water Quality Bulletin.

Philosophy

To resolve historic misunderstandings of the terms variance and new technology and set a common new approach, Chapter 1 replaces these with two new terms: 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.

There are hundreds of domestic wastewater treatment works (DWWTW) in Colorado. Many of the designs received for review are for facilities without the benefit of large amounts of site-specific data and evaluations that are available at some large facilities. The design parameters as represented in the design criteria are intended to identify requirements that result in a well designed facility, with equipment flexibility provided for the operator, for facilities without much site-specific data.

What about the large facilities or specific situation "x"? The design criteria document is structured in Chapter 1 to provide entities and design engineers flexibility for situations by providing design documentation for a site-specific deviation. Some common examples are:

- "Data/Study": Any facility (e.g., larger facility with data, small facility with special needs and talented engineers) have the ability to provide documentation for a site-specific deviation. A common example would be a situation where a large facility has collected operating data and developed a detailed study documenting that something outside the range in the criteria will provide successful treatment and the new design is based on that data/study.
- "Other Design Method": There are not always resources and data available to implement the "data/study" option, so a design would generally follow the design criteria. However, this document also includes in the site-specific deviation process in Chapter 1, the ability for any facility to use a design method other than what is included in the criteria by citing a peer-reviewed document (e.g., a WEF MOP), without requiring an detailed study. This latter situation recognizes that 1) the design criteria are not the exhaustive reference of every acceptable method and 2) there are other acceptable methods than what is included in the criteria. Those methods are also available to be used through a site-specific deviation.

The PDR submittal needs to clearly identify and document the approach upfront as either 1) within the limits in the design criteria or 2) requesting site-specific deviation (e.g., using site-specific studies or using an alternate peer-reviewed reference). The Division believes this approach balances the need for solid criteria for most DWWTW and flexibility for the entities and engineers in situations where something different is needed.

Acknowledgements

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ABBREVIATION LIST

ANSI	American National Standards Institute
ASTM	American Society of Testing and Materials
AWWA	American Water Works Association
BDR	Basis of Design Report
BOD	Biochemical oxygen demand
CCR	Colorado Code of Regulations
CDPHE	Colorado Department of Public Health and Environment
CDPS	Colorado Discharge Permit System
CFR	Code of Federal Regulations
C.R.S.	Colorado Revised Statutes
DAF	dissolved air flotation
Department	Colorado Department of Public Health and Environment
Division	Water Quality Control Division of the Colorado Department of Public Health and Environment
DORA	Colorado Department of Regulatory Agencies
DWWTW	Domestic Wastewater Treatment Works
EPA	US Environmental Protection Agency
FEMA	Federal Emergency Management Agency
gpd	Gallons per day
IF/AS	Integrated fixed-film activated sludge
I/I	infiltration and inflow
ISDS	Individual sewage disposal systems
L/S	Lift Station
MBBR	Moving bed bioreactor
MBR	Membrane bioreactor
MFE	Multi-family equivalent
MGD	Million Gallons per Day
NEMA	National Electrical Manufacturers' Association
NFPA	National Fire Protection Association
OSHA	Occupational Safety and Health Administration
OWTS	Onsite Wastewater Treatment System
PDR	Process Design Report
PELs	Preliminary Effluent Limits or Preliminary Effluent Limitations
PFD	Process flow diagram
P&ID	process and instrumentation diagram/drawing
RBC	Rotating biological contactor
Regulation 22	Regulation No. 22 *Site Location and Design Approval Regulations for Domestic Wastewater Treatment Works* (5 CCR 1002-22)
Regulation 84	Regulation No. 84 *Reclaimed Water Control Regulation* (5 CCR 1002-84)
SA	Site Location Application
SBC	Submerged biological contactor
SBR	Sequencing batch reactor
SCADA	Supervisory Control and Data Acquisition
SFE	Single family equivalent
SS	suspended solids
SSO	sanitary sewer overflow
SWD	side water depth
TMDL	Total Maximum Daily Loads
TSS	total suspended solids
VOC	volatile organic compound
WQCC	Water Quality Control Commission
WWTP	Wastewater treatment plant

CHAPTER 1
DESIGN REVIEW PROCESS AND SUBMITTAL REQUIREMENTS

The Colorado Water Quality Control Act establishes the statutory framework for design approval of domestic wastewater treatment works (DWWTW) by the Water Quality Control Division (Division). The statute, C.R.S. 25-8-702, states "no person shall commence construction of any domestic wastewater treatment works or the enlargement of the capacity of an existing domestic wastewater treatment works, unless the site location and the design for the construction or expansion have been approved by the Division." Specific provisions to implement the statutory requirements regarding site location and design approvals are defined in *Site Location and Design Approval Regulations for Domestic Wastewater Treatment Works, 5 CCR 1002-22* (Regulation 22). Site location approval is a separate step that must occur before design approval.

The *Design Criteria for Domestic Wastewater Treatment Works* (WPC-DR-1) are used by the Division to evaluate whether the DWWTW design, including lift stations, interceptors and outfalls, is adequate for the wastewater conveyance and treatment requirements defined in the site location approval and/or discharge permit. Prior to this revision, these criteria were encompassed in Water Quality Control Commission (WQCC) Policy 96-1. The current version of Policy 96-1 was last updated in May 2002, with an expiration date of 2007. In 2007, the expiration date of the policy was extended to May 31, 2008 with an understanding that the policy would shift from the WQCC to the Division upon its next revision.

1.1.0 SCOPE AND APPLICABILITY

The Division will evaluate the proposed DWWTW to determine if it is in substantial compliance with the criteria set forth in WPC-DR-1. Review of design submittals by the Division is not intended to provide quality control of the proposed DWWTW project. To the maximum extent practical, these criteria are performance based, providing flexibility to tailor the design to specific circumstances of the project. Supporting documentation must be provided in the design submittal for deviations from the design criteria as described in Section 1.7.0.

When changes need to be incorporated into the Division's criteria, they will be added to WPC-DR-1 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 Division will be noticed in the monthly Water Quality Bulletin. Revisions will be incorporated consistent with Division Policy 1 Implementation Policy Framework.

DWWTW is defined as a system or facility for treating, neutralizing, stabilizing or disposing of domestic wastewater that has a designed capacity to receive 2,000 gallons per day (gpd) or more. The term DWWTW also includes appurtenances such as outfall sewers and pumping stations and to equipment related to such appurtenances. Specifically, design approval is required for proposed construction of:

- New domestic wastewater treatment plants (WWTPs), including onsite wastewater treatment systems (OWTSs), also referred to as individual sewage disposal systems.
- Modifications to existing WWTPs or OWTSs. Modifications include, but are not limited to, capacity changes, process changes, new or modified chemical additions, etc. Design approval is not required for modifications meeting the definition of in-kind replacement as defined in Regulation 22.
- New or modified lift stations, including changes in the rated hydraulic capacity or critical components (pumps, wet/dry wells, emergency overflow capacity, etc.), and changes to the location of an existing lift station.
- New or increased size interceptor sewers with an internal diameter of 24-inches or greater.
- Collection system projects if State and/or Federal funds are being utilized.

- Proposed capacity re-ratings (increases or decreases) where no construction has taken or will take place (generally called 'paper re-ratings'). This requirement applies to requests for de-ratings from a capacity that is at or above 2,000 gpd to a capacity that is below 2,000 gpd.
- Outfall sewers (discharge point), whether new or relocated, if the proposed location is on a new property or in a different stream segment than the existing outfall.
- Addition, modification or expansion of a treatment process to generate reclaimed domestic wastewater (reclaimed water as defined in Regulation 84).
- Changes in the type of discharge from a WWTP (i.e. surface water to groundwater or vice-versa; a partial or complete change from surface water or groundwater discharge to reclaimed water).
- Lift stations and associated force mains for reclaimed water where the proposed lift station and associated force main is located upstream of the point of compliance (as defined in Regulation 84).
- Prior to permanent utilization of Division-authorized pilot or full-scale demonstration project facilities/equipment (after completion of the approved pilot/demonstration project).

Requirements for Onsite Wastewater Treatment Systems (OWTS) are provided in the *Guidelines on Individual Sewage Disposal Systems*, 5 CCR 1003-6, (or successor document). An OWTS with capacity of 2,000 gpd or more is a DWWTW requiring site location and design approval. A discharge permit must be obtained from the Division that will specify the monitoring and effluent requirements. For the design review, the PDR must provide information regarding treatment to meet anticipated permit limits (i.e., preliminary effluent limits or PELs) to be achieved with the proposed treatment process (e.g., septic tanks, additional treatment, soil treatment, plant uptake) in accordance with the design criteria in this document.

1.1.1 Terms Used

The design criteria include several types of criteria including prescriptive and descriptive elements. Several types of terms are used in the criteria to express the requirements for designs. The terms shall, must, required with prescriptive criteria are used to indicate that a design is expected to meet these requirements except where a site-specific deviation is being requested.

Where a prescriptive numerical criterion was not warranted, but some element needs to be included in the design, terms such as "must include provisions to" and "must include means to" are intended to provide flexibility to districts and design engineers in the method/approach selected to address the needed element. The method/approach is expected to be described in the BDR or PDR with documentation of the design basis.

Where a prescriptive criterion was not warranted, but some element needs to be thought through in the design process and possibly included in the design, terms such as "must consider" and "must address" are descriptive criteria intended to provide flexibility to districts and design engineers in the method/approach selected to address these possibly needed elements. The method/approach is expected to be described in the BDR or PDR with documentation regarding of the design basis of the proposed approach or a brief technical basis for not needing to include the element in the design.

The terms "(i.e.,)" and "(e.g.,)" are also used in these criteria consistent with their Latin origins. The term "i.e." stands for "that is," (Latin 'id est'), used in place of "in other words," and specifies or makes more clear so the parenthetical phrase is a restated part of the requirement. The term "e.g." means "for example" (Latin 'exempli gratia'), used as "for the sake of an example," or similar to the phrase "including," when the intent is to provide some

examples but not list everything that could be discussed so the examples are not requirements for each design.

1.1.2 Fees Required for Design Review Submittals

The Division is authorized to assess fees for wastewater design reviews (Section 25-8-702 of the Water Quality Control Act). The fees for design reviews are set by statute and are based upon the type of project and the associated, proposed hydraulic capacity. **Fees are required to be paid in advance of any work performed by the Division in the review of design submittals.**

- Instructions for requesting fee and invoice information is available online at: http://www.cdphe.state.co.us/wq/engineering/pdf/2010/RequestSAFees.pdf
- The fee request form can also be accessed at: http://www.cdphe.state.co.us/wq/engineering/reg22/siteappforms/sa_form_hom.html.

1.1.3 Review Timeframes

It is a priority for the Division to act expeditiously on complete design submittals. To facilitate this, submitting entities and their engineers must address all criteria applicable to the unit processes for a project in the design submittal. When a criterion is not satisfied, a demonstration of equivalency or approved site specific deviation from the design criteria is required as provided in Section 1.7.0. The Division's target review time goals for design submittals are provided in the Division's Policy WPC-SA-1, Guidance Document for the Site Location and Design Approval Regulations for Domestic Wastewater Treatment Works 5 CCR 1002-22. The goals do not include days when the entity and their engineers are responding to a request for information letter from the Division.

If an issue is identified during the review process that requires additional information or clarification, the Division will send a request for information letter to the entity and the entity's engineer. If a written response that substantially addresses all issues raised in the letter is not received from the entity within 60 days from the date of the original letter, the Division will issue a non-response letter to the entity indicating that the entity has two available options in lieu of the Division denying approval of the design:

1. Submit a written response to the Division's letter within 30 days that substantially addresses the issues and/or requests clarification, or
2. Withdraw the design review in writing.

If the entity substantially addresses the Division's comments and/or requests clarification within 30 days of the date of the non-response letter, the Division will continue with the design review process. If the entity does not respond in writing within 30 days from the date of the non-response letter or withdraws the design review in writing, the Division will issue a design denial letter and the entity will forfeit its design review fee. Thereafter, the entity must submit a new design package and pay new fees to reinitiate the design review process. If the associated site location approval period is exceeded, a new site location application fee may be required as well.

1.1.4 Streamlined Review Process

In the streamlined design review approach, approval for the final design documents (plans and specifications) is the responsibility of the design engineer. The applicant must submit a letter of intent to self-certify the final design along with the Process Design Report (PDR) (stamped and signed by the applicant's professional engineer who must be registered to practice in the State of Colorado), including the PDR submittal checklist with identification of any deviations from these criteria. When the final design documents are complete, the

engineer of record must submit a stamped, dated, and signed certification on a form provided by the Division affirming that the final design is consistent with the approved site application, the approved PDR (i.e., including approved site-specific deviations and alternative technologies), and the most recent published version of the wastewater design criteria (i.e., version at the time of the Division's acceptance of the self-certification request with the PDR approval, including addenda with accepted alternative technologies), noting any Division approved site-specific deviations from the criteria.

1.2.0 DESIGN REVIEW PROCESS

Site location application and design approvals are issued in writing on Department letterhead. Approvals are not issued verbally.

The Division does not issue concurrent site location application and design approvals. Site location and design approval are always issued via separate letters. If the design submittal will provide additional clarification for the site location review process, it can be submitted prior to site location approval issuance. However, formal design review will not occur until the design review fee is remitted and site location approval has been issued.

1.2.1 Design Review Steps

The design review process is determined by the type of DWWTW, as summarized below:

- Interceptors, collection systems, outfalls and lift station projects require a single submittal that includes the Basis of Design Report (BDR) and the final design.
- Treatment plant projects require two submittals; the PDR and, following PDR approval, the final design.
- For re-ratings (no construction to be done), only PDR submittal and approval is required.
- Applicants may wish to utilize the streamlined review process (Regulation 22.11), where the engineer of record self-certifies that the final design is in conformance with the site location approval, the PDR approval, and the design criteria (and any Division approved site-specific deviations). By utilizing this process, there is no requirement that the Division review the final design prior to construction. Self-certification is currently not available for the following types of projects:
    - Interceptors, outfalls and lift stations.
    - Projects where State or Federal funding is involved.
    - Projects that include an alternative technology not addressed by the design criteria.
- Where a site-specific deviation is being sought, the Division may require the applicant to utilize the two-step design approval process (i.e., separate PDR and final design approvals). The Division's decision will be based on the degree of the deviation, mitigating conditions, and how much information is unknown at the time of PDR review and approval.
- For design-build projects not using the streamlined review process, final design approval must be issued for each phase of the project prior to commencement of construction of that project phase.
- For design-build projects using the streamlined review process, self-certification submittal (i.e., engineer of record certification that the final design is in conformance with the site location approval, the PDR approval, the design criteria, and any

Division approved site-specific deviations) is required prior to commencement of construction for each phase of the project.

- Construction of a DWWTW cannot commence until site location approval, PDR or BDR approval, and final design approval has been obtained from the Division. For streamlined reviews, construction of the proposed project cannot begin without site location approval by the Division, approval of the PDR, Division acceptance of the self-certification request form from the design engineer (i.e., submitted with the PDR), and Division receipt of the self-certification of the final design by the engineer of record.
- Once the project is constructed, a Professional Engineer registered in the State of Colorado must certify that it was constructed in conformance with the approved design documents, regardless of the type of DWWTW or review process used. For design-build projects, certifications for each phase of the project must be submitted.
- Prior to commencement of discharge from a new WWTP, a Colorado Discharge Permit System (CDPS) discharge permit is required. The permittee must request a discharge permit from the Permit Section of the Division separately from the site location and design review process. Permits are issued in accordance with the Colorado Discharge Permit System Regulations (Regulation 61). If the proposed project is associated with an existing WWTP, a permit amendment may be required. Entities are responsible for contacting the Permit Section to determine if an amendment is necessary.
- Final decisions of the Division concerning approval of a proposed facility design may be appealed to the Colorado Water Quality Control Commission pursuant to 25-8-702(4) C.R.S., 5 CCR 1002-22, §22.11(7) and 5 CCR 1002-21, §21.4(B).

1.2.2 Design Review Document Submittals

Documents submitted for review shall be prepared under the supervision of and be submitted with the seal and signature of a professional engineer licensed to practice engineering in the State of Colorado in accordance with the Bylaws, Rules and Policies of the State Board of Licensure for Architects, Professional Engineers, and Professional Land Surveyors by the Colorado Department of Regulatory Agencies (DORA) – Division of Registrations (e.g., title page or signature page of engineering reports, each sheet of engineering drawings, the cover, title page, and table of contents of bound technical specifications).

One (1) hard copy of all documents (i.e., sealed and signed) and one (1) electronic copy (PDF) must be submitted to the Engineering Section for review and approval. The design submittal must include a completed design submittal form.

The report must demonstrate compliance with these criteria, or justify site-specific deviations from the criteria, and include supporting calculations, analyses, historical data, and technical assumptions.

When an alternative technology not covered by the criteria is proposed, a request for acceptance of the alternative technology must be submitted to the Division, as discussed in Section 1.8.0. If an entity anticipates using an alternative technology that is not covered by the criteria, the Division strongly recommends submitting the alternative technology request as soon as possible to minimize potential delays in the review of the PDR, as the PDR review cannot be completed until acceptance of the alternative technology is issued by the Division.

1.3.0 BASIS OF DESIGN REPORT AND PROCESS DESIGN REPORT

The purpose of the BDR or the PDR is to provide sufficient design information so the Division can evaluate whether the proposed DWWTW design can meet the wastewater conveyance and treatment

requirements in the site location approval and/or anticipated discharge permit (e.g., PELs, compliance schedule). To this end, the report must demonstrate conformance with the applicable design criteria provided herein. To facilitate the Division's review, the report shall document references and include at a minimum (as applicable):

1.3.1 Interceptor and Collection System Projects

The BDR shall include the following information:

a. Description and purpose of the project.
b. Supporting calculations, analyses, historical data, and technical assumptions.
c. The design period and the basis for the selected design period.
d. Population densities.
e. Areas served in acres or square miles.
f. Per capita wastewater contribution.
g. Infiltration/inflow analysis.
h. Industrial and commercial wastewater contributions.
i. Design flow rates as discussed in Chapter 3.
j. Size of pipe, grade, velocity, and maximum capacity.
k. Geotechnical report, if necessary.
l. Receiving capacity of downstream facilities (e.g., interceptors, WWTP).

1.3.2 Wastewater Lift Station Projects

The BDR shall include the following information:

a. A map showing the tributary area, any municipal boundaries within the tributary area, the location of the lift station and force main and pertinent elevations.
b. 100-year floodplain elevation map and any wetland areas, if applicable.
c. Evaluation that lift station is not unnecessarily endangered by natural hazards, such as a geotechnical report of the site, prepared by a Colorado licensed Geotechnical Engineer or Professional Geologist, if not previously provided with the site location application (e.g., including soils testing results, identification of any geologic hazards, and a statement that the site will support the proposed facility).
d. Supporting calculations, analyses, historical data, and technical assumptions for the lift station design.
e. Design flow rates as discussed in Chapter 4.
f. Wet well configuration and volume.
g. Number, type, capacity, motor horsepower and net positive suction head (NPSH) requirements of proposed pumps. The design capacity must match the site location approval.
h. A description of motor protection from over-current, over-temperature and voltage imbalance.
i. System head curve and computations justifying the selected operating point for design conditions of pumping system, including the anticipated minimum and maximum performance range (e.g., static head and dynamic losses).

j. Analysis (including pertinent calculations) of flotation potential and ballasting.

k. Description of approach to back-up power sources, alarms, and emergency storage.

l. Receiving capacity of downstream facilities (e.g., interceptors, WWTP).

m. Design basis for any odor control system including materials and equipment selection (e.g., type, capacity, loading).

1.3.3 Wastewater Treatment Plant Projects:

The PDR shall include the following information:

a. Description and purpose of the project, location and pertinent local environmental factors.

b. Description of existing plant, if applicable.

c. Description of contributing service areas.

d. Supporting calculations, analyses, historical data, and technical assumptions for each unit process.

e. PDR submittal checklist with identification of any deviations from these criteria.

f. Historical (to the extent available), present, and projected population.

g. Scaled site map showing the size and location of the proposed structures with the site topography.

h. 100-year floodplain elevation map and any wetland areas, if applicable.

i. Geotechnical report of the site, prepared by a Colorado licensed Geotechnical Engineer or Professional Geologist, if not previously provided with the site location application. The report must include soils testing results, identification of any geologic hazards, and a statement that the site will support the proposed facility.

j. Current and projected influent wastewater strength (i.e., BOD, TSS, TKN, alkalinity, pH, temperature, etc.), along with a discussion of infiltration and inflow and industrial and commercial wastes, if appropriate.

k. Flow and loading (e.g., organic, solids, nutrients) calculations (present and projected). Design flows and loads must be established for the facility as provided in Chapter 2. The design capacity (hydraulic and organic) must match the site location approval.

l. Current CDPS permit limits or preliminary effluent limits (PELs).

m. Discussion of the type of treatment process proposed, based upon the character of the wastewater to be handled, the method of disposal, and the degree of treatment required.

n. A process flow diagram and hydraulic profile. The process flow diagram must show all wastewater liquid and solids flow paths through various unit processes and include proposed sampling locations and bypasses. At a minimum, the hydraulic profile(s) must include hydraulic elevations associated with the high plant flow/high receiving water flow and low plant flow conditions.

o. Selected design flow rates for each unit process determined considering peak rates of flow and the impact on detention time and flow conduits, data from similar municipalities (e.g., new systems), wet weather flows, re-circulation and side stream flows.

p. Process and equipment design parameters for each treatment unit process referencing the applicable design criteria shall be provided in tabular form on the Capacity Evaluation Form in Appendix II and shall consider reliability and redundancy requirements set forth in the design criteria.

q. Oxygen transfer calculations, including data used for oxygen transfer equations, blower or aerator sizing, basin volume, and air flow requirements for treatment and mixing.

r. A discussion of assumptions and appropriateness of the selected biological rate values used in the design. If modeling is used, biological process model inputs and outputs must be submitted with a discussion of the appropriateness of the model (i.e., calibration, validation, accuracy).

s. Where initial operating conditions will be significantly less than design capacity, PDR must document design flexibility allowing the system to operate until sufficiently loaded.

t. Flow and solids balances for appropriate unit treatment processes, including sidestreams.

u. Design basis for any odor control system including materials and equipment selection (e.g., type, capacity, loading).

v. Proposed influent and effluent flow metering and sampling locations to be used for permit compliance.

1.3.4 Outfall Projects:

The PDR shall include the following information for surface water outfall projects:

a. Site map showing outfall location and permit compliance point.

b. Outfall pipeline diameter, material, and key design features.

c. Pump location and design parameters (i.e., flow capacity, total dynamic head [TDH], horsepower [hp]), if applicable.

d. A detailed drawing of any diffusers or other outfall structures, if applicable.

e. Verification of hydraulic performance over the normal range of water levels for the stream, lake, or reservoir, including 100-year flood elevation.

f. Identification of outfall site soils, geology, and fluvial geomorphology.

g. Discussion of design features that will keep the outfall pipeline, diffuser, and/or structure in place and functioning during the normal range of streamflows, especially during high flow periods.

h. For systems using diffusers, demonstration that water quality standards will be met at the boundaries of acute and chronic mixing zones. The analysis must include all critical flow and loading situations expected for the facility.

1.3.5 Groundwater Discharge Projects:

The PDR shall include the following information for groundwater discharge projects:

a. Topographic and geologic maps and cross sections.

b. Seasonal depth to groundwater and groundwater movement, including groundwater elevations, contours and hydraulic grade lines, and natural fluctuations.

c. Hydrologic/hydraulic features, recharge areas, streams, springs, wells, and other discharge areas, such as leakage to other aquifers.

d. Water balance analysis of the proposed discharge area, including recharge, discharge, precipitation, evapotranspiration, runoff, base flow, and natural fluctuations.

e. Soils type and permeability, including aquifer coefficients, hydraulic conductivity/permeability, transmissivity, storage, leakage, and directional transmissivity in anisotropic aquifers.

f. Percolation test data and soil evaluation below the proposed discharge elevation. For onsite wastewater disposal systems, the percolation tests and soil evaluation(s) must be completed in accordance with the *Guidelines on Individual Sewage Disposal Systems* (or successor).

g. Well logs and pumping test data.

h. Discussion of the adequacy of existing data and whether new test wells and/or aquifer testing might be needed to provide adequate hydrogeologic characterization of the project site.

i. Overall effects of the proposed facility upon the groundwater.

j. Map of the infiltration units relative to hydrologic/hydraulic features, including proximity to nearby wells (both monitoring and water supply wells), surface discharges from the aquifer, and other discharges from the aquifer.

k. Plan and profile views of infiltration units, including key design features, dimensions, and elevations.

l. Discussion of the hydraulic continuity between groundwater and surface water and demonstration that discharged effluent will stay in the ground and not surface.

m. Discussion of features that might be vulnerable to high water tables, including building foundations, buried tanks (septic tanks, fuel tanks), pipelines (water, sewer, gas, fuel), surface slopes, and deep excavations.

n. If discharge permit effluent limits will not be met ‘end-of-pipe’, documentation of how the soil and groundwater treatment will meet permit limits to protect water quality as measured in groundwater beneath or down-gradient of the infiltration area considering the new mixture of groundwater and reclaimed water. For surface waters in hydraulic continuity with groundwater, discuss surface water quality impacts of surface discharges from the aquifer.

o. Discussion of water quality monitoring for constituents found in discharged effluent for which effluent limits are anticipated (e.g., PELs). Identification of proposed sampling and monitoring well locations. Note: final monitoring well locations will be determined by the Permits Section in the final discharge permit.

1.3.6 Preliminary Plan of Operation:

A preliminary plan of operation must be submitted for all projects and include a discussion of the following:

a. The expected basic operating configuration and process control procedures and associated staffing requirements for the facilities including anticipated staff needed for operation and maintenance, 24-hour notification, and Operator in Responsible Charge (ORC) certification requirements.

b. Residuals management considerations, including the expected solids generation quantities and quality, and a discussion of the method of final sludge disposal, if applicable.

c. Phased operation of existing facilities to maintain permit compliance during construction, if applicable.

d. Procedures to periodically inspect the outfall diffuser to document its integrity and continued functioning, if applicable.

e. Facility upset and/or emergency response preparedness and procedures, including telemetry, backup power supply, portable emergency pumping equipment, emergency storage/overflow protection, and operator emergency response time.

f. Safety issues for the wastewater treatment facility and individual components and equipment.

g. Facility security provisions.

1.4.0 FINAL DESIGN SUBMITTAL – PLANS AND SPECIFICATIONS

The purpose of the final design is to facilitate construction of the project. Plans must be clear, legible, drawn to a scale which permits necessary information to be shown plainly, and include the following, depending on the scope of the project:

a. Project title; owner's name; date; seal and signature of design engineer.

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

c. Site plan and/or general layout map.

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

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

f. Consistent expression of numerical units.

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

h. Basis of all horizontal and vertical datum control.

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. 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 final 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, etc.

1.4.1 Interceptor and Collection System Projects

Final design plans for interceptor projects must include:

a. Site plans or maps showing interceptor location and streets and sewers.

b. Line of ground surface, pipe size, material and type of pipe, length between manholes, invert and surface elevation (if available) at each manhole and grade of sewer between each two adjacent manholes.

c. Locations of inverted siphons, concrete encasements, highway crossings, elevated sewers, manholes, flow regulators, relief valves, thrust blocks, etc.

d. Locations of known existing structures and utilities (water mains, gas mains, storm drains, telephone lines, etc.), both above and below ground, that could affect the proposed construction.

e. Detail drawings, made to a scale to clearly show the following: 1) all stream crossings and sewer outlets, with stream-bed elevations and normal and high and low water levels and 2) details of special joints and cross-sections.

f. System head calculations that include the size and length of force mains and assumed c (friction) factor.

1.4.2 Wastewater Lift Station Plans

Final design plans for wastewater lift station projects must include:

a. A contour map of the proposed lift station property.

b. Drawings of the proposed lift station and force main, including lift station building, provisions for installation of future pumps or ejectors, and appurtenances (e.g., piping plans, cross sections, tie-ins, surge protection).

c. Drawing of the existing lift station, if applicable.

d. Hydraulic profile including elevation of high water at the site (100-year flood elevation) and maximum elevation of wastewater in the collection system and wet well and location where sewage would overflow in the event of a power failure or backup power failure.

e. Geotechnical test borings and groundwater elevations.

f. Available capacity and maximum hydraulic gradient for the downstream gravity sewer receiving flow from the force main under firm pumping capacity.

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

1.4.3 Wastewater Treatment Plant Plans

Final design plans of WWTPs must include the following:

a. Identification of any changes to the process design described in the PDR.

b. Location, dimensions, elevations, and details of all affected existing and proposed plant facilities including architectural, mechanical, electrical, structural and civil details and appurtenances..

c. High and low water level elevations of the body of water to which the final effluent is to be discharged, including the 100-year flood elevation.

d. Geotechnical test borings and groundwater elevations.

e. Roads and access points for the treatment facility.

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

g. General ideas for future capacity and space for future equipment if future growth and related capacity is anticipated.

h. Other drawings such as process and instrumentation diagram, structural, electrical, instrumentation and controls, mechanical, and civil components.

1.5.0 CONSTRUCTION CERTIFICATION

Record ('as-built') drawings shall be prepared and furnished to the owner at the completion of the approved DWWTW project. Upon completion of construction, a certification indicating the project was constructed in conformance with the approved design must be provided to the Division by a Colorado professional engineer.

1.6.0 CHANGES TO APPROVED DESIGNS

Any deviations from approved plans or specifications affecting capacity, flow, or operation of units must be submitted in writing for Division review and approval before such changes are made. Changes affecting the approved design capacity or treatment process will require a new site location approval.

1.7.0 SUBMITTAL AND DESIGN REVIEW PROCEDURE FOR SITE-SPECIFIC DEVIATIONS

When a design does not specifically meet the design criteria, equivalent measures or, if equivalent measures are not possible, redundant emergency plans (e.g., equipment and procedures) must be provided. If equivalent measures or redundant plans are not possible or not appropriate for a particular design, site-specific deviation from the design criteria may be requested. Deviations from the design criteria must be explicitly identified in the PDR or BDR. The design report 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 DWWTW will function if the site-specific deviation is granted. If such information is specifically documented as proprietary, e.g. the basis of a patent, the proprietary information must clearly be marked as 'confidential' and include an explanation regarding why the information is confidential.

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

c. Documentation of an alternative peer-reviewed design criteria.

The Division may request additional administrative or technical information to better understand possible design implications of a requested deviation. Where a site-specific deviation is being sought in the streamlined review and approval process, the Division may require the applicant to complete the full design approval process as indicated in Regulation 22, Section 22.11 (e.g., where design implications of a requested deviation may not be entirely characterized at the PDR stage). The Division's decision will be based on the degree of the deviation, mitigating conditions, and how much information is unknown at the time of PDR review and approval. If the Division 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 Division may deny the site-specific deviation or require compensatory measures be taken.

1.8.0 SUBMITTAL AND DESIGN REVIEW PROCEDURE FOR ALTERNATIVE TECHNOLOGIES

The alternative technology review process is for new or nonconforming technologies 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 Colorado design criteria have not been developed for the technology 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;

however, pilot testing can be proposed for technologies needing additional data as noted at the end of this section. 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 site location application. It is recognized that, at times, it may not be clear if a substantial reconfiguration of existing treatment technologies constitutes an 'alternative technology' and the Division will make such determinations.

When a proposed design includes alternative or nonconforming technologies not covered by the criteria, then, upon request by the owner, design engineer, or Division staff, the Division shall review the design. The Division will review the history of successful operations, evaluate the efficacy of the technology in providing reliable wastewater treatment under a range of operating conditions, and, if accepted for use in Colorado, develop appropriate criteria for inclusion as addenda to this document. Site location approval and 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) shall include:

a. Discussion of manufacturer's warranty and/or performance warranty. This discussion must include all exclusions or limitations on the warranty.

b. A description of specific operator knowledge and skill that are needed to operate the proposed technology. This description must include 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 facility.

d. Full disclosure of any relationships between the owner, engineer and manufacturer or vendor.

e. Documentation of how the alternative technology functions. Proprietary information shall be marked as 'confidential' in the submittal and include an explanation regarding why the information is confidential. All assumptions must be clearly documented and explained. 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. For textbook references that are not widely available and common to the wastewater design field, a copy of the pertinent chapter(s) from the textbook must be included with the submittal.

f. A discussion of actual, full-scale operating experience and/or pilot test work. For full-scale operating experience, the length of time that each installation has been in operation must be included. For pilot test work, a copy of the associated pilot test plan and final pilot test report must be included.

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

h. Comparison of organic and, if applicable, nutrient loading and loading variations of other installations of the technology with the proposed application (within +/- 25% preferable).

i. Comparison of operating conditions (including temperature, altitude, daylight, darkness, etc.) of other installations of the technology with the proposed application (similar conditions preferable). Specific sensitivities of the proposed technology to

any operating condition(s) must be discussed and viable means to address specifically included.

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

k. Discussion of operational controls to provide flexibility for responding to varying influent characteristics and treatment conditions.

l. Discussion of process control and effluent sampling and monitoring that is proposed to be performed to verify the performance of the alternative technology.

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

If full-scale operating experience is not available for inclusion in an alternative technology submittal (e.g., emerging technology), then pilot test data may be considered for an alternative technology review. The Division's Policy WPC-SA-1, Guidance Document for the Site Location and Design Approval Regulations for Domestic Wastewater Treatment Works 5 CCR 1002-22 provides additional information regarding pilot testing requirements.

CHAPTER 2
GENERAL DESIGN CRITERIA

DWWTW must continuously meet all applicable discharge permit limits under a range of influent flow and loading conditions. This requires a robust design that has sufficient flexibility, redundancy, and reliability. Design conditions for DWWTW must be sufficient to meet existing and/or anticipated permit effluent discharge limits (i.e., PELs, compliance schedule). This chapter provides general requirements applicable to all DWWTWs (i.e., interceptors, lift stations, WWTPs).

2.1.0 DESIGN FLOW AND LOADING

The design loading to a DWWTW is determined by defining the service area, considering historical data, engineering flow and loading (e.g., organic, solids, nutrient) assumptions, the design service area population, land use, and unique customers, and using population and employment projections and/or land use projections as noted in the Service Area Definition of the Regulation 22 Guidance Document §22.4(1)(b)(i). Potential changes in land use, flow, and concentration trends shall be considered in the development of hydraulic and loading forecasts. Design hydraulic and loading conditions for the liquid stream treatment, solids handling, sludge stabilization, conveyance, and other facilities that comprise the proposed project must be documented in the BDR or PDR. The BDR or PDR must clearly document the methodology for determining the flow and loading projections served by the proposed DWWTW for the existing and projected planning period.

The BDR or PDR must document the following flow and loading conditions:

- Annual Average Flow (AAF) and Annual Average Load (AAL) – These values represent the total annual wastewater volume or load divided by the number of days in the year. Annual average values are used primarily as a basis for projecting maximum month and other design conditions.
- Maximum Month Flow (MMF) and Maximum Month Load (MML) – These values represent the highest 30-day average flow or load expected to be received at the DWWTW. Treatment plants are typically rated by the Division on their MMF and MML capacities. Treatment processes are typically designed for maximum month conditions, although hydraulic conveyance facilities are designed for peak flow rates, taking into consideration the presence of flow equalization facilities.
- Peak Hour Flow (PHF) – This flow rate is sustained for at least one-hour duration. While instantaneous flows may exceed this level for portions of an hour, there is typically enough attenuation within the facility to prevent hydraulic surcharging of the unit processes. Peak hour flows are used for unit process design consideration such as, but not limited to, preliminary screens, clarifiers, filters, disinfection, pumping equipment, and equalization tanks.
- Peak Instantaneous Flow (PIF) – This flow rate represents the highest instantaneous flow expected during the design year. Peak instantaneous flow is used to size interceptor sewers, pumps, channels, pipes, wet wells, and other flow structures.

The PDR must include the following start-up considerations to ensure the equipment and unit processes can meet a wide-range of operating conditions.

- Initial Average Flow and Load at Start-up – represents the AAF and AAL condition at start-up of the new or expanded facilities.
- Minimum Daily Flow at Start-up Conditions – The turn down capabilities for equipment and the number of units in service must be considered so solids settling (grit and organics) do not create operational, biomass seeding, and/or odor issues.

2.1.1 Hydraulic Design Considerations

As discussed previously, hydraulic design capacity for a DWWTW is based on the MMF condition except for OWTS which must follow the State Board of Health *Guidelines on Individual Sewage Disposal Systems* (or successor) requirements unless justified otherwise.

The BDR or PDR must include supporting documentation used to calculate the above hydraulic loading conditions. Where available, documentation must include at least five years of historical records. Longer data sets provide for improved statistical reliability and trending. If historical records are not available, documentation must be provided of the assumptions and peaking factors (e.g., using accepted peaking formulas found in widely used and accepted engineering design references, adjusted as required to account for unique local or regional considerations, unusual flow variations, flow equalization), considerations of special events, infiltration and inflow (I/I) impacts, commercial and industrial contributions, seasonal change in water use, or other justifiable and documented events.

For facilities where the duration of loading is less than 24 hours per day (i.e. schools, subdivisions, recreational facilities, etc.) treatment units and equipment shall be increased in size by the factor of 24/loading duration (hours) or appropriate equalization facilities shall be provided.

The flow characteristics from most commercial and industrial developments are important considerations which need to be evaluated; therefore, the design flow rate for commercial and industrial developments must be based on the period of significant wastewater discharge.

2.1.2 Loading Design Considerations

Loading projections must consider historical data, special users (commercial, industrial, etc.), typical domestic loads, and/or local planning requirements. Where available, documentation must include a minimum of five years of historical data for the existing service area. If historical records are not available, an analysis of individual user types and their anticipated loadings must be provided. For single use facilities where historical data is unavailable and for OWTS, the *Guidelines on Individual Sewage Disposal Systems* (or successor) must be followed unless justified otherwise.

The unit process design loadings are usually computed in a manner similar to hydraulic loading and must include re-circulation and sidestream flows and loads. Designs shall be based on the maximum month mass loadings and should account for variation in monthly, weekly, or daily effluent limits to ensure that effluent limits can be met. Loadings for single use facilities such as, camps, food service, events centers, schools, lodges, motels, etc., must be computed for the maximum possible occupancy. An appropriate unit of usage, such as number of meals served for a restaurant, must be used for computation of total organic loading. The adverse impact of high contribution for short periods of time, including septage and industrial loads, must also be considered.

2.1.3 Unit Process Capacities

The BDR or PDR shall provide a comparison of the actual hydraulic and organic loading conditions at the design life and illustrate in tabular or graphical format the fixed/total and firm capacity for each unit process.

- Fixed/Total Capacity – Capacity of a unit process with all facilities and equipment in operation.
- Firm Capacity – Capacity of a unit process with the largest unit (facility or equipment) out of service.

2.2.0 GENERAL CONSIDERATIONS

The design engineer is responsible for ensuring the applicable building codes and regulations governing the design and construction of such facilities are used during the design phase of all wastewater treatment facilities. These codes include the applicable building, electrical, fire, mechanical, and plumbing codes adopted by the jurisdiction for the site location, applicable safety codes (e.g., Occupational Safety and Health Administration or OSHA regulations), chemical and pesticide storage (e.g., 8 CCR 1206-1), and local planning and zoning regulations. The Division's review will not focus on code elements but may include request for additional information where a design does not appear to have adequate protections for the operators to safely operate and maintain the facility so the facility can meet required effluent limits.

2.2.1 Arrangement of Units

Consideration must be given to promote operating convenience, flexibility, and economy, and to facilitate routine maintenance and installation of future units.

Adequate access and removal space shall be provided around all components to permit easy operation, inspection, maintenance, and/or removal and replacement without interfering with the operation of other equipment. Components located inside buildings or other structures shall be removable without affecting the structural integrity of the building or creating a safety hazard.

2.2.2 Emergency Facilities

During loss of primary power, the facility must be able to convey all flows without bypass, sanitary sewer overflow, or other unauthorized discharge. Specific requirements for lift stations are provided in Chapter 4. WWTPs must provide preliminary treatment, the equivalent of primary treatment, plus disinfection and, if appropriate, dechlorination. The permittee is still responsible for meeting all discharge limits. Therefore, the applicant should consider providing sufficient standby power to maintain normal operations at all times.

The design must identify emergency response procedures to maintain operation of treatment processes during generally foreseeable emergency conditions (e.g., electrical power disruptions, mechanical failure, floods). The standby power source may be either a self-starting generator or a second independent power supply. Generators must be designed to enable test operating (e.g., manual, automatic) on a regular basis to ensure proper function in the event of a power outage.

2.2.3 Reasonably Foreseeable Environmental Conditions

The various unit processes and equipment must be designed and sized for the reasonably foreseeable environmental conditions to which they will be exposed at the proposed plant site including wastewater temperature ranges, air temperature ranges, altitude, historical precipitation information, and other environmental conditions.

In-ground tanks, facilities, or basins shall be protected from up-lift due to groundwater (e.g., sufficient ballast or other means).

2.2.4 Floodplain Considerations

The treatment works structures, electrical and mechanical equipment shall be accessible, able to discharge, and protected from physical damage during the 100-year flood (e.g., floodplain as designated by FEMA or other local flood mapping management agency). This requirement applies to new construction and to existing facilities undergoing major modification.

2.2.5 Separation from Other Public Water Supplies

New DWWTW shall be located relative to wells consistent with the Rules and Regulations for Water Well Construction, Pump Installation, Cistern Installation, and Monitoring and Observation Hole/Well Construction 2 CCR 402-2 (Water Well Construction Rules).

2.3.0 GENERAL DESIGN CRITERIA

The DWWTW design must comply with the following criteria.

2.3.1 Conduits and Channels

All piping and channels shall be designed to carry the peak flow expected at the facility's design capacity for that portion of the facility. Bottom corners of the channels shall be filleted. Pockets and corners where solids can accumulate shall be eliminated. Suitable gates shall be placed in channels to seal off unused sections, which might accumulate solids. The use of shear gates or stop planks is permitted where they can be used in place of gate valves or sluice/slide gates.

2.3.2 Flow Measurement

The monitoring of the various flows throughout a WWTP under various flow and organic loading conditions helps provide an audit of plant performance and aids in forecasting the need for additional treatment capacity. Therefore, the design of any new or expanded wastewater treatment facility shall include adequate flow metering and/or measuring of all pertinent liquid and sludge flow streams. The PDR shall include a list of locations where flow metering and/or measuring devices will be provided. For purposes of these criteria, flow metering requires recording whereas flow measuring does not require recording.

Flow metering at the headworks area of any treatment facility shall be provided. The metering device shall be equipped with a local flow indication instrument and a flow recording-totalizing device suitable for providing permanent flow records. Where influent flow metering is not practical and the same results may be obtained with effluent metering, this type of flow metering arrangement will be considered. If influent flow is significantly different from effluent flow, both shall be measured (e.g., installations such as lagoons, sequencing batch reactors, and plants with excess flow storage or flow equalization). Influent and effluent metering must be provided as reasonably anticipated to be required by the Colorado Discharge Permit System (CDPS) permit.

Influent measurements shall be representative of the volume of all influent wastes received at the facility, including septage, biosolids, etc. and shall be taken before the influent wastestream joins or is diluted by any other wastestream or substance (e.g., internal recycle flows). Effluent measurements shall be taken after internal recycle flows are removed and before the effluent joins or is diluted by any body of water. Flow meters shall be located with adequate upstream and downstream hydraulic conditions at each metering device (e.g., avoiding turbulence, eddy currents, air entrainment) to ensure that accuracies within $\pm$ 10% of actual flows during the full range of anticipated flow variations.

The flow measurement equipment (e.g., flume, weir, magnetic meter, venturi meter) must be consistent with the proposed application. All flow measurement equipment must be sized to function effectively over the full range of flows expected and shall be protected against freezing. Flow measurement devices must be accessible for maintenance and calibration.

Where multiple treatment units are proposed, such as two or more clarifiers or two or more aeration basins, provision shall be included for isolation and proportional flow splitting to each treatment unit (e.g., measurement and adjustment as needed).

Flow metering equipment may control chemical addition by signals such that the paced unit varies the chemical, etc. in proportion to the flow variations.

2.3.3 Installations of Mechanical Equipment

The design specifications shall identify when a trained manufacturer representative is required to check the installation and initial operation of major mechanical equipment items.

2.3.4 Unit Process Redundancy

At least two process treatment units of each type shall be provided for domestic WWTPs with a design capacity equal to or greater than 40,000 gpd. Where two units are proposed, each unit shall have a design flow of at least 50 percent of the total design flow. The hydraulic capacity (not necessarily the treatment capacity) of the remaining units shall be sufficient to handle the peak wastewater flow without overflow with the largest unit out of service. Other chapters of this document provide specific process redundancy requirements (e.g., disinfection). If a single train is used, an emergency operation plan (e.g., equipment, procedures, emergency storage, hauling) must be provided to maintain operation during operational impairment, such as power failures, flooding, peak loads, equipment failure, and maintenance shutdowns.

2.3.5 Maintenance Provisions

Piping shall be designed with no isolated pockets that cannot be drained. The DWWTW shall have provisions for cleaning all pipes that are subject to clogging or accumulation of solids (e.g., scum, sludge, lime feed and sludge, drain) without causing violation of effluent limitations.

Chemical or process air feed lines shall be designed to enable repair or replacement without drainage of the basins, wetwells, or tanks.

Vital mechanical components (e.g., pumps, mixers, bar screens, aerators, diffusers, instrumentation, and valves, but not piping, tanks, basins, channels, or wells) shall have provisions (e.g., availability of other equipment) to enable repair or replacement without interrupting DWWTW operation or causing the DWWTW to violate effluent limitations.

The DWWTW shall have lifting and handling equipment available to aid in the maintenance and replacement of all components. Means shall be provided for removal of components located above and below the ground level of buildings and other structures.

2.3.6 Instrumentation and Control Systems

The design must provide monitoring, control, and alarms for operators to control and adjust treatment processes.

Alarms and annunciators shall be provided to monitor the condition of equipment whose failure could result in an interruption of the treatment process (e.g., violation of the effluent limitations), damage to vital equipment, or hazards to personnel. The alarms shall sound in areas normally staffed and also in areas near the equipment. DWWTW not continuously staffed shall have the alarm signals transmitted to a point which is continuously staffed (e.g., autodialer to an on-call operator). Remote facilities without telemetry must provide an equivalent method for an operator to be notified of alarms (e.g., an external light that informed neighbors can see and call the operator). The combination of alarms and annunciators shall be such that each announced condition is uniquely identified. Test circuits shall be provided to enable the alarms and annunciators to be tested and verified to be in working order.

Automatic control systems shall be provided with a manual override. Automatic controls shall have alarms and annunciators to indicate malfunctions that require manual override.

The means for detecting the malfunction shall be independent of the automatic control system, such that no single failure will result in disabling both the automatic controls and the alarm and annunciator.

Where instrumentation failure could result in a violation of the effluent limitations, a backup sensor and readout shall be provided. The backup equipment may be of a different type and located at a different point, provided that the same function is performed. No single failure shall result in the disabling of both sets of parallel instrumentation.

2.3.7 Construction Materials

Due consideration must be given to the selection of materials which are to be used in DWWTW because of the possible presence of hydrogen sulfide and other corrosive gases, greases, oils, added chemicals, and similar constituents. This is particularly important in the selection of concrete, metals, paints and electrical devices. Contact between dissimilar metals should be avoided to minimize galvanic action.

2.3.8 Painting

In order to facilitate identification of piping, pipes must be labeled (i.e., contents and flow direction). Pipes may have contrasting colors as required by local plumbing or building code requirements.

2.3.9 Grading and Landscaping

Upon completion of the construction of the DWWTW, the ground must be graded and have concrete or suitable gravel walkways for access to all units. Steep slopes must be protected to prevent erosion. Surface water shall not be permitted to drain into any unit. Design provisions shall be incorporated to ensure landscaping requirements meet local code requirements. Depending on site-specific conditions, a stormwater discharge permit and stormwater management plan (SWMP) may be required.

2.3.10 Water Supply

An adequate supply of potable water under pressure is required for sanitary, safety, fire protection and drinking purposes, use in the laboratory and general cleanliness around the plant. All building plumbing design aspects must comply with the applicable plumbing codes. Potable water supplies must meet the requirements of the Colorado Primary Drinking Water Regulations 5 CCR 1003-1.

Colorado's Primary Drinking Water Regulations prohibits cross-connections that have the potential to contaminate a potable water system. The water supply must be physically separated into two systems, a plant potable water system and a plant non-potable water system. Where a separate non-potable water supply is to be provided, a break tank, pressure pump and pressure tank or acceptable backflow preventer shall be provided.

2.3.11 Sanitary Facilities

Suitable hand washing facilities must be included in the design of all treatment works. Where at least 8 hours of operation per day is provided, a shower, water closet, and drinking water source (e.g., fountain, bottled water) should also be provided.

2.3.12 Laboratory

All DWWTW shall include a laboratory or other suitable workspace for conducting necessary on-site analytical tests and operating control tests (e.g., sludge settling).

2.3.13 Drains

Means must be provided to empty each unit process for maintenance and repair. Design must include buoyancy protection for when unit processes are empty. Floor surfaces must be sloped adequately to a point of drainage. All drain piping must be routed to the appropriate treatment location to ensure compliance with the effluent permits.

2.3.14 Freeze Protection

All mechanical portions of treatment works shall be protected from freezing or icing problems from very cold weather. Covers over processes affected by temperature and heating systems shall be considered during the design. Enclosures and appropriate temperature control shall be required for all facilities where proper treatment could be adversely affected by extreme cold.

2.3.15 Heating and Ventilation

The design must include appropriate heating and ventilation requirements for wastewater treatment facilities. The design documents must identify the building environmental classification (e.g., as described in the National Fire Protection Association's (NFPA) Standard for Fire Protection in Wastewater Treatment and Collection Facilities) for each enclosed structure impacted and include design considerations to provide an environment suitable for human occupancy and safety.

2.3.16 Odor Control

Unless setback distances in the Regulation 22 Guidance document are provided, the DWWTW design must incorporate reasonable and appropriate odor mitigation elements (e.g., containment, treatment) considering prevailing winds, localized inversion conditions and other physical characteristics of the proposed treatment processes. Please note, the Air Quality Control Commission's Regulation Number 2, Odor Emission applies regardless of setback.

2.3.17 Security Considerations

The WWTP and surrounding property need protection with perimeter fencing and gates to limit access for safety and security purposes. A 6-foot (2-meter) high fence (e.g., chain link, brick) must completely enclose mechanical WWTPs. Locks must be provided for access gates. Buildings that enclose treatment processes and equipment to control unauthorized (e.g., public) access may be used in lieu of or in combination with fence. Waste stabilization ponds may be enclosed by stock type, barbed wire fences; however a 6-foot (2-meter) high chain link fence is preferable.

Additional security requirements may be identified by the design engineer following a vulnerability security assessment or other federal and state guidelines for the protection of the DWWTW.

2.3.18 Safety Considerations

The design must include adequate provision to effectively protect plant personnel and visitors from hazards. This may include but is not limited to minimizing confined spaces, proper ingress and egress to confined spaces and work areas, lighting and ventilation, isolation of process units to allow for maintenance, secondary containment, chemical exposure during loading and operation, use of personnel protective equipment, safety showers, and eyewashes.

Equipment whose failure could be hazardous to personnel or to other equipment shall have means for isolation (e.g., shutoff valves, shutoff switches, controls) located away from the equipment to permit safe shutdown during emergency conditions.

2.4.0 OPERATION AND MAINTENANCE PLANNING

Operations and maintenance manuals shall be furnished to the operations staff prior to start-up of the new facilities. These manuals will describe the overall operation and maintenance of the facility including process operations and controls. The owner will determine the number of manuals and may require training with the manuals. The manual(s) will include but not be limited to the following:

a. Performance requirements/goals.

b. Description, operation and control of the wastewater treatment facility and individual components including handling and disposing of residuals.

c. Types and purposes of laboratory tests required for the specific type of treatment process.

d. Types and purposes of record keeping, practices and example record keeping forms.

e. Maintenance schedules for individual components and equipment.

f. Potential safety issues associated with the wastewater treatment facility and individual components and equipment.

g. Facility upset and emergency response procedures.

CHAPTER 3
WASTEWATER CONVEYANCE

Proper design of wastewater conveyance systems is necessary to ensure adequate hydraulic capacity and operation and maintenance conditions to prevent sanitary sewer overflows (SSOs).

The following gravity wastewater conveyance systems shall conform to the design criteria listed herein.

- Interceptor sewer that is 24-inches nominal diameter or larger subject to site location approval by the Division (WQCC Regulation No. 22)
- Sewers that are not subject to Regulation No. 22 but require Division review as a condition of funding or other program or regulatory requirements.
    - Sewer mains receiving flow from individual service lines, interceptor sewers and outfall sewers.
    - Service lines and the connection to sewer mains to the extent the project includes design and construction of the service lines by the local operating agency or utility.

3.1.0 DEFINITIONS

The following definitions apply to this document.

a. Sewer: A pipeline used to convey wastewater by gravity flow; including sewer main and interceptor, also includes siphons.

b. Sewer main: A pipeline that conveys wastewater by gravity flow from a service line connection to an interceptor, a wastewater pump or lift station or the headworks of a treatment facility.

c. Interceptor: As defined in Regulation No. 22, a sewer line with an internal pipe diameter equal to or greater than 24 inches, if it performs one or more of the following functions as its primary purpose:

1. It intercepts domestic wastewater from a final point in a collection system and conveys such waste directly to a treatment plant;
2. It is intended to replace an existing treatment plant and transports the collected domestic wastewater to an adjoining collection system or interceptor sewer for treatment;
3. It transports the domestic wastes from one or more municipal collection systems to a regional treatment plant;
4. It is intended to intercept an existing major discharge of raw or inadequately treated wastewater for transport directly to another interceptor sewer or to a treatment plant. A sewer with a minor number of building or lateral connections may be considered an interceptor sewer if it performs one or more of the functions listed above. Interceptor sewers are appurtenances to domestic wastewater treatment works.

d. Service line: A pipeline that conveys wastewater from a structure where wastewater is generated to a connection with a sewer main. The service line may be a gravity flow pipeline or a pressurized pipeline; however, for purposes of this policy, reference will only be made to gravity flow pipelines.

3.2.0 DESIGN CRITERIA AND CONSIDERATIONS

Gravity wastewater conveyance system designs must comply with the following criteria.

3.2.1 Service Area

The service area for any segment of interceptor or sewer main shall be defined for purposes of determining the volume of wastewater to be conveyed by the pipeline. The BDR shall present the ultimate service area tributary to any segment of interceptor or sewer main and develop the rationale for generation of wastewater from that service area. The appropriate design service period shall be based on the status of development and level of detail in land use planning within the service area as indicated below with the design basis presented in the BDR.

a. Service areas fully developed: 50 or more years

b. Service areas with substantial development and well defined future planning or other development constraints: 50 years

c. Service areas with little existing development and very little detailed land use planning: 20 to 40 years

d. Service areas with no development and speculative development potential: 15 to 20 years

3.2.2 Hydraulic Loading Criteria

Existing measured unit contribution volumes and recorded flow rates shall be used to develop hydraulic loading criteria when such data is available. Data from utilities with similar conditions may be used to supplement or form the basis of hydraulic loading criteria. The BDR shall include all background data to develop and/or justify the proposed hydraulic loading criteria. Metered water delivered to customers may be used as a rational basis of developing wastewater volumes.

a. Unit volume contributions from user classes shall conform to the following in those situations where there is no data from the 1) existing system, 2) the local governing authority or utility has not adopted its own hydraulic loading criteria and 3) there is not a utility with similar conditions which can be used as a basis of design:

1. Residential.

A. Single-family, detached and attached, such as townhomes or mobile homes: Maximum month average daily flow no less than 180 gallons per day (gpd) per unit.

B. Multi-family dwelling structures: Maximum month average daily flow no less than 165 gpd per unit.

2. Non-Residential.

A. Commercial land uses without definition of specific commercial or business activity to be conducted: Maximum month average daily flow no less than 1,500 gpd per gross acre.

B. Commercial land uses with specific definition of commercial or business activity to be conducted: Average daily flow will be as provided in the *Guidelines on Individual Sewage Disposal Systems* (or successor document) or other applicable and widely accepted planning or engineering references documented in the BDR, with any appropriate adjustments for unique conditions.

C. Industrial land uses without definition of specific industrial activities to be conducted: Maximum month average daily flow no less than 2,000 gpd per gross acre.

D. Industrial land uses with specific definition of industrial activities to be conducted: Maximum month average daily flow shall be developed from an analysis of the specific industrial activity, process wastewater to be generated, discharge to the local governing authority or utility proposed and other site specific factors.

b. Volume contribution from extraneous sources of wastewater:

1. Existing measured unit volume contribution shall be the preferred data to evaluate the contribution of extraneous wastewater from such sources as infiltration and inflow. No less than 12 months of data will be evaluated to determine seasonal changes in extraneous wastewater flow contributions.

2. Infiltration and inflow allowances for interceptor and sewer main extensions or expansions shall use records from the local operating agency or utility to which the new interceptor or sewer main(s) will connect. It will be presumed that new construction will permit no more than existing contributions of extraneous wastewater flow.

3. Where existing service lines will be connected to a new sewer main or sewer mains will be connected to a new interceptor, extraneous wastewater contribution used in design shall be no less than that observed and metered in the existing system unless the BDR thoroughly and substantially demonstrates that the service lines to be connected to the new sewer main(s) or sewer mains to be connected to the new interceptor(s) are sound and are not the source of extraneous wastewater. In this case, an allowance of no less than 100 gpd per inch of pipe diameter per mile of sewer main shall be included in the hydraulic loading criteria for the new sewer main.

c. Maximum month average daily per capita wastewater contribution must be not less than 75 gallons per capita per day (gpcd) nor greater than 100 gpcd unless satisfactory justification is provided for using a lower or higher value.

d. Peak flow to annual average day flow ratio must be based on site-specific data (i.e., an appropriate and defensible peaking factor data/equation from an established public entity) or Figure 3.1. If site-specific data is not available, the design peak flow to average flow ratio shall not be less than 2.5:1 for interceptors.

3.2.3 Hydraulic Design Criteria

a. Minimum flow velocity.

1. The design (i.e., build out) annual average day flow velocity in a gravity flow interceptor or sewer main shall be no less than 2 feet per second (fps) and documented in the BDR.

2. Initial operating conditions may not provide for conditions to attain a flow velocity of 2 fps at annual average daily flow. In this case, the flow velocity at peak hour flow must be analyzed. If the initial peak hour flow velocity is 2 fps or greater, the minimum flow velocity criteria is satisfied.

3. If initial operating conditions do not provide for conformance with the minimum flow velocity criteria at average daily flow or peak hour flow, written acknowledgement of initial and future operating conditions by the responsible local operating agency or utility shall be provided to the Division. Written acceptance shall include:

A. Agreement to provide all necessary operation and maintenance attention required to provide for satisfactory operation of the interceptor or sewer main including periodic flushing to remove accumulated solids

B. A plan of operation defining all necessary activities and planned scheduling to assure satisfactory operation of the sewer main and assure prevention of SSOs.

b. Design conditions shall provide for maximum depth of flow at peak hour flow rate of no more than 80 percent of the internal pipe diameter (i.e., d/D). Full pipe design conditions shall not be allowed, except for siphons which require full pipe flow.

c. Interceptor or sewer main pipe and hydraulic design parameters shall be documented in the BDR.

d. Application of peer-reviewed hydraulic principles shall be used in the preparation of the BDR. The Division recognizes the following as the primary sources of hydraulic principles for use in design of interceptors and sewer mains:

1. Gravity Sanitary Sewer Design and Construction, published as American Society of Civil Engineers (ASCE) Manuals and Reports on Engineering Practice No. 60 and Water Environment Federation (WEF) Manual of Practice No. FD-5 (MOP FD-5), latest edition.

2. Manning's Equation; unless conditions require or are best addressed with other methods referenced in MOP FD-5.

<u>3.2.4 Minimum Pipe Size (i.e., sewers not subject to Regulation 22 but otherwise require design review by Division)</u>

a. Service lines shall be a minimum of 4-inches in diameter.

b. Sewer mains shall be a minimum of 8-inches in diameter except for small diameter sewer system components other than service lines.

c. Small diameter sewer mains may be a minimum of 4-inches in diameter if specific solids control, removal or treatment at the source is provided and the local operating agency or utility provides written acknowledgement to the Division of the additional required operation and maintenance.

<u>3.2.5 Horizontal Alignment of Interceptors and Sewer Mains</u>

a. Horizontal alignment of interceptors and sewer mains shall be in a straight alignment between manholes or points of termination. Curved horizontal alignment may be used provided it is acceptable to the local governing agency or utility, can be maintained by the local agency with available equipment and is designed and constructed to conform to specifications and recommendations of pipe material manufacturers.

1. Curved horizontal alignment may be accomplished by bending each pipe segment or deflecting at the joint in accordance with the pipe manufacturer's guidance.

2. Curved horizontal alignment (without manholes) may be accomplished with factory-fabricated bend fittings with deflection angles not exceeding 3-degrees (i.e., must be capable of being maintained using typically available equipment).

b. Location of interceptors and sewer mains shall accommodate other underground facilities including utilities, storm drainage facilities and laterals and services lines.

c. Location of interceptors and sewer mains shall accommodate access for operation and maintenance under adverse surface and weather conditions (e.g., mud, snow, and ice). Access shall be provided for trailer or truck mounted high-pressure water jet pipeline cleaning equipment. This is not intended to preclude construction of sewers within a floodplain with appropriate provisions to minimize inflow.

3.2.6 Vertical Alignment of Interceptors and Sewer Mains (except siphons)

a. Continuous pipe slope shall be maintained in the direction of flow between manholes.

b. Variable grade between manholes for interceptors and sewer mains will be considered on a case-by-case basis by the Division.

3.2.7 Corrosion Control

Corrosion control shall be addressed in the BDR such that materials specified for all components will provide for satisfactory performance through the service life of the sewer. This may include specific provisions for maintenance, rehabilitation and/or replacement of coatings, linings or structural materials.

3.2.8 Pipeline Materials, Loading, and Corrosion Control

a. Pipeline materials for sewers shall be those identified in WEF MOP FD-5. The BDR shall demonstrate the suitability of the proposed interceptor or sewer main material to provide satisfactory performance for a service life of 50 years or the planning period used to define hydraulic loading conditions, whichever is longer. If a service life of at least 50 years cannot be demonstrated, required periodic maintenance, rehabilitation of coatings and linings and/or pipe material replacement must be discussed in the BDR.

b. External loading and structural design of the pipeline shall be completed in accordance with the guidance of WEF MOP FD-5 and documented in the BDR.

c. Buoyancy of sewers must be considered and pipe flotation must be prevented with appropriate construction where high groundwater conditions are anticipated.

d. Cleanouts may be provided at the upstream terminus of a sewer main. If a cleanout is used, it shall be designed and constructed to accommodate all necessary cleaning, maintenance and operations activities required to assure satisfactory performance and prevent SSOs.

e. Inverted siphon (aka depressed sewers) with redundancy and maintenance provisions will be considered by the Division on a case-by-case basis. Review of inverted siphon will use the principles in WEF MOP FD-5. The BDR must include a review of alternatives and maintenance requirements.

3.2.9 Sewer Joints

Pipe joints, fittings, and gaskets shall provide for permanent watertight installations, preventing infiltration, exfiltration, and the intrusion of roots, and be structurally sufficient and corrosion resistant.

3.2.10 Manholes

a. Minimum manhole internal diameter shall be 4-feet.

b. Manhole internal diameter shall be increased to accommodate the largest interceptor or sewer main pipe penetrating the manhole. For pipe diameters less than or equal to 48 inches, the manhole must provide for a bench on each side of the largest pipe no less than 1-foot in width, unless using a pipe tee fitting. For pipe diameters greater

than 48 inches, a bench is not required unless specified by the local operating agency or utility.

c. Flow channels in manholes shall be designed and constructed with a U-shaped cross-section with a depth no less than the diameter of the largest pipe penetrating the manhole for pipe diameters up to 24 inches and a depth no less than 24 inches or the mid-point of pipe diameter whichever is greater for larger pipes.

d. Location of manholes shall be arranged to provide for optimum operation and maintenance. Manholes shall be located at intervals no greater than 400 feet for sewer mains 24-inches in diameter or less and 500 feet for sewer mains larger than 24-inches in diameter. Alternative manhole spacing specified in WEF MOP FD-5 or specified by the local operating agency or utility in published design criteria is acceptable if documented in the BDR or PDR. If the proposed manhole spacing is greater than the referenced peer reviewed criteria, the local operating agency or utility shall document in the BDR or PDR that it has the capability to adequately operate and maintain the interceptor or sewer main with the proposed manhole spacing conditions, including periodic flushing to remove accumulated solids and an operations plan with necessary activities and schedules to ensure satisfactory operation of the sewers and prevention of SSOs.

e. Pipeline connections to manholes shall be designed to provide for permanent watertight connections and assure structural integrity of the manhole and the pipe material.

f. Buoyancy of manholes must be considered and flotation must be prevented with appropriate construction where high groundwater conditions are anticipated.

g. Drop manholes may be used to accommodate excessive pipe slopes and other conditions between manholes such as conflicts with other underground infrastructure. The design must demonstrate satisfactory hydraulic performance according to WEF MOP FD-5, accessibility for operation and maintenance and structural integrity and performance through the service life of the interceptor or sewer main.

h. Manhole rings and covers shall be designed and specified to accommodate the specific site conditions and any specifications or criteria of the local governing authority or utility. The BDR or PDR shall address specifications for ring and cover materials, exclusion of surface water, special coatings or materials or corrosion control, security provisions, and suitability for adequate access for operation and maintenance.

i. Manhole steps are not required but may be provided at the option of the local governing authority or utility. In any case, the responsible local governing authority or utility shall provide all necessary guidance, processes and procedures to provide adequate access to manholes for all necessary operations and maintenance activities.

3.2.11 Crossings of Railroads, Roadways, Streams, Drainage Ways

a. Documentation of structural capacity of the pipeline for the anticipated design conditions is required in the BDR or PDR.

b. A casing pipe may be required for interceptors and sewer main railroad and roadway crossings by the jurisdictional agency. Criteria provided by the railroad owner or the responsible highway or transportation agency shall govern the casing pipe design and construction.

c. Stream or drainageway crossing designs shall ensure support of the interceptor or sewer main and protection from structural failure, damage from erosion and infiltration from ground or surface water.

d. Encasement of an interceptor or sewer main in reinforced concrete may be considered for special installations requiring protection from structural damage, erosion and other external conditions. Design principles shall be detailed in the BDR or PDR to demonstrate that use of concrete encasement will not result in shearing of the pipe material from the weight of the encasement or other conditions (e.g., soil, surface loading).

3.2.12 Relationship of Sewers to Potable and Reclaim Water Pipelines and Facilities

a. Where interceptors or sewer mains will be installed adjacent to other utilities, the BDR or PDR must include documentation that the installation methods will not adversely impact the adjacent utility.

b. Parallel installation of interceptors and sewer mains with potable, reclaim, and irrigation (raw water) water pipelines shall be accomplished in a fashion to preclude contamination of the water facilities. The separation distance shall be measured edge-to-edge of the interceptor or sewer main and the water pipeline. The interceptors and sewer mains shall be located no less than 10-feet away from (i.e., between pipes, outside to outside) and 1.5-feet below the potable water pipeline. The interceptors and sewer mains shall be located no less than 4-feet away from and 1.5-feet below the reclaim water pipeline or irrigation (raw water) pipeline.

c. If the interceptor or sewer main crosses under the water main but less than 1.5-feet of clear space will exist, the sewer main shall be installed in a pipe casing extending no less than 9-feet each side of the water main centerline. The pipe casing shall be of watertight material with no joints. The casing pipe material may be steel, ductile iron, fiberglass, fiberglass reinforced polymer mortar (FRPM), or polyvinylchloride (PVC) with suitable carrier pipe supports and casing pipe end seals. Alternatively, reinforced concrete encasement of the carrier pipe extending no less than 10-feet each side of the water main centerline may be used.

d. If the interceptor or sewer main will cross above or over the water main, the interceptor or sewer main shall be installed in a pipe casing extending no less than 9-feet each side of the water main centerline. The casing shall be a single section of steel or ductile iron pipe. The design shall include means to support the interceptor or sewer main to prevent settlement and permit maintenance of the water main without undue damage to the interceptor or sewer main.

e. If the minimum clearances cannot be satisfied, the Division will consider alternative designs on a case-by-case basis.

f. Sewer installations near water supply wells must conform to requirements of the Colorado Design Criteria for Potable Water Systems and the Colorado Division of Water Resources, State Board of Examiners of Water Well Construction and Pump Installation Contractors, Water Well Construction Rules.

3.2.13 Trenchless Installation

Trenchless installations for gravity wastewater pipelines shall conform to the design criteria for other gravity flow pipelines including pipe materials, hydraulic design principles, structural conditions, appurtenances and testing. The BDR shall identify the allowable trenchless installation method(s) and a plan for connecting other pipes.

3.3.0 CONSTRUCTION SPECIFICATIONS AND QUALITY CONTROL

The final design shall contain specifications, drawing details and other necessary conditions to assure conformance of the constructed project with the design criteria specified in the BDR. Specifically, the final design documents shall include the following:

a. Pipe trenching, backfill and bedding requirements shall be consistent with external loading and structural design principles provided in WEF MOP FD-5.

b. Pipe material specified shall be consistent with BDR provisions for structural sufficiency and corrosion control.

c. Specifications shall include requirements for pressure testing or other evaluation of water tightness to minimize extraneous wastewater contribution (e.g., methods such as low pressure air testing, infiltration flow rate, volume evaluation, Uni-Bell Plastic Pipe Association methods). Specifications shall require all tests to be recorded and results filed with the construction document files for the Owner. For water (hydrostatic) tests, the exfiltration or infiltration must not exceed 100 gallons per day per inch of pipe diameter per mile (93 liters/day/centimeter diameter/kilometer) for any section of the system with a minimum positive head of 2 feet.

d. Internal video inspection and records or passing a physical “pig” or “ball” may be used to verify the interceptor or sewer main is clear of all debris prior to acceptance and operation. Internal video inspection may be used to verify and confirm that the vertical alignment of the constructed interceptor or sewer main is compliant with the final design documents.

e. Pipe deflection testing and evaluation by laser or mandrel with documentation records.

f. Trench and other excavation backfill density requirements, testing and records.

CHAPTER 4
WASTEWATER LIFT STATIONS AND FORCE MAINS

Proper design of wastewater lift stations and force mains is necessary to prevent SSOs and control fats, oil and grease (FOG), floatable solids, grit and screenings.

4.1.0 GENERAL LIFT STATION DESIGN CONSIDERATIONS

Wastewater lift station designs must include the following provisions.

a. The lift station design must prevent accumulation of grit and other settleable solids. The BDR or PDR must include documentation of possible alternatives and maintenance requirements if the lift station is to be designed and constructed without grit and screening upstream of pumping equipment.

b. Safe access for operations personnel and adequate access for maintenance and equipment replacement.

c. Protection from physical damage (e.g., flooding, structural, uplift conditions) from 100-year surface runoff conditions. Lift station shall be designed to be accessible and able to discharge during the 100-year flood.

d. Security to restrict unauthorized access (e.g., locked structures, security fencing).

e. A self-activated alarm system in case of power failure, pump failure, high wet well water level, or any cause of pump station malfunction. Alarms must be transmitted to a continuously monitored location or operator (e.g., autodialer to an on-call operator). Additionally, an audio or visual device (e.g. light or horn) must be installed at the station for external observation unless disallowed by local ordinance. Remote facilities without telemetry must provide an equivalent method for an operator to be notified of alarms (e.g., an external light that informed neighbors can see and call the operator).

f. Reliability for emergency conditions shall include both of the following provisions.

    1. Power shall be provided from at least two independent sources (i.e., different substations or on-site backup power generation with an automatic transfer switch). Permanent on-site backup power generation is not required when adequate overflow storage is provided and the local operating agency can provide portable backup power generation equipment and/or temporary pumping capability.

    2. Overflow storage of raw wastewater shall be provided at the lift station in the event of an extended power outage, electrical failure, or mechanical failure, including force main interruptions. The overflow storage volume must be sufficient to contain all wastewater during the period of time required to restore pump station operation, install temporary pumping capacity or haul raw wastewater to an acceptable point of discharge (e.g., depending on methods and availability of staff, materials, equipment).

4.2.0 LIFT STATION STRUCTURES

The wastewater lift station shall comply with the following criteria.

4.2.1 Wet Wells

a. The suction vessel for the pumping equipment shall be sized to accommodate the design pumping rate and pump operation cycle at initial and design operating conditions

b. Configuration and geometry of the wet well shall prevent accumulation of grit and other settleable solids and provide for control of floatable solids with a minimum wet well floor slope of 10 percent to pump suction pipe or submersible pump inlet.

c. The wet well operating level shall be sized to provide a maximum detention time of one hour at average daily flow.

d. A method shall be provided to enable the wet well to be removed from service for maintenance (e.g., multiple wet wells, partitions, acceptable upstream pipeline storage, off-line storage, pumping direct from influent sewer, portable by-pass pumping) and be identified in the BDR.

e. Upstream pipeline storage shall not be used to satisfy wet well volume requirements for normal operating conditions

f. The structural design shall accommodate external, internal and buoyancy forces and loadings based on the findings of the site geotechnical evaluation.

g. Watertight construction must be provided to prevent infiltration and exfiltration.

h. Wet well corrosion control shall be addressed in the BDR. This may include specific provisions for maintenance, chemical addition, rehabilitation and/or replacement of coatings, linings or structural materials.

i. Wet well level mechanisms must be located to be unaffected by flows entering the wet well, rags, grease, other floating material, or by the suction of the pumps.

j. Common wall construction with a dry well is acceptable provided the design documents provide for watertight and gastight construction at penetrations in the dry well walls.

4.2.2 Dry Wells for Pumping Equipment

a. Access to dry wells shall be provided for operating personnel and maintenance in conformance with OSHA confined space entry requirements unless justification is given for space not being classified as confined space.

b. A ladder, stair or mechanical elevator, with fall prevention equipment shall be provided for necessary staff.

c. Lighting operated with lockout switch near entry hatch or door shall be provided.

d. Light fixtures, conduit, junction boxes and other apparatus of design, construction and materials shall be suitable for high humidity space to provide for satisfactory performance through the service life of the lift station.

e. A dedicated pump shall be provided to remove accumulated seepage water and water from pump seals, maintenance work and cleanup.

4.2.3 Appurtenant Structures and Facilities

a. All lift stations must have suitable devices, means or methods for measuring, recording and totaling sewage flow.

b. Ventilation of wet wells and dry wells must be consistent with appropriate fire, electrical, and building codes for the intended personnel and equipment use with appropriate devices for continuous or intermittent operation. Ventilation systems for wet wells and dry wells shall not be interconnected.

c. The lift station design shall minimize odor potential. Odor control methods shall be documented in the BDR, if applicable.

d. Materials of construction shall be suitable for the intended use and location (e.g., wet well, dry well). The BDR shall document potential corrosion conditions and detail all corrosion control methods including chemical application.

e. If separate screening or grit removal is included, the process design shall be consistent with the preliminary treatment criteria in Chapter 5.

4.3.0 PUMPING EQUIPMENT

Raw wastewater pumping equipment shall comply with the following criteria.

4.3.1 General

No less than 2 pumping units shall be provided. For ejector type pumps, at least two ejectors and two compressors shall be provided.

a. Pump units shall be sized to accommodate initial and future operating conditions.

b. Pumping equipment shall be designed to prevent clogging and be capable of conveying the equivalent of a 3-inch sphere. Alternatively, grinding capability shall be provided unless preliminary treatment equipment for screening is provided upstream of the wet well.

c. The pumping capacity shall be sufficient to maintain the wet well water surface level below design maximum high water (alarm) level at peak flows with largest pump out of service. Flow equalization in the wet well may be utilized to accommodate peak inflow and design pumping capacity, with or without separate or multiple wet well chambers or cells.

d. Pump discharge-head performance characteristics shall satisfy pump station design flow rate requirements with multiple pumps in operation, demonstrated with manufacturer's pump performance data and discharge system conditions (system "curve" analysis).

e. Pumping equipment must accommodate the minimum design flow velocity in the force main as required in Section 4.4.1.

f. Individual intakes shall be provided for each pump.

g. Pumping equipment shall be placed for adequate priming and to provide positive suction head under all conditions.

h. Pumps must operate automatically, based on the water level in the wet well, with provision for manual operation.

i. Capacity and pump discharge flow rate control must be provided to match flow capacity design for downstream treatment equipment and processes.

j. Where discharge from the pump station and force main is to gravity flow pipeline(s), pump discharge flow rate design and/or control shall be provided to prevent short-term, intermittent overloading or surcharging of gravity flow pipeline system. Where multiple lift stations and forcemains discharge to a single gravity flow pipeline, pump discharge flow rate design and/or control shall be provided to prevent short-term, intermittent overloading or surcharging of gravity flow pipeline system under simultaneous operation of the lift stations.

4.3.2 Submersible Pumping Equipment

a. Arrangement in the wet well shall conform to pump manufacturer's recommendations for pump spacing and minimum low water depth to accommodate

motor cooling and control of floatables with consideration of satisfactory hydraulic operation with adjacent pump(s) operating at the same time.

b. The connection to the lift station discharge piping design must be capable of being maintained or repaired without operating personnel entering or dewatering the wet well.

c. Pump removal must be possible without requiring operating personnel to enter or dewater the wet well. A corrosion resistant guiderail system shall be provided for each pump in the wet well. Guiderails and lifting chairs or cables shall be constructed of a material that has corrosion resistance equal to or better than Series 300 stainless steel.

4.3.3 Dry Well Pumping Equipment

a. Cleanout and inspection access shall be provided on the pump suction and discharge. Adequate access must be provided for maintenance of the pump (e.g., access to internal workings, pump removal and replacement).

b. Suitable pump support and management of vibration at all pump operating conditions shall be provided.

c. A dry well pump relationship to the corresponding wet well elevation that will satisfy pump performance requirements for net positive required suction head, flooded suction, self-priming conditions and/or requirements for an independent vacuum priming system for each pump shall be provided.

4.4.0 FORCE MAINS

A force main is a pressure pipeline that conveys raw wastewater that may or may not be degritted and screened before pumping. Force mains shall comply with the following criteria as well as applicable criteria presented in Chapter 3.

4.4.1 Hydraulic Design

a. The hydraulic design shall be developed in accordance with peer-reviewed principles and the design basis documented in the BDR.

1. Design of Wastewater and Stormwater Pumping Stations, Water Environment Foundation Manual of Practice No. FD-4.
2. Wastewater Engineering: Collection and Pumping of Wastewater, Metcalf & Eddy, Inc. with Dr. George Tchobanoglous, 1981.
3. Pumping Station Design, 2008, Editor Garr M. Jones with Robert L. Sanks, George Tchobanoglous, and Bayard E. Bosserman II, published by Butterworth-Heinemann.
4. Hydraulic Institute Pump Standards, 2010-2011.

b. The minimum velocity in the force main piping shall be no less than 2 fps.

c. Pumping equipment and controls will be arranged such that the force main can be operated (e.g., manually by operator) at a velocity no less than 3.5 fps on a periodic basis (generally once per week) to re-suspend settled solids and flush accumulated solids from the pipeline.

d. The minimum nominal internal diameter shall be 4 inches unless grinding of wastewater solids is incorporated into the lift station facility.

e. The force main must terminate in a structure (e.g., gravity sewer manhole) designed to withstand receiving flows without structural degradation.

f. The force main shall be installed with appropriate separation to potable water lines (see Chapter 3).

g. Air release or air vacuum valves must be appropriately incorporated into the force main design at high points or otherwise warranted by force main hydraulics. Isolation valves shall be provided on air release or air vacuum valves to minimize spills during maintenance or replacement.

h. Pressure testing of the constructed pipelines at 150 percent of working pressure shall be specified to confirm watertightness of the completed force main.

4.4.2 Pipe Materials

a. Pressure rating for pipe, fittings and joints suitable for normal operating pressures, and test pressures and accommodation for pipeline surge and water hammer conditions shall be documented.

b. The force main shall be designed for surge conditions due to sudden pump stop and closure of check valve on pump discharge.

c. Pipe materials shall be suitable for intended use in accordance with applicable ASTM, ANSI or AWWA designation and/or specifications.

d. Force main corrosion control (i.e., internal and external) shall be addressed in the BDR. This may include specific provisions for maintenance, chemical addition, rehabilitation and/or replacement of coatings, linings or structural materials.

e. Color and/or marking of pipe material for simple identification upon excavation shall be provided in accordance with standard color coding and identification.

f. Tracer wire or detectable tape shall be provided with nonmetallic pipe materials.

4.4.3 Odor Control

a. Evaluation of odor control requirements and the potential for hydrogen sulfide generation shall be included in the BDR.

b. Odor control methods (e.g., chemical addition facilities) shall be documented in the BDR, if applicable.

CHAPTER 5
PRELIMINARY TREATMENT

Preliminary treatment includes processes normally located at the beginning of a DWWTW for removal and handling of large solids, grit, and debris that can negatively impact downstream treatment processes. Treatment processes addressed in this chapter include: screening, grinding/shredding, and grit removal.

5.1.0 GENERAL

Preliminary treatment units shall:

a. Meet the electrical and mechanical requirements of NFPA 820 and all other applicable codes.

b. Include ventilation as required by appropriate codes for the intended use (e.g., human occupancy, hazardous gases, fire hazard, explosion proof).

c. Include freeboard of at least 18 inches at design peak hour flow.

d. Provide adequate physical access for operation, maintenance, repair, and replacement.

5.2.0 SCREENING

Screening devices, or equivalent method (e.g., septic tank), shall be provided for all WWTPs for the purpose of removing debris and nuisance materials from the influent wastewater. Generally screening includes coarse screens that are mechanically or manually cleaned and fine screens that are mechanically cleaned.

5.2.1 Design Flow Capacity and Redundancy (see also Section 2.3.4).

a. Firm capacity of screening facilities shall meet design peak hour influent flow. A single mechanically cleaned screen and a bypass channel with a manually cleaned screen may be provided.

b. Overflow or bypass to a redundant flow channel, capable of carrying the design peak hour flow, shall occur automatically if the primary screen fails or becomes overloaded. For a WWTP with multiple screening devices (i.e., firm capacity in item 5.2.1.a above), the overflow or bypass channel does not require a screen.

5.2.2 Screen Openings

a. For manually cleaned screens, clear openings must be at least 1 inch but not more than 1.75 inches and bars must be placed at a slope of 30 to 45 degrees from the vertical.

b. For mechanically cleaned coarse screens, clear openings must be greater than 0.25 inches but not more than 1.75 inches.

c. A fine screen is any mechanically cleaned screen with a clear opening less than or equal to 0.25 inch. A coarse screening device or grinder must be provided ahead of a fine screen unless the manufacturer does not require prescreening before the fine screen.

5.2.3 Velocity

a. The inlet channel for a screening device must have velocity sufficient to minimize deposition of solids. The PDR must provide a plan for minimizing solids deposition at a range of flows (e.g., initial, design capacity).

b. The design maximum velocity shall be less than 3 fps through the screen at design peak hour flows. Velocity through the screen shall be calculated using the open space along the length of the screen [i.e., $V= (Q/W_o)(\sin A)/d$ where V is velocity through the screen, Q is the peak hour flow, W_o is the width of the open area, A is the screen angle measured from the horizontal, and d is the flow depth in the channel].

c. A fine screen must be designed in accordance with the manufacturer's recommended velocity and head loss through the screen.

5.2.4 Cleaning and Material Handling

a. If the clear opening of the screen is less than 1 inch, a mechanical cleaning system must be provided.

b. For a WWTP with a design capacity of 0.5 mgd or more, screens in the normal flow channel(s) shall have a mechanical cleaning system.

c. Safe access for manual cleaning shall be provided including a horizontal platform that has provisions to drain and temporarily store the screenings.

d. Adequate facilities for safe and sanitary screening material storage, handling, and disposal, as well as separate handling of drained liquids, shall be provided.

e. Screenings washing facilities shall be provided for fine screens and considered for mechanically cleaned screens.

5.3.0 GRINDING/SHREDDING

A grinding/shredding unit process is not required. If grinding/shredding is included, the process shall meet the following requirements (see also Section 2.3.4).

a. Firm capacity of grinding facilities shall meet design peak hour influent flow.

b. If a shredding device is used to grind large debris, a screen or other suitable means of removing the debris (including materials that will tend to float in secondary clarifiers) must be installed.

c. Overflow or bypass to a redundant flow channel, capable of carrying the design peak hour flow, shall occur automatically if the primary grinding unit fails or becomes overloaded.

d. Grinding units must be designed in accordance with the manufacturer's recommended velocity and head loss through the grinder.

5.4.0 GRIT REMOVAL

Grit removal facilities shall be provided for all mechanical WWTPs to remove grit and other settled non-biodegradable solids from the influent wastewater, unless adequate other components to remove grit and other settled non-biodegradable solids from basins are provided instead.

5.4.1 Design Flow Capacity and Redundancy. See also Section 2.3.4.

a. Grit removal facilities with fixed capacity shall meet design peak hour influent flow.

b. Overflow or bypass to a second grit chamber or redundant flow channel, capable of carrying the design peak hour flow, shall occur automatically if the grit removal facilities are offline, fail, or become overloaded.

5.4.2 Velocity and Channel Ratios by Chamber Type

a. Channel type grit chambers shall be designed to minimize turbulence and provide uniform controlled velocities, between 0.8 fps and 1.3 fps over the range of

anticipated flow conditions, while accommodating grit storage and grit removal capacity in the channel.

b. Aerated grit chambers shall be designed with a length-to-width ratio between 3:1 and 8:1, a width-to-depth ratio between 0.8 and 0.9, a minimum hydraulic detention time of 3 minutes at design peak hour flow, sloped floors (e.g., 30 degrees), an inlet or inlet baffles to direct flow perpendicular to the spiral roll pattern, and methods to provide variable air rates (e.g., 3 to 8 standard cubic feet per minute [scfm] per linear foot).

c. Vortex grit chambers shall be designed with a straight inlet channel (e.g., length equal to the greater of seven times the width or 15 feet, or manufacturer's recommendation) and a velocity to minimize deposition of solids in the inlet channel prior to the grit chamber.

d. Proprietary grit chambers (e.g., multi-tray separator) must be designed in accordance with the manufacturer's recommended velocity and detention time through the chamber.

5.4.3 Cleaning and Material Handling

a. If the WWTP has grit removal, adequate facilities for safe and sanitary grit material collection/removal, storage, handling, and disposal, as well as separate handling of drained liquids shall be provided.

b. Grit washing facilities shall be provided if large amounts of organic material are anticipated to be removed through the process (e.g., facilities not providing positive velocity control).

c. Grit washers/classifiers must be designed in accordance with the manufacturer's recommended design conditions.

CHAPTER 6
PRIMARY TREATMENT

Primary treatment (i.e., settling, sedimentation, or clarification) typically follows preliminary treatment of influent wastewater and involves the quiescent detention of wastewater in specially designed settling tanks to remove settleable and floating solids. Solids are removed from the liquid flow by sedimentation and flotation, and thickened for removal and subsequent processing. Treatment processes addressed in this chapter are primary clarifiers septic tanks.

6.1.0 PRIMARY CLARIFIERS

Primary clarifiers are not required for WWTPs. However, primary clarifiers must be considered if anaerobic sludge digestion is planned. If primary clarifiers are provided at a WWTP, the design must meet the requirements of this section.

6.1.1 Design Capacity and Redundancy (see also Section 2.3.4).

a. At least two primary clarifiers with fixed capacity shall meet design peak hour influent flow (e.g., each designed for 50 percent capacity), unless the design maximum month flow capacity is below the threshold for a single train.

b. Surface overflow rates calculated as the clarifier influent flow rate (including any plant recycle streams), divided by the total tank area within the outer walls (including the area of the effluent collection troughs within the outer walls) shall meet the requirements in Table 6.1, based on the function of the clarifier.

Table 6.1 – Maximum Surface Overflow Rates for Primary Clarifiers

Type of Settling	Surface Overflow Rate	
	Design Flow (gpd/sf)	**Peak Hour Flow (gpd/sf)**
Primary solids settling only	800 to 1,200	2,000 to 3,000
Primary and waste activated sludge settling (co-thickening)	600 to 800	1,200 to 1,700
Chemical sludge settling	See Note*	See Note*
*Acceptable surface overflow rates will depend on the particular chemical treatment and shall be determined by pilot plant testing or the results of similar application. Source: Metcalf & Eddy 2003, *Wastewater Engineering: Treatment and Reuse*, 4th Edition, Table 5-20.		

c. The side water depth (SWD) for primary clarifiers shall be at least 10 feet. SWD is defined as the water depth from the top of the cone in a cone bottom tank to the water surface; or the water depth from 2.0 feet above the bottom of a flat bottom tank with a hydraulic sludge removal mechanism.

d. Rectangular clarifiers shall have a minimum length from inlet to outlet of 10 feet with additional tank length required to provide space for the effluent trough area.

e. Freeboard for primary clarifiers shall be at least 12 inches at design peak hour flow.

f. Organic removal credit from primary clarification of no greater than 35 percent of five-day biochemical oxygen demand (BOD_5) shall be included in the design, unless a higher efficiency is justified by a pilot study or data from a similar full-scale operation.

g. Effluent weirs shall be designed to prevent turbulence or localized high vertical flow velocity in the primary clarifier and shall be placed to allow maximum development

of the clarifier surface area. Effluent trough depths shall be adequate to carry peak hourly flow without submerging the launders. All effluent launder designs shall accommodate the collection and removal of scum by a clarifier skimmer system. Weir loading rates at design peak hour flow shall be between 10,000 and 40,000 gpd per linear foot.

h. Flow control shall be provided for controlling flows to individual clarifiers and for by-pass and maintenance.

i. Inlets of primary clarifiers shall be designed to dissipate inlet velocity, distribute flow equally, and prevent short-circuiting. Channels and piping shall be designed to prevent deposition of solids. Corner pockets and dead ends shall be avoided. Where inlet structures have submerged ports, the design shall include a method(s)for eliminating or removing floating materials that can accumulate inthe inlet structures.

j. Automatic scum collection and removal shall be provided. Each primary clarifier shall include provisions for separate draw-off and scum inspection and sampling. Scum pumps and withdrawal equipment shall be designed to transport the anticipated maximum scum density and flow and shall operate frequently enough to prevent excessive accumulation of scum in the sump or backup in the clarifier.

k. The design torque loading shall be documented in the PDR.

6.1.2 Sludge Collection and Removal

a. Mechanical sludge collection and removal mechanisms must be provided. For all primary clarifiers, the scraper size, quantity, configuration, and travel speed shall be adequate to convey the maximum expected amount of settled solids accumulation to the sludge removal sump.

b. A separate sludge draw-off shall be provided for each clarifier. Each draw-off shall have provisions for individual sampling and controlling of sludge flow.

c. Sludge withdrawal and conveyance piping shall be at least 4 inches in diameter and must include adequate cleanouts, flush connections, and pigging ports to allow access for clearing obstructions.

d. Primary sludge shall be removed from clarifiers and discharged to sludge processing facilities by pumping. Primary sludge pumps shall be a type and size capable of pumping primary solids without plugging. The minimum velocity in sludge lines shall be 2 fps to prevent solids deposition.

e. Biological sludge from the downstream secondary treatment process may be discharged to the primary clarifier for co-thickening with the primary sludge. Sludge collector equipment for these clarifiers shall be designed for more rapid sludge removal than conventional primary clarifiers to prevent septic conditions and to avoid solubilization of BOD_5 due to the decomposition of the biological waste solids. Sludge pumping and treatment systems shall be sized to handle larger volumes and reduced thickness of primary sludge due to the additional biological sludge.

f. Chemical coagulants (such as iron salts, aluminum salts, lime, and polymers) may be added to raw wastewater entering primary clarifiers to increase removal of particular constituents. Removal efficiencies and design surface overflow rates shall be based on jar tests, pilot plant testing, and/or results from similar plants treating wastewater with similar characteristics. Positive control of chemical feed rate shall be provided. Clarifier sludge handling equipment and downstream sludge pumping and processing facilities shall be capable of handling the increased mass and composition (density,

dewaterability, abrasiveness, scaling, pH, corrosivity, inert concentration) of primary sludge produced due to the chemical addition.

6.2.0 SEPTIC TANKS

In some limited circumstances (e.g., small systems), septic tanks may be used for solids separation before secondary treatment. Solids accumulate in the sludge where the organics are broken down into soluble fatty acids that enter the liquid phase and pass out of the tank. In effect, the tanks are producers of soluble BOD. The removal efficiency of a septic tank is related to the hydraulic retention time of the tank, the available capacity for solids to settle, and the actual operational conditions including wastewater characteristics (e.g., organic, inorganic, fats, oils, grease, detergents, chemicals), hydraulic and temperature variations, solids collection, BOD conversion, and tank maintenance received.

a. If septic tanks are used for solids separation, the septic tank must be designed to the standards provided in the *Guidelines on Individual Sewage Disposal Systems* (or successor). A septic tank shall have total hydraulic retention time of at least 48 hours in two or more sequential compartments or more than one tank may be used in series.

b. A total BOD removal credit of up to 30 percent may be approved by the Division for a design with properly maintained septic tank(s) meeting these criteria.

c. Tanks not specifically designed as septic tanks (e.g., inlet, outlet, baffles, dimensions) are not eligible to receive BOD removal credit.

CHAPTER 7
MECHANICAL LIQUID STREAM TREATMENT
(SECONDARY, ADVANCED/TERTIARY, SECONDARY CLARIFICATION)

Mechanical liquid stream treatment is the term used in these criteria to describe the treatment processes between preliminary/primary treatment (Chapters 5 and 6) and pathogen removal/disinfection (Chapter 9), other than ponds and wetlands. The processes included in this chapter include secondary treatment, tertiary treatment, side-stream treatment, and secondary clarification. Treatment in ponds and wetlands is covered separately in Chapter 8.

Secondary treatment is used for the removal of suspended solids and carbonaceous oxygen demanding material, although incidental removal of nutrients, such as nitrogen and phosphorus and other trace pollutants may occur.

Treatment to meet effluent limits beyond biological oxygen demand (BOD) and total suspended solids (TSS) such as nitrification, denitrification, phosphorus removal, is considered advanced or tertiary treatment.

- "Advanced Treatment" encompasses biological nutrient removal (BNR) and chemical addition processes that may be incorporated into secondary or tertiary treatment for improved effluent quality beyond conventional secondary treatment. Advanced treatment may incorporate physical, chemical and/or biological processes to improve suspended solids, BOD, turbidity and color removal, nitrification/denitrification, effluent oxygenation, nutrient removal, etc.
- "Tertiary Treatment" describes treatment process steps that occur after a conventional secondary treatment process. Tertiary treatment processes may be physical, biological, chemical or a combination of these.

Advanced and tertiary treatment processes must be clearly identified within the PDR. Individual design criteria requirements are described in the following sections. Advanced and tertiary treatment processes are often based on proprietary modeling or site specific conditions. In instances where published literature concerning specific process is not available, data from existing similar full-scale installations, applicable pilot study data, or verifiable manufacturer operating data must be provided.

7.1.0 GENERAL REQUIREMENTS FOR SECONDARY TREATMENT SYSTEMS

Secondary treatment systems are generally biological systems.

7.1.1 General

a. Calculations shall be submitted to justify the basis of design for all process components of the secondary treatment, including the biological process, clarification and solids recycling. The calculations shall demonstrate the basis for sizing the treatment tanks, aeration equipment, secondary clarifiers, return sludge equipment, and waste sludge equipment.

b. Process simulators, such as commercially available modeling tools, can be used in addition to or in lieu of manual process calculations for the development of mass balances to account for the mass flows of various parameters such as chemical oxygen demand (COD), total suspended solids (TSS), and total Kjeldahl nitrogen (TKN) in the liquid and solids stream treatment processes. Process modeling must be based on industry recognized standards (e.g., WEF MOP 31 – An Introduction to Process Modeling for Designers, International Water Association's Guidelines for Using Activated Sludge Models). When process simulators are used, the PDR must include a discussion of modeling protocols, justification of parameter changes from default values (e.g., kinetic rate constants), sensitivity evaluations, safety factors, and calibration efforts.

c. The following factors must be included in the PDR:

1. Secondary influent flows (peak hour, maximum month, average daily).
2. Secondary influent loadings.
3. Anticipated effluent quality.
4. Design basis of treatment units (e.g., size, depth, detention, overflow)
5. Design basis of equipment (e.g., horsepower, rated capacity, size, speed)
6. Basin mixing requirements.
7. Air requirements.
8. Process kinetics.
9. Solids retention time (SRT).
10. Mixed liquor suspended solids (MLSS) and mixed liquor volatile suspended solids (MLVSS).
11. Food to microorganism (F:M) ratio.
12. Solid loading, organic loading, and hydraulic loading rate (HLR).
13. Clarification, recycle, wasting.
14. Alkalinity.
15. Wastewater and ambient temperatures.
16. Hydraulic retention times (HRT).

d. Activated sludge plants can be classified by flow pattern and organic loading. There are many variations of the activated sludge process. Design parameters for activated sludge processes must fall into the general ranges published in the latest edition of MOP 8 and meet the requirements included in sections of these criteria.

e. All process calculations shall be based on a maximum month hydraulic and organic loading except as follows:

1. Where large seasonal variations in loadings occur, the design must be based on peak season loads.
2. Where the duration of loading is less than 24 hours per day (i.e. schools, subdivisions, recreational facilities, etc.), treatment units and equipment must be increased in size by the factor of 24/loading duration (hours) or appropriate flow equalization facilities shall be provided.

f. The design must provide sufficient dissolved oxygen (DO) in the final effluent following all treatment to meet discharge requirements (e.g., residual DO, baffles, aeration system).

g. Redundancy (see also Section 2.3.4).

1. Secondary process units, including secondary clarifiers when used, shall be divided into two or more trains capable of independent operation where maximum month flows exceed 0.04 mgd.
2. Peak hour hydraulic flow must be passed (i.e., hydraulic capacity, not treatment design) with largest unit process out of service (e.g., aeration basin, clarifier).

3. Equipment critical to process operation shall be designed to meet capacity with the largest unit out of service.

4. If there is a single activated sludge train, the design must identify the method for conducting typical maintenance operations such as diffuser maintenance, grit removal, etc.

7.1.2 Pretreatment

Where primary settling tanks are not used, removal or exclusion of grit, debris, excessive oil or grease (i.e., greater than 100 milligrams per liter [mg/l]), and screening of solids shall be accomplished prior to the secondary treatment process.

7.1.3 Scum and Floatable Material

The design must include provisions so that floating materials from the secondary treatment process (e.g., tanks, clarifiers) can be directly removed from the treatment facilities, avoiding the recycling of foam-causing microorganisms. Chlorination of recycle lines may control such microorganisms and, if used, separate control of the chlorine dosage shall be provided.

7.1.4 Sidestream Management

Sidestreams are plant solids process recycle and decant liquors.

The design, documented in the PDR, shall include an analysis of relevant sidestream characteristics (e.g., organic, nutrient, solids, total and soluble COD, total and soluble carbonaceous BOD_5, total and volatile suspended solids, total solids and total volatile solids, pH, alkalinity, TKN, ammonia, nitrite, nitrate, total phosphorus and orthophosphorus) returned to the mainstream process and include provisions to minimize adverse impacts to the mainstream treatment (e.g., batch loading from dewatering processes, ammonia bleed through the mainstream process, decreased phosphorus removal performance). Provisions could include flow equalization, physiochemical removal processes, and biological sidestream management.

a. If flow equalization of return sidestreams is provided, the PDR shall provide design details, as applicable, including equalization volume, mechanical mixing, odor treatment, sloped floor with drain, and struvite minimization.

b. If physiochemical removal processes for sidestreams are provided (e.g. membrane separation processes, ion exchange, ammonia stripping, breakpoint chlorination, coagulation, and filtration), the PDR shall provide design details, as applicable, including chemical dosing calculations, and solids flux analyses.

c. If biological sidestream treatment is provided, the PDR report shall provide design details, as applicable, including consideration for temperature, pH, HRT, SRT, clarifier overflow rate, oxygen demand, and alkalinity demand required for the sidestream treatment method selected. The design shall be supported with pilot study data or adequate data from similar full-scale installation, design calculations, and process control instrumentation.

7.1.5 Solids Management

The solids wasting design must be adequate to store and process the wasted sludge under all flow conditions.

a. A waste sludge pumping system requires at least two pumping units and must be sized to prevent excessive solids accumulation in the treatment process.

b. The design of a sludge piping system must prevent scouring at anticipated normal operating conditions and accommodate cleaning and flushing.

c. A sludge piping system must have a minimum diameter of 4 inches and be sized for a minimum velocity of 3 fps at the minimum return rate to prevent solids from settling.

7.1.6 Electrical and Instrumentation Systems

a. All three-phase motors must have phase failure protection.

b. Instrumentation and monitoring equipment must have power surge protection.

c. A facility must conduct fault monitoring and reporting on high water level, power interruption, disinfection failure, blower failure, and return sludge pumping failure.

d. The required alarm condition indicators must include:

1. Pumps – high temperature, general failure.
2. Basins – high level.
3. Aerators/Blowers – high pressure, high temperature, general failure.

7.2.0 ACTIVATED SLUDGE SECONDARY TREATMENT

7.2.1 Aeration Tanks

a. The size of the aeration tank shall be determined by calculations based mainly on mixed liquor solids concentration, the organic loading, and the SRT needed to meet the degree of treatment required. The aerobic SRT shall be based on the mass of solids under aeration divided by the mass of solids exiting the activated sludge system on a daily basis (equal to sludge wasted plus TSS in the secondary effluent). Calculations shall be submitted to the Division to justify the aeration tank capacity.

b. The design SRT and temperature shall be clearly stated, and justified for suspended growth systems. For carbonaceous BOD removal, design SRT values must be in accordance with the ranges provided in Table 7.1 and meet the requirements included in sections of these criteria. A means of solids separation shall be provided. Because the mixed liquor concentration affects the solids loading on the secondary clarifiers, selection of the MLSS concentration must be consistent and integrated with the secondary clarifier design.

c. The design must identify the location for measurement of sludge wasting.

d. Mixed liquor suspended solid design concentrations must be in accordance with the ranges provided in Table 7.1 and meet the requirements included in sections of these criteria.

e. The dimensions of each aeration tank and each zone shall maintain effective mixing and use of air. Liquid depths shall not be less than 10 feet or more than 25 feet.

f. Inlets and outlets for each aeration tank shall be equipped with valves, gates, stop plates, weirs, or other devices for controlling the flow to any unit and maintaining equal liquid levels and hydraulic equalization between aeration tanks.

g. Freeboard of not less than 18 inches at peak hour hydraulic flow must be provided in all aeration tanks under normal operations (i.e., not to meet requirement to hydraulically contain all flow with one process train out of service). Aeration tanks with mechanical surface aerators must prevent splashing on walkways.

h. Froth and foam control (e.g., water spray systems, other) must be considered. If provided, froth and foam control systems must be protected from freezing.

i. Each aeration basin must have provisions for dewatering (e.g., drains, pumps, hoses, piping).

Table 7.1 – Design Parameters for Activated Sludge Process[a]

Process Modification	SRT, d	F:M, lb BOD_5 applied/d/lb MLVSS	Volumetric loading, lb BOD_5/d/1000 cf	MLSS, mg/L	V/Q, h	Q_r/Q (Q=forward flow)
Conventional	5-15	0.2-0.4	20-40	1,500-3,000	4-8	0.25-0.75
Complete-mix	5-15	0.2-0.6	50-120	2,500-4,000	3-5	0.25-1.0
Step feed	5-15	0.2-0.4	40-60	2,000-3,500	3-5	0.25-0.75
Modified aeration	0.2-0.5	1.5-5.0	75-150	200-1,000	1.5-3	0.05-0.25
Contact stabilization	5-15	0.2-0.6	60-75	(1,000-3,000)[b] (4,000-10,000)[c]	(0.5-1.0)[b] (3-6)[c]	0.5-1.50
Extended aeration	20-30	0.05-0.15	10-25	3,000-6,000	18-36	0.5-1.50
High-rate aeration	5-10	0.4-1.5	100-1,000	4,000-10,000	2-4	1.0-5.0
Kraus process	5-15	0.3-0.8	40-100	2,000-3,000	4-8	0.5-1.0
High-purity oxygen	3-10	0.25-1.0	100-200	2,000-5,000	1-3	0.25-0.5
Oxidation ditch	10-30	0.05-0.3	5-30	3,000-6,000	8-36	0.75-1.50
Sequencing batch reactor	N/A	0.05-0.3	5-15	1,500-5,000[e]	12-50	N/A
Single-stage nitrification	8-20	0.10-0.25 (0.02-0.15)[d]	5-20	2,000-3,500	6-15	0.50-1.50
Separate stage nitrification	15-100	0.050-0.2 (0.04-0.15)[d]	3-9	2,000-3,500	3-6	0.50-2.00

Notes:
[a] Process modifications are described in Table 14.2 of WEF MOP 8 and Table 8-15 of Metcalf & Eddy 2003, *Wastewater Engineering: Treatment and Reuse*, 4th Edition. SRT = solids retention time, d = days, F:M = food to microorganism ratio, MLVSS = mixed liquor volatile suspended solids, cf = cubic feet, V = aeration volume, Q = forward flow rate, h = hours, Q_r = return activated sludge (RAS) flow
[b] Contact unit
[c] Solids stabilization unit
[d] TKN/MLVSS
[e] MLSS varies depending on the portion of the operating cycle
Source: WEF, MOP 8, *Design of Municipal Wastewater Treatment Plants*, 2010, Table 14.3.

j. Selectors, or flow patterns within aeration tanks, can be used to combat the growth of filamentous organisms and to enhance the settling of the mixed liquor. If used, selector design must provide the following information:

1. Type and function of selector (anaerobic, anoxic, aerobic).
2. F/M ratio.
3. Hydraulic and solids retention time.
4. Mixing.
5. pH.

7.2.2 Aeration Systems

a. Oxygen Requirements.

1. Mechanical and diffused aeration systems shall provide sufficient oxygen to satisfy peak carbonaceous BOD oxidation and, where applicable, ammonia oxidation needs presented in Table 7.2 below.

2. Sufficient oxygen shall be provided to meet both carbonaceous BOD oxidation and ammonia oxidation needs. Firm aeration equipment capacity shall be capable of maintaining 2.0 mg/L of DO in the mixed liquor at all times for the maximum month average day and provide thorough mixing of the mixed liquor. This criterion does not apply to anaerobic zones specifically designed for phosphorus removal or anoxic zones used as selectors or for nitrate removal.

3. The aeration system and blower design must be sized to accommodate startup conditions and diurnal variations.

Table 7.2 – Minimum Oxygen Requirements for Activated Sludge Processes

Process	Oxygen Requirement
Oxygen requirement for carbonaceous BOD (activated sludge treatment systems with SRT 5 to <20 days, pounds (lbs) O_2/lb BOD)	0.9-1.3[a]
Oxygen requirement for carbonaceous BOD (activated sludge treatment systems with SRT $\geq$20 days, lbs O_2/lb BOD)	1.5
Nitrogenous oxygen demand (lbs O_2/lb TKN)	4.6
Oxygen credit for denitrification (lbs O_2/lb N)	2.86[b]

[a]Design must justify selection with design SRT. In absence of case specific justification, design must use 1.2 lbs O_2/lb BOD.

[b]Use of oxygen credits from denitrification must be justified based on the specific process design (e.g., anoxic zone location, supplemental carbon, recycle, seasonal operation) to assure denitrification will occur.

b. The aeration system shall provide sufficient mixing to maintain suspension of MLSS under any flow condition unless a means for separate mixing is included. Minimum air mixing requirements are identified below. If the aeration system design deviates from these criteria, the PDR must include justification that demonstrates adequate mixing is still provided.

1. Fine bubble, full-floor coverage: 0.12 scfm per square foot of tank area.

2. Spiral roll: 20 scfm per 1,000 cubic feet of tank volume.

3. Mechanical aeration: justified by type of mechanical aerator and tank geometry or in absence of this information, use 0.6 horsepower per 1,000 cubic feet of tank volume.

4. Coarse bubble: greater than or equal to 20 scfm/1,000 cubic feet of tank volume.

5. Horizontally mixed aeration tank system: maintain an average velocity of 1 fps.

c. The PDR must include the design basis for determining the size of the aeration system, including supporting calculations. The following factors must be provided in the aeration system and blower design:

1. Flows (maximum month).

2. BOD and TKN maximum design loadings.

3. Anticipated effluent quality.

4. Standard oxygen transfer efficiency of system provided.

5. Actual transfer efficiency.
6. Alpha and beta factors.
7. Correction factors of oxygen saturation for plant altitude and diffuser submergence.
8. Design DO concentration.
9. Maximum and minimum ambient temperature.
10. Minimum, maximum, and average wastewater temperature.
11. Ambient pressure at site location.
12. Aerobic and total SRT, MLSS concentration.
13. Diffused air system, type of diffusers.
14. Minimum equipment rated capacity, number of units.
15. Anticipated seasonal Sludge Volume Index (SVI) values.

d. Blowers and Air Compressors.

1. Blowers and air compressors must have sufficient capacity to provide the required aeration rate for biological treatment and the air requirements of any supplemental unit (i.e., together "process air") with the largest single unit out of service.
2. The PDR must include blower or compressor calculations that show the actual air requirements for the expected temperature range, including both summer and winter conditions, and the impact of the actual site elevation on the air supply.
3. Blower capacity must be based on the air volume required on the expected summer conditions. The size of motors for compressors must be based on summer air flow rates and the winter temperature (or other means provided to control mass air flow rate and prevent motor overload).
4. Blower and compressor units must restart automatically after a power outage or the design must include a telemetry system or an auto-dialer with battery backup to notify an operator of any outage.

e. Aeration System Control.

1. The design must include methods to measure (e.g., DO, ammonia, pressure, air flow) and adjust the aeration supply and distribution to the aeration tank (e.g., valves).
2. A diffused air system must have methods to provide an adjustable air supply to meet the variable load and changing process conditions (e.g., sufficient turndown, multiple compressors, valves).

<u>7.2.3 Diffuser Systems.</u>

a. A submerged depth for a diffuser of less than 9.0 feet is prohibited.

b. The PDR must identify the basis for the diffuser design (e.g., what diffuser, how arranged) using the specific diffuser capabilities and oxygen transfer rates. The design spacing and arrangement of diffusers must be consistent with process oxygenation requirements throughout the tank and expected process operating modes. If alternate operating modes such as plug flow and step feed are provided,

the PDR must indicate how the diffuser layout is arranged so as to accommodate each mode.

c. Each diffuser system grid must have the ability to be isolated.

d. Valves must be provided to allow for variation in air flow rates to various aeration tanks and each diffuser header including an open/close and throttling type control valve that can withstand the heat of compressed air.

e. Air headers must withstand temperatures up to 250 degrees Fahrenheit (°F).

f. The size of air piping must be based on expected summer temperatures and design flows.

g. Air piping system components must withstand or account for expansion caused by a range of temperatures from minimum winter to maximum summer blower discharge.

h. Piping for fine bubble systems shall have non-scaling interior surfaces to minimize diffuser clogging.

i. Air pipes must include provisions for draining moisture.

7.2.4 Mechanical Aeration Systems.

a. The PDR must include the clean water oxygen transfer rate, not to exceed 2.0 pounds of oxygen per horsepower-hour unless justified by full scale performance data, and data to justify the design wastewater oxygen transfer efficiency.

b. The mechanical aeration system must be capable of re-suspending the MLSS after a shutdown period.

c. Mechanical aeration systems with channel or basin layout must have a minimum 0.75 horsepower per thousand cubic feet of aeration basin volume.

d. Each basin must include a minimum of two mechanical aeration devices.

e. The mechanical aeration system must meet the maximum design requirements for oxygen transfer with the largest single unit out of service.

f. The mechanical aeration device must automatically restart after a power outage, or an alarm notification system (e.g., telemetry system with battery backup or an auto-dialer with battery backup) must notify a facility operator or owner.

g. Other types of aeration systems (i.e., pure oxygen, turbine aeration, jet aeration, combination systems, etc.) shall meet the applicable oxygen supply and mixing criteria outlined in Section 7.2.2. Specific design characteristics of each of these systems will be reviewed on a case-by-case basis.

7.3.0 SECONDARY CLARIFIERS

Design of sedimentation for secondary treatment processes requires consideration of the overall secondary treatment process. Secondary clarifiers must be designed together with aeration basins and sludge return facilities. Design values shall be identified for the following secondary clarifier process parameters including overflow rate, solids loading rate, sludge settleability, underflow or return sludge pumping rate, and tank hydraulic characteristics.

7.3.1 Secondary Clarifier Sizing Criteria

a. Clarifier and return sludge pumping must be designed with the capability to allow operation over a range of SRTs, providing flexibility to prevent denitrification in the clarifier from low DO levels in the sludge blanket that could lead to violations of other effluent limits (i.e., suspended solids).

b. The peak solids loading rate must be based on the design MLSS under aeration and the maximum daily flow rate plus the corresponding recycling rate required to maintain the design MLSS.

c. Design solids loading rates and design overflow rates must be in agreement with Table 7.3 or be determined using state point analysis, expected sludge characteristics, solids loading, and a clarifier factor of safety. Supporting calculations, including identifying the peer-reviewed design method and the sources of the method must be submitted with the PDR.

Table 7.3 – Secondary Clarifier Overflow and Solids Loading Rates

Treatment Process	Surface Overflow Rate* (gpd/sf)		Solids Loading Rate (lb/day/sf)	
	At Design Max Month Flow	At Design Peak Hourly Flow	At Design Max Month Flow	At Design Peak Hour Flow
Attached Growth Biological Reactors – Trickling Filters, Rotating Biological Contactors, Submerged Biological Contactors	700	1,200	Not applicable	Not applicable
Suspended Growth Biological Reactors – Conventional, Step Aeration, Complete Mix, Oxidation Ditch, Contact Stabilization, Carbonaceous Stage of Separate Stage Denitrification, IF/AS	700	1,200	29	40
Extended Aeration (SRT ≥20 days)	400	700	24	35
MBBR	500	850		
Phosphorus Removal – Based on Effluent Total P Concentration 2 mg/L 1 mg/L (occasional chemical addition) 0.2-0.5 mg/L (continuous chemical addition)	 700 600 500			
*Based on influent flow only. Peak rate is 1.7 times the average overflow rate. Source: Metcalf & Eddy 2003, *Wastewater Engineering: Treatment and Reuse*, 4th Edition.				

7.3.2 Clarifier Design Criteria

a. Inlets.

1. Clarifiers must have an inlet valve or gate.
2. Influent baffling must be provided.
3. Clarifier inlets must include provisions for uniform flow and stilling.
4. Inlet conditions shall be designed to provide effective energy dissipation with minimum shearing of the biological floc.
5. Transfer pipes shall be designed to prevent trapping or entraining air.
6. Inlet distribution channels shall be designed to prevent the settling of solids in the channel.

7. Circular, center-feed clarifiers with conventional center wells must use a riser pipe inlet design that provides a maximum inlet velocity of 6 fps. Center well diameters must not exceed 25 percent of the clarifier diameter.

b. Scum removal.

1. Clarifiers must include scum baffles and a means for the collection and disposal of scum.

A. Scum removal equipment must accommodate changes in the water surface elevation in the clarifier.

B. Scum collected from the clarifiers must not be returned to the aeration tanks. A suitable method for disposal of the scum must be identified. Discharge of scum to an open drying area is prohibited.

2. Clarifiers with a design flow equal to or greater than 10,000 gallons per day gpd must use a mechanical skimmer.

3. Clarifiers with a design flow less than 10,000 gpd may use hydraulic differential skimming if the scum pickup is capable of removing scum from the entire operating surface.

c. Effluent weirs.

1. Design must consider provisions to prevent short circuiting (e.g., baffles), turbulence, and a localized high vertical flow velocity in a clarifier at the effluent weirs.

2. Weirs must be adjustable to allow leveling of the weir during installation (e.g., slotted holes) and to provide for minor changes to the water surface elevation in a clarifier.

3. Weir loading rate and supporting calculations must be submitted with the PDR for peak hourly flow.

4. A center-feed circular clarifier must have effluent weirs around the entire perimeter of the clarifier (e.g., inboard/outboard launder, inboard only).

5. Submerged launders (aka orifice collector tubes) may be considered, provided that the design basis is included in the PDR with the appropriate peer-reviewed design method references.

d. For a facility with pumped inflow, a clarifier must be able to accommodate all anticipated flow without overflow.

e. Side water depth (SWD) is defined as the water depth from the top of the cone in a cone bottom tank to the water surface or the water depth from 2.0 feet above the bottom of a flat bottom tank with a hydraulic sludge removal mechanism.

f. Rectangular clarifiers must have a minimum SWD of 10.0 feet. Circular clarifiers must have a minimum SWD in accordance with Table 7.4.

Table 7.4 – Secondary Clarifier Minimum Side Water Depths

Tank Diameter (feet)	Minimum SWD (feet)
Up to 40	10
40-70	11
70-100	12
100-140	13
>140	14
Source: WEF, MOP 8, *Design of Municipal Wastewater Treatment Plants*, 2010, Table 14.40.	

g. Clarifiers must have a minimum freeboard of 12 inches at the peak hour flow.

h. Sludge Removal.

1. Clarifiers must include a mechanism for sludge removal. A monitoring and control system must provide a means to control return and waste sludge flows from each clarifier, to control return sludge flows into each aeration basin, to meter return sludge flows, and to measure waste sludge flows (e.g., valves, pumps for measuring runtime).

2. Sludge pipes must be a minimum of 4.0 inches in diameter and design must include means to remove blockages in sludge pipes. For small WWTPs, smaller diameter pipe may be used if design includes adequate means to minimize and remove any blockages in sludge pipes.

3. Chain and flight sludge collectors in rectangular clarifiers must be designed with a minimum horizontal velocity of 2 feet per minute (fpm) with flights at least 10 feet on center. Multiple-speed collectors with speed capability of 2 to 6 fpm shall be required for tanks with high solids loadings or long flight travel times.

i. Return Sludge Pumping Capacity.

1. The actual rate of return sludge withdrawal is a function of the concentration of the mixed liquor suspended solids, the settling of the activated sludge, and the process control requirements. Return sludge firm pumping capacity shall be at least 100 to 150 percent of maximum month flow.

2. The return sludge system must be able to vary the flow rate from a minimum of 25 percent of the maximum month flow up to the maximum firm capacity using throttling, variable speed drives, intermittent pump operation, and / or multiple pump operation.

3. Provisions for measuring, sampling, and controlling return activated sludge (RAS) must be provided.

4. A centrifugal sludge pump must have a positive suction head, unless the pump is self-priming.

5. An airlift pump must allow for cleaning without draining a basin.

6. A RAS system must have sufficient pumping units to maintain the maximum design return pumping rate with the largest single pumping unit out of service.

j. Means for measuring, sampling, and controlling the rate of waste activated sludge (WAS) flow must be provided for SRT control. Waste sludge facilities must have capacity and capability to vary flow rate to pump the expected minimum and maximum rates of wasting (e.g., valves, pumps for measuring runtime). A WAS system must have sufficient pumping units to maintain sludge wasting capacity with the largest single pumping unit out of service.

k. Redundancy (see also Sections 2.3.4 and 7.1.1).

1. Multiple clarifier units capable of independent operation must be provided where maximum month flows exceed 0.04 mgd. Design must include provisions so the process can be maintained if a clarifier is taken out of service. Clarifiers must be interconnected such that each individual clarifier can support multiple upstream biological treatment process trains, when required.

2. For WWTPs with three or more clarifiers, there must be a sufficient number of units of a size such that with the largest flow capacity unit out of service, the remaining units must have a design flow capacity of at least 75 percent of the total design flow to that unit operation.

l. Flow Control.

1. Internal and interconnecting pipes must be capable of hydraulically passing the peak flow without overflow and with the largest clarifier out of service.

2. Each clarifier must have gates or valves to allow it to be hydraulically isolated.

3. Each clarifier must have a means for dewatering.

m. Use of coagulant aids must be considered where peak hydraulic loadings in existing clarifiers are beyond the limits recommended herein or where effluent TSS concentrations of less than 15 mg/L are required.

n. Provisions for control of filamentous bacteria must be considered as part of the design (e.g., chlorine dosing of RAS).

7.4.0 OXIDATION DITCH SECONDARY TREATMENT

An oxidation ditch is considered an activated sludge process and must be designed using the same requirements, except as follows:

a. Minimum oxidation ditch SWD is 8 feet.

b. Horizontal mixing must be provided to maintain a minimum velocity of 1 fps measured at the midpoint (i.e., width, depth) of the oxidation ditch straight channel.

c. A minimum of two mixers/aerators per ditch must be provided to maintain horizontal mixing with one unit out of service. The design must include two independent trains. If only one train is provided, the design must include provisions for taking this train out of service for maintenance or during an upset.

7.5.0 MEMBRANE BIOREACTOR SECONDARY TREATMENT

A membrane bioreactor (MBR) is considered an activated sludge process and must be designed using the same requirements, except as follows:

7.5.1 Pretreatment

a. Screen size shall be less than or equal to 2 millimeters (mm) for hollow fiber membranes or 3 mm for flat plate membranes and must be consistent with membrane manufacturer requirements. Fully redundant fine screens shall be provided for WWTPs with membranes.

b. Grit removal shall be provided if primary clarification is not provided.

c. The design must include removal of FOG to prevent fouling of the membranes.

7.5.2 Biological Treatment for MBR Systems

a. The design MLSS concentration range must be less than 12,000 mg/L.

b. The design SRT must be greater than or equal to 10 days. For site-specific deviation requests in accordance with Chapter 1, the design basis justification must include long-term process data from operational facilities to demonstrate no detrimental impacts on membrane operation and permeability.

c. Aeration tank volumes and the selected aeration system must be capable of providing the predicted oxygen uptake rate (OUR) at the design MLSS concentrations.

d. The PDR shall provide a clear rationale for the α-value selected. Higher mixed liquor concentration in MBRs are expected to result in lower design α-values than for conventional activated sludge.

e. The design must include aeration blowers to provide adequate air for membrane scour and process requirements.

7.5.3 Sludge Recycling and Wasting

a. Design sludge recycle rates for MBR systems must be at least 400 percent of influent flow. The PDR must include justification for the selected recycle rate, taking into account peak hour flows and DO requirements in the aeration basin.

b. Sludge recycle pumps must include provisions for operator adjustment.

c. The PDR must consider prevention of excess DO from entering anoxic and anaerobic zones (if applicable) or account for oxygen recycle.

d. The PDR must identify location(s) and metering of waste sludge flow (e.g., membrane basin, aeration basin, recirculation lines, or basin surfaces).

7.5.4 Membrane Design Factors

a. The MBR system (including membranes and flow equalization) must be sized to hydraulically pass peak instantaneous flows anticipated in the MBR reactors.

b. The PDR must identify the average day, peak hour, and peak day flux based on design temperature, solids concentration, and solids retention time.

1. Average flux at maximum month flows shall be no greater than 15 gallons per day per square foot (gpd/ft^2) at 20°C, with adjustment for lower temperatures.

2. Maximum flux at peak hour flow shall be no greater than 30 gpd/ft^2 at 20°C, with adjustment for lower temperatures.

3. Maximum flux at peak day flow shall be no greater than 23 gpd/ft^2 at 20°C, with adjustment for lower temperatures.

4. Facilities that expect a peak instantaneous flow rate greater than 2.5 times the maximum month average daily flow must accommodate higher flows with equalization volume, off-line storage or reserve membrane basin capacity.

5. Flux rates other than these requirements may be considered on a case-by-case basis (e.g., demonstrated long-term performance data, adequate safety factors).

c. Membrane Cleaning

1. The PDR shall identify an appropriate combination of cleaning strategies to maintain membrane permeability.

A. Hollow fiber membrane cleaning methods typically include air scour, backpulse/backwash, chemical backwash, clean in place (CIP), chemically enhanced backwash (CEB), and recovery cleaning.

B. Flat plate membrane cleaning methods typically include air scour, relaxation, and CIP.

d. Redundancy

1. WWTPs with maximum month flows greater than or equal to 1 mgd, the MBR process must be designed to treat the daily average flow with one membrane train/tank out of service (e.g., 4 design tanks + 1 out of service = 5 total).

2. WWTPs with maximum month flows more than 0.1 mgd but less than 1 mgd, the MBR process must be designed to have at least four membrane trains.

3. WWTPs with maximum month flows more than 0.04 mgd but less than 0.1 mgd, the MBR process may be designed to have two membrane trains. WWTPs with maximum month flows less than 0.04 mgd, the MBR process may be designed to have a single membrane train provided:

A. The design includes provisions to manage flows during CIP and recovery cleaning (e.g., temporary storage, provisions to remove/replace individual rack/cassette for separate cleaning without impacting remainder of membranes in the tank).

B. Design flux criteria must be satisfied with one membrane rack/cassette out of service in each membrane train (e.g., for external CIP, recovery cleaning, repair). For purposes of these criteria, a membrane rack/cassette is the smallest membrane unit capable of separate removal from the tank while maintaining operation of other membrane units in the same tank.

C. Membranes may be placed in the aeration basin(s) rather than a separate membrane tank, if the following are satisfied: 1) individual racks/cassettes and individual diffusers can be removed separately for maintenance and repair, and 2) the aeration basin(s) volumes are sized for complete nitrification.

4. A facility must have the ability to run in full manual mode in case of an automatic control failure. An operational backup programmable logic controller (PLC) is required if manual control is not possible.

5. The facility shall have sufficient standby power generating capabilities to provide continuous flow through the membranes during a power outage (e.g., preliminary screening, process aeration, recycle/RAS/permeate pumps, air scour, vacuum pumps) or an adequate method to handle flow for an indefinite period (e.g., private control of influent combined with contingency methods).

7.5.5 Other MBR System Considerations

a. The MBR design must include provisions for scum and foam control.

b. The MBR design must include provisions for the operator to remove membrane cartridges for cleaning considering the membrane cassette wet weight plus additional weight of the solids accumulated on the membranes.

c. The MBR design must include provisions for the operator to monitor membrane integrity. For a WWTP with maximum month flows greater than or equal to 0.04 mgd, on-line continuous turbidity monitoring of filtrate or an equivalent must be provided for operational control and indirect membrane integrity monitoring.

7.6.0 SEQUENCING BATCH REACTOR SECONDARY TREATMENT

A sequencing batch reactor (SBR) is considered an activated sludge process and must be designed using the same requirements, except as follows:

a. WWTPs with maximum month flows less than 0.04 mgd having a single SBR train must have ability to hold influent flow for peak hour conditions during the settle and decant cycle duration.

b. Each component of the SBR, including aeration volume, clarification, and oxygen supply, shall comply with the applicable requirements for continuous flow systems in this section. Requirements may be adjusted for batch operation of the system, but evidence shall be supplied to the Division demonstrating compliance with the applicable requirements of Section 7.2.0 (activated sludge).

c. Calculation of aerobic SRT includes aeration cycle time only and does not include anoxic, settling, decant, or fill (unless fill time is aerated) cycle time.

d. SBRs used for biological nutrient removal or reduction must meet the design requirements of Sections 7.8.0 through 7.12.0 relating to advanced nutrient removal, as applicable.

e. Decanter Design.

1. The decanter design must control the velocity at an inlet port or at the edge of submerged weirs to prevent vortexing, disturbance of the settled sludge, and entry of floating materials.

2. The entrance velocity to a decanter must not exceed 1.0 fps.

3. Decanters must draw effluent from below the water surface and include a device that excludes scum.

4. Decanters must maintain a zone of separation between the settled sludge and the decanter of no less than 12 inches.

5. Decanters must prevent solids from entering during a react cycle by 1) physically raising the decanter above the water surface, 2) recycling treated effluent to wash out solids trapped in a decanter, or 3) mechanically closing a decanter when it is not in use.

6. The decanter and related pipes and valves must include freeze protection if located in an area subject to freezing.
7. A fixed decanter may be used except in a basin where simultaneous fill and decant may occur. Two trains or floating decanter are acceptable alternatives.
8. A SBR with a fixed level decanter must include a means of positively preventing the flow of mixed liquids into the decanter and additional decantable storage volume because of the added settling time before a discharge may occur.
9. A SBR that does not accommodate the design flow requires an equalization basin.
10. For any system of tanks that is fed sequentially, the size of the decant system must accommodate the design flow with a constant cycle time and the largest tank out of service.
11. A SBR system utilizing more than two basins must allow the decanting of at least two tanks simultaneously.
12. If units downstream of an SBR are not capable of accepting the peak flow rate of the decanting cycle, flow equalization must be provided between the decanter and the downstream units (e.g., disinfection).

f. SBR Tank Details.

1. The minimum SWD of a SBR tank is 10 feet.
2. A SBR with two tanks or a SBR system operating with a continuous feed during settling and decanting phases must include influent baffling and physical separation from the decanter.
3. A SBR tank must have a minimum freeboard of 18 inches at the maximum liquid level.
4. A SBR system must have a dedicated means of transferring solids between aeration basins.
5. A SBR system must include a means of scum removal in each aeration basin.
6. Each SBR tank must include an overflow to another aeration tank(s) or a storage tank.
7. At a facility that is not staffed 24-hours each day, each SBR tank must include a high-level alarm that notifies facility staff.

g. Control Systems.

1. The motor control center (MCC) must include PLCs with the ability to operate with limited operator adjustment and be programmed to meet the required effluent limitations for the design loadings.
2. A hard-wired backup means of operating the SBR is required.
3. The PLC must include battery backup. A redundant electronic copy of the program must be provided and maintained at the plant.
4. Controls for the separate operation of each reactor tank must be provided.
5. A tank level monitoring and control system must be included.

6. A secondary level monitoring alarm system with a float or other mechanical level indicating device must be installed and must be protected from prevailing winds and freezing. A bubbler system in a tank level system is prohibited.

7.7.0 BIOFILM SECONDARY TREATMENT

This section includes secondary treatment requirements for trickling filters (TFs), rotating biological contactors (RBCs), submerged biological contactors (SBCs), moving-bed biofilm reactors (MBBRs), and integrated fixed film and activated sludge (IF/AS) systems. This section also includes carbon oxidation design considerations and requirements for fixed film processes.

7.7.1 Trickling Filters for Secondary Treatment

Trickling filters are classified according to applied hydraulic loading, including recirculation, in mgd per acre of filter media surface area and influent organic loadings in pounds of BOD_5 per day per 1,000 cubic feet of filter media. The following factors must be considered when determining the design hydraulic and organic loadings are determined considering the 1) strength of the influent wastewater, 2) effectiveness of pretreatment, 3) type of filter media, and 4) treatment efficiency required.

Trickling filters are classified in one of the following categories. The trickling filter design classification must be identified in the PDR.

- Roughing filter, which provides at least 50 percent but not more than 75 percent removal of soluble BOD_5;
- A secondary treatment filter, which provides the required settled effluent BOD_5 and total suspended solids (TSS);
- A nitrifying filter (see Section 7.9.2).

a. The PDR must specify the trickling filter efficiency formula used in the design calculations as well as any operating data from an existing trickling filter of similar construction and operation used to justify the projected treatment efficiency, biofilm kinetic coefficients, and other design parameters.

b. Pretreatment.

1. Upstream preliminary treatment shall be provided with the following design conditions and considerations:

A. Capacity to remove grit, debris, suspended solids, oil, and grease.

B. Capability to remove particles with a diameter greater than 3 mm.

C. Ability to mitigate the release of odorous hydrogen sulfide.

2. If the design includes a primary clarifier, scum and grease removal must be provided upstream of rock media trickling filters.

c. Trickling filters shall have a minimum flow rate equal to or greater than 1.0 mgd per acre of filter surface area.

d. Trickling filters with design capacities equal to or greater than 0.4 mgd that include BOD_5 removal shall include variable speed pumps with flow measurement capability.

e. Trickling filter systems shall include a means to measure both the flow to a filter and the recirculation flow.

f. Design hydraulic and organic loadings must be in accordance with the ranges provided in Table 7.5.

Table 7.5 – Typical Trickling Filter Design Loadings

Design Parameter	Roughing	Carbon Oxidizing (cBOD)
Media Used*	VF	RA, RO, XF or VF
Wastewater Source	Primary effluent	Primary effluent
Hydraulic Loading, gpm/sf (plan area)	0.5-2.9	0.25**-1.5
Organic Loading, lb BOD_5/day/1000 cf media	100-220	20-60
Ammonia Loading, lb NH_3-N/day/1000 sf media	N/A	N/A
Depth, feet	3-20	≤40
Effluent Quality	40-70% BOD_5 conversion	15-30 mg/L BOD_5 and TSS

*VF = vertical flow, RA = random pack, XF = crossflow, RO = rock, TSS = total suspended solids
**Applicable to shallow trickling filters.
N/A = Not applicable.
Source: WEF, MOP 8, *Design of Municipal Wastewater Treatment Plants*, 2010, Table 13.26.

g. Synthetic (Manufactured or Prefabricated) Media Materials.

1. Any synthetic media material must be used in accordance with manufacturer's recommendations (e.g., support beams, grating, clearances).
2. The suitability of synthetic media material must be evaluated based on experience with an installation treating wastewater under similar hydraulic and organic loading conditions. The PDR must include a relevant case history involving the use of the synthetic media.
3. Synthetic media must be insoluble in wastewater and resistant to flaking, spalling, ultraviolet degradation, disintegration, erosion, aging, common acids and alkalis, organic compounds, and biological attack.
4. Synthetic media must protect against creep and deformation for the design life of the media.
5. The structural design must support the synthetic media, water flowing through or trapped in voids, and the maximum anticipated thickness of the wetted biofilm.
6. The synthetic media must support the weight of a person, unless a separate provision is made for maintenance access to the entire top of the trickling filter media and to the distributor.
7. Modular synthetic media must be installed with the edges matched as nearly as possible to provide consistent hydraulic conditions within the trickling filter.

h. Rock Trickling Filter Media

1. Rock media may be used for rehabilitating existing trickling filters but shall not be used in new trickling filters.
2. Rock media using crushed rock, slag, or similar material containing more than 5 percent by weight of pieces with their longest dimension three times greater than the least dimension is prohibited.

3. Rock media must conform to the following size distribution based on mechanical grading over a vibrating screen with square openings:
   A. Passing 5.0 inch sieve - 100% by weight;
   B. Retained on 3.0 inch sieve - 95-100% by weight;
   C. Passing 2.0 inch sieve - 0.2% by weight;
   D. Passing 1.0 inch sieve - 0.1% by weight; and
   E. The loss of weight by a 20-cycle sodium test, as described in American Society of Civil Engineers' Manual of Engineering and Engineering Practice No. 13, must be less than 10 percent.
4. Rock Media Placement.
   A. Rock media must be at least 4.0 feet deep at the shallowest point.
   B. Crushed rock, slag, and other similar media must be washed and screened or forked to remove clay, organic material, and fines prior to placement.
   C. Design must include provisions for placing rock media without damaging underdrains. Rock media must be placed by hand to a depth of 12 inches above the underdrains. The remainder may be placed by belt conveyor or an equivalent mechanical method. Vehicles and equipment are prohibited from driving over the filter media.

i. Filter Dosing.
   1. Suitable flow characteristics must be used for the application of wastewater to a filter by siphon, pump, or gravity discharge from preceding treatment unit.
   2. A filter must be designed to control instantaneous dosing rates under both normal operating conditions and filter-flushing conditions. Design and flushing dosing intensities shall not be achieved solely by the control of distributor operation.
   3. The distributor speed and the recirculation rate must be adjusted for the dosing intensity as a compensatory measure under low-flow conditions. The design dosing intensity for normal usage periods and for flushing periods must be consistent with Table 7.6.

Table 7.6 – Trickling Filter Dosing Intensity Ranges

Total Organic (BOD_5) Load kilogram (kg)/m^3/day (lb BOD_5/d/1000 ft^3)	**Design Operating Dosing Rate mm/pass (in/pass)**	**Flushing Dosing Rate mm/pass (in/pass)**
<0.4 (<25)	25-75 (1-3)	≥100 (4)
0.8 (50)	50-150 (2-6)	≥150 (6)
1.2 (75)	75-225 (3-9)	≥225 (9)
1.6 (100)	100-300 (4-12)	≥300 (12)
2.4 (150)	150-450 (6-18)	≥450 (18)
3.2 (200)	200-600 (8-24)	≥600 (24)
Source: WEF, MOP 8, *Design of Municipal Wastewater Treatment Plants*, 2010, Table 13.27.		

4. A design must be based on instantaneous dosing intensity for rotary distributors using the following equation:

Equation 7.1 Instantaneous Dosing Intensity for Rotary Distributors

$$\text{Dosing Intensity} = \frac{(q + r) \times (1000\ \text{mm/m})}{(a) \times (n) \times (60)}$$

Where:

	Dosing intensity in millimeter (mm)/pass of an arm
q =	influent flow/filter top surface area, in cubic meters (m^3)/ square meter (m^2)/hour
r =	recycle flow/filter top surface area, m^3/m^2/hour
a =	number of arms
n =	revolutions per minute

Source: Texas §217.182, Equation G.1, 2008.

j. Distribution Equipment.

1. The design shall include a rotary, horizontal, or traveling wastewater distribution system that distributes wastewater uniformly over the entire surface of a filter at the design and flushing dosing intensities.
2. The design shall provide control mechanisms to manage distributor speed and recycle pumping rate. The controls shall provide optimum dosing intensity under all anticipated influent flow conditions.
3. The design shall provide a means to control dosing intensity independent of recirculation pumping (e.g., electrically driven, variable speed control for distributors).
4. Retrofits of existing rectangular trickling filters with rotary distributors that do not fully wet the filter surface area (i.e., corners) shall not be considered part of the required effective media treatment area.
5. The center column of a trickling filter rotary distributor shall include overflow ports to prevent water from coming into contact with the bearings in the center column.
6. The trickling filter distributor must include cleanout gates on the ends of the distributor arms and an end spray nozzle to wet the edge of the media.
7. The trickling filter walls must extend at least 12.0 inches above the top of the ends of the distributor arms.
8. The use of a mercury seal in a distributor of a trickling filter is prohibited for new facilities. If an existing treatment facility is materially altered, any mercury seal in a trickling filter must be removed and replaced with an oil or mechanical seal.
9. The minimum clearance between the top of the filter media and the distributing nozzles shall be 6.0 inches.
10. Rotary distributors shall be capable of operating at minimum speeds of one revolution per 30 minutes. Hydraulically driven rotary distributors shall maintain minimum flow rate by turning at the minimum design rotational velocity.

11. A trickling filter with a height or diameter that does not allow distributors to be removed and replaced by a crane shall provide jacking columns and pads at the distributor column.

k. Recirculation.

1. The PDR shall provide design calculations for removal of remaining organic matter by recirculation.
2. The PDR shall provide design calculations evaluating the effect of influent dilution on the rate of dissolved organic substrate diffusion into the biofilm.
3. The PDR shall address the effect of reduced influent concentrations on reaction rates in each section of a filter.
4. The recirculation rate may exceed four times the design flow if calculations to justify the higher rate are included in the PDR.
5. Facilities with constant organic loadings may provide direct recirculation of unsettled trickling filter effluent. Facilities with variable influent organic loadings shall equalize organic loadings by recirculating effluent from the final clarifier to either a primary clarifier or the trickling filter directly.
6. Distributor nozzles shall accommodate recirculated sloughed biofilm.
7. The PDR shall ensure minimum recirculation during periods of low flow to maintain filter media biofilm and to promote continuous biological growth.
8. The PDR shall provide, at a minimum, performance removal efficiency calculations using applied minimum recirculation rates.

l. Underdrain System Design Requirements.

1. Trickling filters shall include underdrains with semicircular inverts that cover the entire floor.
2. Trickling filter underdrains shall be vitrified clay or pre-cast reinforced concrete.
3. Trickling filter underdrains shall not be constructed of half tile.
4. Trickling filter underdrain inlet openings shall have a gross cross-sectional area greater than 15 percent of the filter's surface area.
5. The trickling filter underdrain and effluent channel floor shall have a minimum slope of 1 percent. The floor of a new trickling filter using stackable modular or synthetic media shall slope toward a drainage channel at a minimum of at least 1 percent but not more than 5 percent. The slope shall be determined based on trickling filter size and hydraulic loading.
6. The effluent channel shall deliver a minimum flow velocity of 2.0 fps at the design flow rate.

m. Passive Ventilation.

1. The effluent channel and pipe of an underdrain system or a synthetic media support structure shall permit free passage of air.
2. Any drain, channel, or effluent pipe shall have a cross-sectional area of not more than 50 percent of the area submerged at peak flow plus recirculation.

3. The effluent channels shall accommodate the specified flushing hydraulic dosing intensity and allow the possibility of increased hydraulic loading.
4. A ventilation system shall include continuous pathways for air flow (e.g., an extension of an underdrain through a filter sidewall, a ventilation opening through a sidewall, and an effluent discharge conduit designed as a partially full flow pipe or an open channel).
5. A vent opening through a trickling filter walls shall include hydraulic closure to allow for flooding of a trickling filter for nuisance organism control.
6. A passive ventilation design shall provide at least 2.5 square feet of ventilating area per 1,000 lbs of primary clarifier effluent BOD_5 per day.
7. An underdrain system for a rock media filter shall provide at least 1.0 square feet of ventilating area for every 250 square feet of plan area.
8. The minimum required ventilating area for a synthetic media underdrain shall be provided in the PDR with supporting calculations from the media manufacturer. The ventilating area shall be the greater of 1.0 square feet per 175 square feet of synthetic media area or 2.6 square feet per 1,000 cubic feet of synthetic media volume.

n. Forced Ventilation.

1. Forced ventilation shall be provided for any trickling filter for any location where seasonal or diurnal temperatures do not provide sufficient difference between the ambient air and wastewater temperatures to sustain passive ventilation. The PDR shall provide supporting rationale and calculations for the minimum airflow for forced ventilation and optimized process performance.
2. When used, down-flow forced ventilation systems shall include provisions for removal of entrained droplets or return of air containing entrained moisture to the top of a trickling filter, and a reversible fan or other mechanism to reverse the airflow when a wide temperature difference between the ambient air and wastewater create strong updrafts.
3. A ventilation fan and the associated controls must withstand flooding of a trickling filter without sustaining damage.
4. Equation 7.2 and the values in Table 7.7 shall be used to determine the minimum airflow rate (MAFR):

Equation 7.2 – Trickling Filter Minimum Airflow Rate

$$MAFR = \frac{(R_A) \times (L) \times (P_F)}{1440 \text{ min/day}}$$

Where:

MAFR =	Minimum airflow rate, scfm
R_A =	Aeration rate from Table 7.7, scf/lb
L =	Loading rate from Table 7.7, lb/day
P_F =	Loading peaking factor

Source: Texas §217.182, Equation G.2, 2008.

Table 7.7 – Aeration Rate and Empirical Loading Rate Factors

Filter Application	R_A (scf/lb)	Loading Rate (lb/day)
Roughing Filter (Design rate 75-200 lb BOD_5/1000 cf/day)	1080	L = design BOD_5 daily loading rate
Secondary Treatment Filter (Design rate 25-50 lb BOD_5/1000 cf/day)	1200	L = design BOD_5 daily loading rate
Combined or Tertiary Filter	2400	L = (1.25 * design BOD_5 daily loading rate) + (4.6 * design total Kjeldahl nitrogen (TKN) daily loading rate)
Source: Texas §217.182, Table G.3, 2008.		

o. Maintenance Provisions.

1. All flow distribution devices, underdrains, channels, and pipes shall provide access to allow for maintenance, flushing, and drainage.
2. The trickling system shall hydraulically accommodate the specified flushing hydraulic dosing intensity and shall facilitate cleaning and rodding of the distributor arms.
3. The trickling filter system shall prevent recirculation of sloughed biomass in pieces larger than the distributor nozzle opening or the filter media voids.
4. The design shall provide for control of nuisance organisms during operation of trickling filters using proper design dosing intensities, with periodic flushing at higher dosing intensities.
5. The structural and hydraulic design of a new trickling filter shall enable flooding of the trickling filter for fly control.
6. The trickling filter system shall minimize areas where sludge may accumulate. The system shall include a low-velocity, open channel between a trickling filter and final clarifier for manual removal of snails.
7. The design must use corrosion-resistant materials for all components.

p. Odor Control.

1. To minimize potential odor, the trickling filter design must include ventilation and ability for periodic flushing at a higher dosing intensity.
2. If a cover is included for odor control, the design shall provide methods for operator access to the entire top of the trickling filter media and to the distributor for maintenance and removal, and have a forced ventilation system with properly designed odor control.
3. A trickling filter with high influent organic loading must consider forced ventilation in a down-flow mode to minimize odor. Odorous off-gases may be: 1) recycled through a trickling filter, 2) diffused into an aeration basin, or 3) treated separately using a scrubber or an adsorption column.

7.7.2 Rotating Biological Contactors for Secondary Treatment

RBC systems achieve carbon oxidation treatment utilizing biofilm media rotated within the basin in a manner that achieves some aeration through the motion of the media above the water surface.

a. Pretreatment Design Considerations.

1. Pretreatment shall precede a RBC unit to remove grit, debris, and excess oil and grease.

2. The PDR shall provide supporting design calculations when primary clarifiers, fine screens, or grit removal chambers are used to control high levels of grease, oil, grit, or other debris in the influent waste stream.

3. The PDR shall include supporting design calculations for pre-aeration if influent to RBC unit has a high hydrogen sulfide concentration.

b. The PDR shall provide supporting design calculations for carbon oxidation.

c. Organic Loading Design Requirements.

1. The RBC design must be based on the total BOD_5 in the waste.

2. The maximum loading rate must not exceed 6.0 pounds of BOD_5 per day per 1,000 square feet of media in any stage.

3. The PDR shall include a RBC media area adjustment to compensate for the effects of the ratio of soluble BOD_5 to total BOD_5.

4. The PDR shall specify the design biofilm active surface area.

5. The allowable organic loading for the entire RBC system must not exceed 3.0 lbs of BOD_5 per day per 1,000 square feet of media area for facilities required to meet secondary treatment.

6. The RBC system shall be designed to maintain a minimum DO concentration of 1.0 mg/L in all stages during the maximum organic loading rate.

d. Stages.

1. An RBC system designed for a BOD_5 removal must have at least three stages in series, unless justification is provided for a lesser number using operational data from either a full-scale operating facility or pilot unit with an appropriate scale-up factor.

2. The first stage of the RBC system must include a means of spreading the influent flow evenly across the media.

e. The RBC system must include flow equalization when the peak-to-design flow ratio is higher than 2.5 to 1.0 to prevent loss of fixed growth from the media.

f. Enclosures and Ventilation.

1. The process cover shall have working clearance of at least 30 inches above the RBC unit, unless the cover can be removed with on-site equipment.

2. Enclosures shall be constructed of a corrosion resistant material.

3. The RBC unit must include access doors on each end and observation ports with covers at 3.0 foot intervals along the RBC unit.

g. Media Design.

1. The RBC unit shall provide self-cleaning action for the media.

2. The RBC media shall be insoluble in wastewater and resistant to flaking, spalling, ultraviolet degradation, disintegration, erosion, aging, common acids and alkalis, organic compounds, and biological attack.

3. An RBC design using multiple stages shall use low-density media for the first stage.

h. The PDR shall include the following:

1. Controlled flow to multiple first stages.

2. Alternate flow and staging arrangements.

3. Removable baffles between stages.

4. Provision for step feed and supplemental aeration.

i. The design must ensure that the RBC tank minimizes zone volumes that promote solids settling and includes tank drains to facilitate removal of any accumulated solids.

j. The design shall include provisions for chlorine or sodium hypochlorite addition upstream of the RBC system to control the growth of beggiatoa.

k. Maintenance Provisions.

1. Each process train shall be capable of being removed from service when maintenance or cleaning is required.

2. RBC bearings shall be easily accessible for inspection and lubrication.

l. The RBC drive system must handle the maximum anticipated media load and may be a variable speed system. An RBC unit may be mechanically driven or air driven.

1. Mechanical Drive.

A. A mechanical drive shall have a motor and speed control unit capable of maintaining the required revolutions per minute (rpm) within the range of 1.2 to 1.6 rpm.

B. A fully assembled spare for each size mechanical drive unit must be on-site.

2. Air Drive.

A. Each RBC unit shall have air diffusers mounted below the media and off-center from the vertical axis of the RBC unit and must have air cups mounted on the outside of the media to collect the air. Air drive units shall be designed for a shaft rotational speed in the range of 1.0 to 1.4 rpm.

B. The blowers shall supply adequate airflow for: 1) each RBC unit, 2) double the airflow rate to any one unit while the others are running normally, and 3) the required airflow with the largest blower out of service.

C. The air diffuser pipe to each unit must be capable of being removed without draining the tank or without moving the RBC media and must include an air control valve to each RBC unit.

7.7.3 Submerged Biological Contactor for Secondary Treatment

SBC systems achieve carbon oxidation treatment utilizing submerged biofilm media fixed within the basin.

a. A SBC system shall be air driven, if rotating media, and does not require a cover.

b. A SBC system requires the same pretreatment as a RBC system and shall meet the criteria in Section 7.7.2, except as follows for systems involving rotating media:

1. Each SBC unit shall include two air headers, one for rotation of the unit and one to provide dissolved oxygen for the biological activity.

2. The submerged bearings shall be sealed to prevent intrusion of the wastewater.

c. If lubrication is required, a SBC unit must have lubrication access above the water level.

d. For SBC systems with fixed biofilm more similar in application to MBBR, the SBC system shall meet the criteria in Section 7.7.4 with appropriate exceptions (e.g., media supports needed instead of media retention screens). The PDR shall provide supporting data, calculations, process descriptions, and vendor information (e.g. pilot data, long-term performance data) to justify the proposed treatment performance.

7.7.4 Moving-Bed Biofilm Reactors for Secondary Treatment

MBBR systems achieve carbon oxidation in a single pass through a basin with treatment utilizing biofilm on free-floating media contained within the basin.

a. The screen size shall be less than or equal to 5 mm when primary clarifiers are used or 3 mm without primary clarifiers.

b. The PDR shall document the specific surface area for the proposed free-floating biofilm media as validated through third-party testing.

c. The PDR shall provide calculations for the following net effective biofilm surface area parameters:

1. Surface area removal rate (SARR)

2. Surface area loading rate (SALR). Secondary treatment MBBR systems shall provide a SALR for normal-rate carbon oxidation (i.e., 5 to 10 g $BOD_5/m^2/d$), unless otherwise justified by supporting calculations, data from an existing similar full-scale installation, or applicable pilot study data.

d. The PDR shall consider the effects of media retention screens on overall hydraulic profile and include the following considerations:

1. Media retention screens (e.g., cylindrical, flat panel) shall be provided to retain media within the appropriate basin (e.g., anoxic, aerobic).

2. The design shall provide for complete scouring of sieves by combined scour energy imparted by coarse-bubble aeration.

3. The sieve loading rate shall be provided.

4. The approach velocity shall be less than 30 m/hr.

5. The length to width ratio of each MBBR zone shall be provided.

e. The design shall provide diffuser configuration and DO process design calculations unique to MBBR due to oxygen transfer to fixed film biota, with consideration for roll mixing pattern to enhance oxygen transfer efficiency.

f. Coarse bubble diffusers shall be required. Fine bubble diffusers may be considered for a site-specific deviation with special review of the media holding basin, data from an existing similar full-scale installation, applicable pilot study data, and supporting calculations.

g. The media fill fraction shall be no greater than 65 percent. The selected fill fraction shall be supported with design calculations.

h. The PDR must include provisions for media removal and storage during basin maintenance and provisions to maintain treatment capacity.

7.7.5 Dual Treatment Systems Utilizing Integrated Fixed Film and Activated Sludge for Secondary Treatment

IF/AS systems achieve carbon oxidation through a combination of suspended solids, with return sludge, and biofilm on free-floating media contained within the basin. An IF/AS system must meet the requirements of Section 7.7.4 (related to MBBR), the general requirements of activated sludge in Section 7.2.0, and the following.

a. The PDR shall provide calculations that describe the interdependency of carbon uptake rates by the bulk MLVSS as well as the biofilm at different MLSS concentrations, SRT, and design temperatures.

b. The PDR shall consider the facility's propensity to accumulate foam. If foam is likely to accumulate, the design shall include provisions to limit the MLVSS, MLSS, SRT, and to provide a higher quantity of biofilm media.

c. The design shall be supported by empirical methods (i.e. experience of each manufacturer or process supplier) or process-kinetics-based models (i.e. different levels of integration of activated sludge and biofilm kinetics).

7.7.6 Dual Treatment Systems Utilizing Trickling Filters for Secondary Treatment

A trickling filter in series with a suspended-growth process is considered a dual treatment process that is classified as one of the following:

- An activated biological filter (ABF) consists of a trickling filter and a final clarifier. An ABF system recirculates settled solids from the final clarifier through the trickling filter with no separate aeration basin or solids contact basin.
- A trickling filter/solids contact (TF/SC) system consists of a trickling filter sized to remove the majority of the soluble BOD_5, followed by an aerated solids contact basin sized to provide polishing and improved sludge settleability, followed by a final clarifier. A TF/SC system recirculates activated sludge to a solids contact basin. The design shall consider including a sludge re-aeration basin.
- A roughing filter/activated sludge (RF/AS) system consists of a trickling filter sized to perform primary treatment, followed by an aeration basin sized to remove the majority of the soluble BOD_5. The activated sludge stage is followed by a final clarifier. A RF/AS system recirculates activated sludge to the aeration basin.
- An activated biological filter/activated sludge (ABF/AS) system consists of a trickling filter sized to perform primary treatment, followed by an aeration basin

sized to remove the majority of the soluble BOD_5, followed by a final clarifier. An ABF/AS system recirculates activated sludge to the trickling filter.

- A trickling filter/activated sludge (TF/AS) system consists of a trickling filter sized to perform roughing and concentration dampening, followed by an intermediate clarifier, followed by an aeration basin sized to remove the majority of the soluble BOD_5, followed by a final clarifier. A TF/AS system circulates activated sludge to the aeration basin.

The PDR for a dual treatment process shall include all of the features and operational capabilities required for the same treatment unit used for single-process treatment, as well as items within this Section.

a. Dual System Process Design.

1. The PDR shall consider the effluent quality from the first stage of treatment in determining the basis of design for the second stage of a combined attached and suspended growth sub-processes. When activated sludge is recycled to the first-stage trickling filters, the process design shall not include the reduction of oxygen demand to the second-stage aeration basin because of sludge recirculation to the trickling filters.

2. The PDR shall include an estimate of the performance of the second stage of a dual system using data from existing similar installations, process calculations, and applicable pilot studies.

3. The PDR shall document assumptions (i.e., the applicable design equations and methodology used for a single stage process).

4. Return Sludge.

A. A dual system that includes recirculation of activated sludge or sloughing to trickling filters shall be designed to prevent recirculation of pieces larger than will pass through the distributor nozzles or the filter media voids.

B. The trickling filters in a dual system that recirculate sludge to the trickling filters must be high-rate, vertical flow, and fully corrugated media.

C. Sludge shall be combined with the raw wastewater influent prior to application to the trickling filters. Sludge shall also be combined in the effluent from first-stage processes prior to being introduced into second-stage aeration basins.

5. An aeration system for second-stage treatment units in a dual system not designed for nitrification must transfer at least 1.2 pounds of oxygen per pound of first stage effluent BOD_5 per day.

6. The design of second-stage suspended growth process must include methods to vary SRT.

<u>7.7.7 Dual Treatment Utilizing Rotating Biological Contactors for Secondary Treatment</u>

a. A RBC unit may be used in conjunction with activated sludge to create a combination fixed film and suspended growth process.

b. If a dual system employs an RBC unit, the PDR must include all of the required information in Section 7.7.2 (related to RBC secondary treatment) and meet the general requirements of activated sludge in Section 7.2.0. The PDR shall provide

supporting data, calculations, process descriptions, and vendor information (e.g. pilot data, long-term performance data) to justify the proposed treatment performance.

7.7.8 Dual Treatment Systems Utilizing Submerged Biological Contactor for Secondary Treatment

a. A SBC unit may be used in conjunction with activated sludge to create a combination fixed film and suspended growth process.

b. If a dual system employs an SBC unit, the PDR must include all of the required information in Section 7.7.3 (related to SBC secondary treatment) and satisfy the general requirements of activated sludge in Section 7.2.0. The PDR shall provide supporting data, calculations, process descriptions, and vendor information (e.g., pilot data, long-term performance data) to justify the proposed treatment performance.

7.8.0 GENERAL REQUIREMENTS FOR NITRIFICATION AND BIOLOGICAL NUTRIENT REMOVAL

a. A facility designed to provide nitrification and BNR of nitrogen and phosphorus must specify the process units needed to achieve the permit's effluent limits.

b. If nitrification and BNR is proposed, the PDR must include:

1. TKN, ammonia, nitrite, nitrate, total phosphorus, alkalinity, and design secondary influent concentrations, at a minimum.

2. Detailed calculations and/or process model results including all inputs and assumptions. The effects of residual organic loading and wastewater temperature on nitrification and denitrification biological growth rates must be included.

c. The nitrification and BNR system design must include provisions to minimize and control foam, froth, scum, and filamentous bacteria.

7.9.0 NITRIFICATION

A WWTP designed to provide nitrification must include design information required in previous secondary treatment sections for the appropriate technology as well as the requirements indicated below.

7.9.1 Suspended Growth Nitrification

The design basis in the PDR must include:

a. Aerobic SRT.

b. Basin sizing.

c. Sufficient oxygen to meet both carbonaceous BOD oxidation and ammonia oxidation needs presented in Table 7.2.

d. Sufficient alkalinity (i.e., 50 mg/L excess) or the design must include provisions for providing adequate alkalinity.

e. Provisions for pH and DO monitoring and control must be provided.

7.9.2 Nitrifying Trickling Filters

The following types of nitrifying trickling filters are addressed in this section:

- A trickling filter intended to perform nitrification and treating influent having a BOD_5 to TKN ratio of greater than 1.0 or soluble BOD_5 greater than 12 mg/L is a combined BOD_5/nitrification filter.

- A trickling filter treating influent having a BOD_5 to TKN ratio of equal to or less than 1.0 and soluble BOD_5 less than or equal to 12 mg/L is a tertiary nitrification filter.

The PDR must justify the projected treatment efficiency and other design parameters (e.g., kinetic coefficients) by including operating data from any existing trickling filter of similar construction and operation.

a. The nitrifying trickling filter shall include forced ventilation to distribute airflow throughout the underdrain area. The minimum design airflow rate must provide the greater of:

    1. 50 pounds of oxygen provided per pound of oxygen required at average organic loading, based on stoichiometry.

    2. 30 pounds of oxygen provided per pound of oxygen required at peak organic loading, based on stoichiometry.

b. The PDR must justify the temperature used in the design equations. The design may include deep towers or other means to minimize recirculation while providing a design hydraulic dosing intensity that lessens the effects of temperature on removal efficiency.

c. The PDR must verify that the design recirculation rates are appropriate for dealing with the effects on pH.

d. The nitrifying trickling filter must include a means for effective control of biomass predators, such as snails.

e. The nitrifying trickling filter must operate at a design dosing intensity of at least 1.47 gallons per minute per square foot and provide operational control of dosing intensity.

f. Cross-flow synthetic media is required for a new tertiary nitrification filter or for the nitrifying section of a new combined nitrification filter.

g. A tertiary nitrifying filter design must minimize pH depression due to recirculation and control influent instantaneous application rates by means of either: 1) a tower less than or equal to 20 feet or 2) a series of towers less than 20 feet operating in series if the design includes provisions to readily switch the operating sequence of the filters.

h. A combined BOD_5/nitrification filter must be designed to achieve effluent total BOD_5 of less than or equal to 15 mg/L to receive nitrification credit. The design must not take credit for nitrification in sections of the filter having soluble BOD_5 greater than 20 mg/L.

i. A combined BOD_5/nitrification filter design must enable a high recirculation rate with turndown capability.

j. The design hydraulic and organic loadings must be in accordance with the ranges provided in Table 7.8.

Table 7.8 – Typical Nitrifying Trickling Filter Design Loadings

Design Parameter	Combined BOD and Nitrification	Nitrifying
Media Used*	RA, RO, or XF	RA or XF
Wastewater Source	Primary effluent	Secondary effluent
Hydraulic Loading, gpm/sf (plan area)	0.25**-1.5	0.6-1.5
Organic Loading, lb BOD_5/day/1000 cf media	5-15	N/A
Ammonia Loading, lb NH_3-N/day/1000 sf media at 10 °C***	$0.164(BOD/TKN)^{-0.44}$ ^	0.1-0.24 #
Depth, feet	≤40	≤40
Effluent Quality	<10 mg/L BOD_5 >5 mg/L NH_3-N	0.5-3 mg/L NH_3-N

*VF = vertical flow, RA = random pack, XF = crossflow, RO = rock
**Applicable to shallow trickling filters.
***At wastewater temperatures less than 10 °C, trickling filter nitrification rates are reduced and designs must be appropriately adjusted to gain equivalent treatment. Colder ambient air greatly impacts trickling filter temperatures as the wastewater is cooled. Temperature adjustment shall be: ammonia loading at temperature T = ammonia loading limit at 10 °C x (1.045^{T-10}) [from WEF, MOP 35, *Biofilm Reactors*, 2010, page 125].
^ BOD/TKN = influent BOD to TKN ratio (unitless) [from Equation 9-24, Metcalf & Eddy 2003, Wastewater Engineering Treatment and Reuse, 4th Edition, 2003].
# At lower effluent ammonia concentrations (i.e., below 4.6 mg/L NH_3-N), trickling filter nitrification rates are reduced and designs must be appropriately adjusted to achieve adequate treatment. Adjustment for effluent ammonia concentration shall be: allowable ammonia loading limit at 10 °C = (ammonia loading limit above x $(S/4.6)^{0.75}$) where S = effluent ammonia concentration [from WEF, MOP 35, *Biofilm Reactors*, 2010, Equation 3.26].
N/A = Not applicable.
Source: WEF, MOP 8, *Design of Municipal Wastewater Treatment Plants*, 2010, Table 13.26, except as noted.

7.9.3 Nitrifying Rotating or Submerged Biological Contactors.

a. A RBC or SBC system designed for BOD_5 removal and nitrification of domestic wastewater in a single system shall include four stages and have a maximum overall organic loading rate of 1.6 pounds of BOD_5/day/1,000 square feet of media (8 $g/m^2/d$).

b. A nitrifying RBC or SBC shall be designed to allow chemical addition if the influent pH is below 7.0.

c. A RBC or SBC system designed for nitrification shall have a maximum overall organic loading rate of 0.2 pounds of NH_3-N/day/1,000 square feet of media (1 $g/m^2/d$) calculated for the fourth stage only, for wastewater temperature of 20 °C. At wastewater temperatures less than 20 °C, nitrification rates are reduced and designs must be appropriately adjusted to gain equivalent treatment. Temperature adjustment shall be: ammonia loading at temperature T = ammonia loading limit at 20 °C x (1.058^{T-20}) [from WEF, MOP 35, Biofilm Reactors, 2010, Table 5.6]. The PDR shall provide calculations, assumptions, pilot study data, or other information to justify the nitrification rate of a system.

d. A SBC system requires the same design parameters as a RBC system with the following exceptions. Four stages may not be required. The number of stages shall be justified through supporting information (e.g., calculations, pH testing, long-term

performance data from similar sized facilities with similar influent characteristics) and the design elements listed in Section 7.2.0 (activated sludge) as applicable to the SBC system.

7.9.4 Nitrifying Moving-Bed Biofilm Reactors

a. As a pre-requisite, the organic load shall be substantially removed prior to the nitrifying MBBR stage. If carbonaceous treatment is achieved with MBBRs, the carbonaceous removal reactors shall be designed for low-rate loading classification to ensure that a high nitrification rate can be achieved in the downstream nitrifying MBBR. Low-rate loading systems are designed for carbon oxidation prior to nitrification and have a BOD design surface area loading rate equal to or less than 1.0 pound of BOD_5/day/1,000 square feet (5 g/m^2/d).

b. A nitrifying MBBR system can consist of a single reactor or two reactors in series. Two nitrifying reactors in series should be considered when a consistent low effluent ammonia (<<2 mg/L) is desired. A single nitrifying reactor MBBR system shall have a maximum overall ammonia loading rate of 0.2 pounds of NH_3-N/day/1,000 square feet of media (1.0 g/m^2/d), for wastewater temperature of 20 °C. A two-reactor nitrifying MBBR system shall have a maximum overall ammonia loading rate (including both reactors) of 0.3 pounds of NH_3-N/day/1,000 square feet of media (1.5 g/m^2/d), for wastewater temperature of 20 °C. At wastewater temperatures less than 20 °C, nitrification rates are reduced and designs must be appropriately adjusted to gain equivalent treatment. Temperature adjustment shall be: ammonia loading at temperature T = ammonia loading limit at 20 °C x (1.058^{T-20}) [from WEF, MOP 35, Biofilm Reactors, 2010, Table 5.6].

c. Firm aeration equipment capacity shall be capable of maintaining at least 4.0 mg/L of DO in the reactor at all times for the maximum month average day in a single nitrification reactor system or in the first of two nitrification reactor system. Firm aeration capacity shall be capable of maintaining 2.0 mg/L of DO in the reactor at all times for the maximum month average day in a second nitrification reactor.

d. The design shall include supporting calculations to justify the ammonia loading entering the nitrification zone from the effluent of the carbon oxidation step.

7.9.5 Nitrifying Dual Treatment Systems Utilizing Integrated Fixed Film and Activated Sludge

A nitrifying IF/AS system must meet the requirements of Section 7.7.5 (related to general IF/AS), Section 7.9.4 (related to nitrifying MBBR), and the following. The PDR shall provide supporting design calculations and operational plans that demonstrate adequate treatment while compensating for the limitation of SRT and carbon concentrations in the bulk liquid relative to nitrification in IF/AS nitrification reactors.

7.9.6 Nitrifying Dual Treatment Systems Utilizing Trickling Filters

a. Dual system trickling filters shall be designed with a total combined SRT in the attached and suspended growth systems of at least 10.0 days with capability to provide at least 6.0 days SRT in the suspended growth process alone.

b. An aeration system for second-stage treatment units in systems designed for nitrification shall transfer sufficient oxygen to meet stoichiometric requirements for:

1. Biomass growth.
2. Respiration for both carbonaceous material oxidation and nitrification.
3. Oxygen demand due to biomass sloughing events from the first stage.

4. A sludge re-aeration basin if the second process is an aerated solids contact basin.

c. The second-stage processes must have a minimum hydraulic residence time of: 0.5 hour if the second process is an aerated solids contact basin, or 3.0 hours if the second process is an activated sludge aeration basin.

7.9.7 Nitrifying Dual Treatment Systems Utilizing Rotating or Submerged Biological Contactors

A nitrifying dual treatment system employing an RBC or SBC unit must meet the requirements of Section 7.7.7 (related to dual treatment with RBC) or Section 7.7.8 (related to dual treatment with SBC), Section 7.9.3 (related to nitrifying RBCs and SBCs), Section 7.2.0 (related to general requirements of activated sludge), and Section 7.9.1 (related to general requirements of suspended growth nitrification). The PDR shall provide supporting data, design calculations, process descriptions, and vendor information (e.g. pilot data, long-term performance data from similar sized facilities with similar influent characteristics) to justify the proposed treatment performance.

7.10.0 DENITRIFICATION

A WWTP designed to provide denitrification must include design information required in previous secondary treatment and nitrification sections for the appropriate technology as well as the requirements indicated below.

a. If a system is designed for denitrification with an isolated tank, baffled zone, or cycle isolation (e.g., SBR) for anoxic treatment, the nominal HRT (based on the influent flow rate only without recycle flows) of the anoxic zone shall be identified and supported with design calculations. Design parameters at maximum month flow and loading must be within the ranges provided in Table 7.9.

b. For systems designed for simultaneous nitrification and denitrification, the anticipated nitrogen removal process efficiencies shall be identified and supported with design calculations.

c. Reactor configuration designs must include detailed calculations and/or model inputs, outputs and assumptions.

d. Mixed liquor recycle pumps must be adequately sized to meet the effluent quality objectives.

e. Design must include provisions to minimize oxygen introduced to anoxic zones and provide operational flexibility.

f. The wastewater must have sufficient carbon or the design must include provisions for providing supplemental carbon source.

g. Anoxic and anaerobic zones shall be sufficiently mixed to keep the MLSS in suspension (Table 7.9).

h. The method for supplemental carbon dosage control must be identified. The aerobic reactor (i.e., nitrogen stripping zone) that follows the anoxic reactor must be properly designed to assure compliance with BOD effluent limits in case of overdosing of the supplemental carbon. Storage volume provided for the supplemental carbon must be documented in the PDR relative to the anticipated need, product stability, and supplier availability.

Table 7.9 – Typical Criteria for Nitrification/Denitrification Systems (20 °C MLSS Temperature)*

Parameter	Predenitrification	Postdenitrification	Combined Pre- and Postdenitrification
System SRT**, days	6-30	6-30	8-40
HRT**, hours			
First Anoxic Zone	2-8	--	2-6
First Aerobic Zone	6-12	6-12	6-12
Second Anoxic Zone	--	2-6	2-5
Reaeration Zone	--	--	0.5-1.0
MLSS, mg/L	1500-4000	1500-4000	2000-5000
Nitrate recycle	2-4Q	--	2-4Q
RAS flow	0.5-1Q	0.5-1Q	100% (Q design)
Dissolved Oxygen, mg/L			
Anoxic Zones	0	0	0
Aerobic Zones	1-4	1-4	1-4
Mixing Requirements***, kw/10^3 m^3 (kw/1000 cubic feet)			
Anoxic Zones	4-10 (0.1-0.3)	4-10 (0.1-0.3)	4-10 (0.1-0.3)
Aerobic Zones	20-40 (0.6-1.1)	20-40 (0.6-1.1)	20-40 (0.6-1.1)
Airflow (aerobic) m^3/min-10^3 m^3 or cubic feet/min-1000 cubic feet	10-30	10-30	10-40

*At wastewater temperatures less than 20 °C, nitrification and denitrification rates are reduced (e.g., 20%-40% based on the EPA Nitrogen Control Manual, EPA/625/R-93/010, September 1993) and designs must be appropriately adjusted to gain equivalent treatment.
**Forward flow without recycle flows.
***Energy input is an important parameter; however, the manufacturer should be consulted for determining the number and placement of mixers. Propeller and turbine mixers have been used successfully.
Source: WEF, MOP 34, *Nutrient Removal*, 2011, Table 6.2.

7.10.1 Denitrifying Moving-Bed Biofilm Reactor and Integrated Fixed Film-Activated Sludge Systems

MBBR and IF/AS systems involving denitrification must also satisfy the following additional requirements. The PDR shall include process design calculations, mass balances, and/or assembled data (e.g. influent characterization, pilot tests, carbon dosing, long-term performance data, etc.) for the following:

a. Carbon-to-nitrogen ratio of wastewater entering a MBBR or IF/AS denitrification reactor.

b. Level of denitrification required.

c. Nitrate recirculation rate.

d. SARR.

e. SALR.

f. Means to prevent oxygen carryover from aerated nitrification zones to denitrification zones.

g. Mixing requirements.

h. Historical base cold weather water temperature.

i. Media fill fraction.

7.11.0 BIOLOGICAL PHOSPHORUS REMOVAL

A WWTP designed to provide biological phosphorus removal (BPR) must include design information required in previous secondary treatment sections for the appropriate technology as well as the requirements indicated below.

a. The PDR must specify the process units needed to achieve the required effluent limits.

b. The sizes of the anaerobic and aerobic reactors of the BPR system must be based on the degree of treatment required, influent BOD and TP loads, MLSS concentration, and expected mixed liquor temperatures. The design detention time for anaerobic reactors in mainstream BPR processes must be between 30 to 60 minutes and the SRT of the anaerobic reactors between 0.3 to 0.5 days.

c. Methods for supplemental volatile fatty acids (VFAs) must be identified. Storage volume provided for supplemental VFAs must be documented in the PDR relative to the anticipated need, product stability, and supplier availability.

d. The BPR system design must consider having alternatives for phosphorus removal (e.g., chemical removal facilities) for process reliability relative to expected process performance and permit effluent limitations.

7.12.0 BIOLOGICAL NITROGEN AND PHOSPHORUS REMOVAL

A WWTP designed to provide both biological nitrogen and phosphorus removal must include design information required in previous sections for secondary treatment, nitrification, denitrification, and phosphorus removal for the appropriate technology as well as the requirements indicated below.

a. The PDR must specify the process units needed to achieve the required effluent limits.

b. The design must include provisions for preventing secondary phosphorus release (i.e., in anoxic zones and clarifiers) unless desired and included in design considerations.

7.13.0 CHEMICAL ADDITION

Wastewater treatment uses chemicals in various forms to aid in sedimentation, nutrient removal, pH adjustment, corrosion and odor control, disinfection, and sludge conditioning. This section addresses: 1) chemical selection and handling and 2) the general design of chemical treatment units for enhanced sedimentation and phosphorous removal.

7.13.1 Chemical Selection and Handling

a. The design must consider the following for treatment chemicals:

1. Compatibility with other chemicals being used.
2. Compatibility with other liquids, solids, and air treatment processes (e.g., interference).
3. Provisions for avoiding adverse impacts to effluent, receiving waters, biosolids, or air quality (e.g., interference, inhibition, pass through, accumulation in biosolids).
4. Calculated appropriate design dosage ranges, including laboratory tests (jar tests or pilot-scale studies) on actual process wastewater or operational data from similar facilities.

b. Chemical storage design must provide adequate storage capacity as well as efficient and safe chemical handing. Important factors in determining storage capacity include reliability of the supply, quantity of shipment, the range of chemical use rates, and chemical decomposition during storage. Specifically, the chemical storage design must consider:

1. Sufficient chemical storage for design application.
2. Compatibility with the chemical type and form (dry, liquid, or gas).
3. Temperature and moisture controls.
4. Safe and easy operator access.
5. Dust control.
6. Containers stored in manner to allow floor level cleanup.
7. High and low level indicators in tanks and bins.
8. Provisions for continuous feed, if used, including angle of repose and vibrators.
9. Spill and overflow containment with sufficient volume to hold the contents of the largest tank in the containment area. Ability to access drain valves safely without entering containment area.
10. Leak-detection indicator and alarm for hazardous chemicals.
11. Adequate connections and equipment for washing, flushing, and cleanout in chemical storage areas.
12. Pressure/vacuum relief on enclosed tanks.
13. For hazardous chemicals, appropriate safety provisions such as eyewash stations, emergency showers, and emergency communication documents.

c. Chemical Handling Design

1. The design must provide for safe and efficient unloading, storage, transfer, and use of chemicals in accordance with appropriate codes considering types of chemicals, compatibility, and the amount of handling required.
2. The liquid chemical storage tank and tank fill connections shall be located within a containment structure. Valves on discharge lines shall be located adjacent to the storage tank and within the containment structure. Auxiliary facilities, including pumps and controls, within the containment area shall be located above the highest anticipated liquid level. Containment areas shall be sloped to a sump area and shall not contain floor drains.
3. Platforms, stairs, and railings shall be provided as necessary, to afford convenient and safe access to all filling connections, storage tank entries, and measuring devices. Storage tanks shall have reasonable access provided to facilitate cleaning.
4. Above-bottom drawoff from chemical storage or feed tanks shall be provided as necessary to avoid withdrawal of settled solids into the feed system. Provisions for periodic removal of accumulated settled solids must be included. Provisions must be made in the fill lines to prevent back siphonage of chemical tank contents.

5. All liquid chemical mixing and feed installations must be installed on corrosion resistant pedestals and elevated above the highest liquid level anticipated during emergency conditions. The chemical feed equipment shall be designed to meet the maximum dosage requirements for the design conditions.
6. The design must include equipment to measure quantities of chemicals fed from bulk storage and day storage tanks over the range of design application rates.
7. Critical chemical feed equipment must have a backup system. Firm capacity shall meet design requirements.

7.13.2 Chemically Enhanced Sedimentation

The criteria in Section 7.13.1 apply in addition to this section for facilities designed for chemically enhanced sedimentation.

a. The design must include low velocities downstream of flocculation, generally less than or equal to 0.5 fps, to avoid sheering the floc.
b. The design must include provisions for increased sludge volume in the tanks, piping, and sludge handling equipment and impacts on digestion.
c. The design must provide multiple coagulant and flocculant injection points in piping or channel before the sedimentation process.
d. Each chemical must be mixed rapidly and uniformly with the flow stream. Where separate mixing basins are provided, they shall be equipped with mechanical mixing devices. The detention period should be at least 30 seconds.
e. The flocculation methods or equipment shall be adjustable in order to obtain optimum floc growth, control deposition of solids, and prevent floc destruction.
f. The velocity through pipes or conduits from flocculation basins to settling basins shall not exceed 1.5 fps (0.5 m/s) in order to minimize floc destruction. Entrances to settling basins shall also be designed to minimize floc shear. Settling basin designs shall be in accordance with criteria outlined for the appropriate type of clarifier (i.e., primary, secondary).
g. The design must include automated control of coagulant and flocculant addition with dosing parameters based on plant flow.
h. The design must include automated chemical dosing for pH adjustment of effluent to compensate for the potential pH reduction caused by some coagulants and flocculants, if such coagulants and flocculants are proposed or may be used.
i. The design shall address the type and volume of sludge generated. Sludge density and compaction must be considered in chemical sludge pumping designs.

7.13.3 Phosphorus Removal by Chemical Treatment

Designs may include chemical removal of soluble phosphorus (e.g., by addition of aluminum salts, iron salts, or lime to react with the phosphorus to form insoluble compounds). Those insoluble compounds may be flocculated with or without the addition of a coagulant aid such as a polyelectrolyte to facilitate separation by sedimentation, or sedimentation followed by filtration. The criteria in Section 7.13.1 apply in addition to this section for facilities designed for chemical phosphorus removal.

a. Systems shall be designed with sufficient flexibility, considering necessary reaction times, to allow for several operational adjustments in chemical feed location, chemical feed rates, and for feeding alternate chemical compounds.

b. The design chemical dosage shall include the amount needed to react with the phosphorus in the wastewater, the amount required to drive the chemical reaction to the desired state of completion, and the amount required due to inefficiencies in mixing or dispersion. The equipment capacities shall provide capability for a range of flows and alternate chemicals for operational flexibility.

c. The choice of chemical shall be based on the wastewater characteristics, chemical availability and handling, sludge processing and disposal methods, and the economics of the total system. When lime is used, the engineer must evaluate the necessity to neutralize the high pH prior to subsequent treatment in secondary biological systems or prior to discharge. Potential problems associated with lime usage, handling, and sludge production and dewatering shall be evaluated and mitigation measures documented in the PDR.

d. Each chemical must be mixed rapidly and uniformly with the flow stream. Where separate mixing basins are provided, they shall be equipped with mechanical mixing devices. The detention period should be at least 30 seconds.

e. Consideration shall be given in the process design to the addition of synthetic polyelectrolytes to aid settling. The flocculation equipment shall be adjustable in order to obtain optimum floc growth, control deposition of solids, and prevent floc destruction.

f. The velocity through pipes or conduits from flocculation basins to settling basins shall not exceed 1.5 fps (0.5 m/s) in order to minimize floc destruction. Entrances to settling basins shall also be designed to minimize floc shear. Settling basin designs shall be in accordance with criteria outlined for the appropriate type of clarifier (i.e., primary, secondary).

g. The design shall provide adequate methods for handling and management of the type and volume of sludge generated in the phosphorus removal process.

h. The need for effluent filtration shall be evaluated where effluent phosphorus concentrations of less than 1 mg/L must be achieved.

i. Liquid chemical feed pumps must be of the positive displacement type with variable feed rate. Pumps shall be selected to feed the full range of chemical quantities required for the phosphorus mass loading conditions anticipated with the largest unit out of service. Screens and valves shall be provided on the chemical feed pump suction lines. An air break or anti-siphon device shall be provided where the chemical solution stream discharges to the transport water stream to prevent an induction effect resulting in overfeed. Consideration shall be given to providing pacing equipment to optimize chemical feed rates.

j. Dry chemical feeders shall be equipped with a dissolver which is capable of providing a minimum 5-minute retention time at the maximum feed rate. Polyelectrolyte feed installations shall be equipped with two solution vessels and transfer piping for solution make-up and daily operation. Make-up tanks shall be provided with an eductor funnel or other appropriate arrangement for wetting the polymer during the preparation of the stock feed solution. Adequate mixing shall be provided by a large-diameter low-speed mixer.

7.15.0 FILTRATION

This section covers tertiary filtration used to remove suspended solids, nutrients, precipitated metals, inorganic ions, or synthetic organic compounds following conventional secondary treatment. This section addresses the design of granular media filters, microscreens (typically opening size 6 to 100 um), and carbon filtration.

7.15.1 Granular Media Filtration

a. A facility using filtration must have a minimum of two filter units. Firm capacity shall have a capacity of at least 50 percent of the total peak hour design flow.

b. The PDR must address the following factors:

1. Water temperature.
2. Relevant influent water chemistry (e.g., TSS, phosphorus).
3. Chemical dosages.
4. Seasonal changes in water quality.
5. Solid loading on monthly and peak basis.
6. Upstream flow equalization.
7. Continuous or intermittent back-wash.
8. Washwater troughs, surface wash, and/or air scouring provisions.
9. Flow meter locations.
10. Measurement of filter head loss and means for shut off when maximum filter head loss differential is reached.
11. Manual override for automatic control.
12. Water quality monitoring equipment.
13. Underdrain system with provisions to minimize clogging.
14. Filter housing.
15. Backwash flow equalization.
16. Sizing of clean well for backwash water.
17. Appropriate return location for backwash water with flow measurement.

c. The filtration system must not use unfiltered effluent as the source of backwash water.

d. A sedimentation process or clarifier must precede filtration unless the filtration design includes compensation for the anticipated solids loading without a preparatory solids removal step.

e. The design must include provisions to prevent effluent or partially treated effluent from overflowing any filtration unit at peak wastewater flow with the largest unit out of service.

f. The filtration system must provide periodic disinfectant in the influent stream, backwash water, or both to control slime growth in the filter, and backwash storage tank if present.

g. Design peak hour filtration rates for different types of filters must be less than 5 gpm/sf for gravity filters (i.e., single media, dual media, multi-media). If direct

filtration without a preparatory solids removal step is used, the filtration rate shall be reduced to compensate for the anticipated solids loading to the filter.

h. Media Design.

1. The uniformity coefficient of media used in a filter must be 1.8 or less.
2. The particle size distribution for dual and mixed media filters must result in a filter bed with a pore space graded from progressively coarse to fine from the top of the media to the supporting layer.
3. Media depths for the various filter types must conform to the values in Table 7.10.

Table 7.10 – Minimum Filter Depths for Deep Bed, Intermittently Backwashed Filters

Filter Type	Type of Media	Range of Effective Particle Size (mm)	Typical Effective Size (mm)	Range of Depth (inches)	Typical Depth (inches)
Single Media (Rapid Filtration)	Sand Anthracite	1.0 1.2	1.0 1.2	24 36	24 36
Single Media (Deep Bed)	Sand	1.0-4.0	1.5	48-72	48
Dual Media	Anthracite Sand	0.8-2.0 0.4-0.8	1.2 0.55	12-24 6-12	18 12
Mixed Media (Tri-Media)	Anthracite Sand Garnet or Similar Material	1.0-2.0 0.4-0.8 0.2-0.6	1.4 0.5 0.3	8-20 8-16 2-6	16 10 4
Mixed Media (Quad-Media)	Anthracite (top) Anthracite (second) Sand Garnet or Similar Material	1.3-2.0 1.0-1.6 0.4-0.8 0.2-0.6	1.6 1.2 0.5 0.3	8-16 4-16 8-16 2-6	8 8 10 4
Source: WEF, MOP 8, *Design of Municipal Wastewater Treatment Plants*, 2010, Table 16.3 and Section 2.3.1.3.1.1 (single media).					

i. Backwash Systems.

1. A backwash system design must provide for a media expansion of at least 30 percent at the highest backwash water temperature anticipated.
2. A single media filter must provide a minimum backwash flow rate of 6.0 gpm/sf of media area. The backwash flow rate needs to be designed to accommodate the filter media selection, grain distribution, temperature, and design bed expansion.
3. A dual and mixed media must provide a minimum backwash rate of 15 gpm/sf of media area. Media must be properly classified by a 1-2 minute water wash at 5 gpm/sq ft at the end of the backwash period. The backwash flow rate needs to be designed to accommodate the filter media selection, grain distribution, temperature, and design bed expansion.
4. The design must identify the filter operating plan including anticipated backwash times, sequencing of filters, and backwash volumes needed.

5. The DWWTW must have a method for controlling the return rate to the head of the plant (e.g., equalization) so the design backwash return flows must not be greater than 15% of the design flow at any given time.
6. Pumps for backwashing filter units must deliver the required rate with the largest pump out of service, and be sized for the warmest wastewater temperature anticipated.
7. A backwash system employing automatic controls must include a manual override system.

j. Supplemental Systems.

1. A media filter system must include an air scour system or combination air and water scour system in addition to an up-flow backwash water system.
2. Air scour system flow rates must be at least 2.0 scfm per square foot (scfm/sf) of media surface area but not more than 6.0 scfm/sf of media surface area. Deep beds require flow rates at the upper part of the range with the option to provide lower flow rates for shallow beds.
3. Water scour system flow rates must be at least 0.5 gpm/sf of media area but not more than 2.0 gpm/sf of media area.

k. The filter underdrain system must include a graded gravel layer with a minimum depth of 15 inches or other filter media support material. The underdrain system must provide a uniform distribution for filter backwash without plugging or exceeding the manufacturer's recommendation for maximum headloss.

l. The bottom of a wash water collection trough must be a minimum of 6.0 inches above the maximum elevation of the expanded media during backwash.

m. A wash water trough must have a minimum freeboard of 2.0 inches during the maximum backwash flow rate.

7.15.2 Other Tertiary Filtration Technologies

Other technologies for tertiary filtration treatment vary between manufacturers and will be reviewed on a case-by-case basis as an alternative technology in accordance with Chapter 1. Some types of these technologies include:

a. Microscreening, typically involving a variable (low) speed rotating filters or drum to which filter frames and stainless steel or polyester filter fabric are attached.

b. Traveling bridge filtration, typically involving sand or cloth media in several individual filter cells with a bridge traveling horizontally along the cells, backwashing individual cells while the other cells continue to filter water.

c. Upflow sand filtration, typically involving flow upwards through filter media.

d. Compressible media filtration, involving flow through highly porous, compressible synthetic media.

e. Bag filter systems (e.g., disposable or reusable fabric bags).

7.15.3 Carbon Filtration

Granular activated carbon filters include up-flow or down-flow, fixed bed, expanded bed or counter-current adsorption bed.

a. Where organic removal is necessary to meet effluent limits, at least two parallel process units must provided. Units must be designed for continuous operation.

Consideration should be given also for two units in series for continuous operations. The minimum height to diameter ratio must be 2:1.

b. The design influent characteristics shall be provided in the PDR including suspended solids concentrations (typically <20 mg/L), pH, temperature, flow rate, and expected colloidal material concentrations.

c. The design shall promote aerobic conditions in the filters.

d. The properties and specifications of the activated carbon shall be provided in the PDR. Media depth shall range from a minimum of 10 feet to 40 feet (3 to 12 m).

e. Activated carbon filters shall be designed for a flow rate of 4-10 gpm/sf (160- 400 L/min/m^2) based on average daily flow for upflow type filters and 3-5 gpm/sf (120-200 L/ min/m^2) for down flow type filters. Typical detention (contact) times shall range from 15-35 minutes.

f. Sufficient head must be available to operate filter at highest anticipated head loss.

g. Underdrains shall distribute wash water as uniformly as possible over the area of the filter. Underdrain systems shall be of corrosion-resistant materials.

h. The backwash system shall be designed to remove all of the foreign material collected during the filter run. The system shall be designed for a maximum upward flow of 12 to 20 gpm/sf (600 to 800 L/min/m^2), or a 10 to 50 percent bed expansion. The system shall be designed to prevent media loss (blowout) and separation in multi-media systems.

i. Adequate provisions shall be made for handling the total influent flow during backwashing of one or more filters.

j. All recycle streams and chemical additions related to filtration shall be considered in the overall plant flow and solids balances. The backwash stream shall be directed back to the proper process for treatment. The backwash shall be monitored for both quality and quantity.

k. The minimum equipment required for each operating filter shall include indicators for headloss, filter flow rate, and backwash flow rate.

CHAPTER 8
PONDS AND WETLANDS TREATMENT

This chapter addresses design criteria for pond wastewater treatment systems and constructed wetlands systems. Pond wastewater treatment systems include:

- Stabilization ponds.
- Aerated ponds or lagoons.
- Facultative ponds or lagoons.
- Advanced integrated wastewater pond system (AIWPS).
- Evaporative ponds or lagoons.

Facultative ponds or lagoons include facilities where aerobic, anaerobic and anoxic processes occur simultaneously or in various zones or areas of a given pond or lagoon impoundment. Separate design criteria are not provided for facultative ponds or lagoons as facultative processes also occur in stabilization ponds and aerated ponds and lagoons.

Constructed wetlands systems include:

- Free surface flow system.
- Subsurface flow system.

8.1.0 STABILIZATION PONDS

8.1.1 Pond Configuration and Geometry

a. Depth shall be no less than 3.0 feet and no more than 5.0 feet at design operating conditions.

b. Length to width ratio shall be no less than 1:1 and no greater than 5:1.

c. Side slopes shall be constructed at a ratio of 3 horizontal to 1 vertical unless the 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 in the PDR by a slope stability analysis (e.g., underlying soil, clay or synthetic liner, saturated soil from future liner leak) stamped and signed by a qualified geotechnical engineer registered to practice in the State of Colorado. The design must also consider reasonable constructability of a synthetic liner, when included, on the final slope.

d. Corner configurations shall 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. The corner configuration of the treatment cells shall be no less than 20-foot radius and no more than a 100-foot radius at the operating water surface elevation.

e. Freeboard shall be no less than 2.0 feet from the normal design water surface elevation to the crest of the embankment. Freeboard shall be increased to be a minimum of 1.0 feet above maximum wave generation to contain pond contents below the crest of the embankment with a wind speed of 80 miles per hour and the maximum fetch across the impoundment surface (e.g., by procedures in "Engineering Technical Release No. 69, May 24, 1983, U.S. Soil Conservation Service). The crest of the embankment shall be that location at the edge of the embankment and does not include crown on an adjacent access road.

f. Stabilization pond DWWTW shall be constructed with no less than three ponds with interconnecting piping suitable for bypassing any single pond while maintaining the remaining two ponds in operation. In general, raw wastewater shall be introduced to only two of the three ponds in a stabilization pond treatment facility with the third pond receiving treated effluent from either of the two influent ponds.

8.1.2 Pond Appurtenances

a. Yard piping and flow controls.

1. All yard piping shall be capable of conveying design flow rates in accordance with the hydraulic design criteria for gravity collection system piping (e.g., maximum month average day, peak hour, minimum flow).

2. Yard piping shall be arranged such that any given cell can be bypassed for maintenance and adjustment of hydraulic and organic loading.

3. Level control structures will be provided to maintain consistent and adjustable water surface elevations in each pond.

b. Flow measurement.

1. Influent flow measurement and recording facilities shall be provided.

2. Measurement of effluent flow will be required for a pond system to assess effluent flow rates, waste loading from the DWWTW to the receiving waters and accomplish water balance calculations.

3. The means and methods for influent and effluent flow measurements shall be suitable for the range of flow rates designed for the facility. Particular attention shall be given to the potential for clogging of the flow measurement device by wastewater solids and other debris and maintenance of required accuracy and precision in accordance with Colorado Discharge Permit System regulations.

c. Inlet piping shall 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) shall be provided to preclude any erosion around the discharge point.

d. Pond outlet piping exiting each cell shall be located so as to minimize potential for short circuiting of the pond contents and maximize the length to width ratio of the pond geometry. The outlet piping shall include or be integrated with a water surface elevation control structure and be constructed and operated in a fashion to preclude entry of excessive wastewater solids, scum and other debris, including accumulation of biosolids in the pond.

e. Lining and seepage control.

1. Seepage less than 10^{-6} cm/sec shall be attained for all wastewater impoundments with soil (items 2 and 3 below) or synthetic (item 4 below) liner materials.

2. Detailed on-site geotechnical investigations, field permeability and analysis and laboratory permeability and geotechnical evaluations will be required to confirm the suitability of on-site, native soil materials, with or without soil amendments, to attain the specified maximum seepage rate under design conditions.

3. Attainment of maximum seepage rates may be accomplished with manipulation (i.e., removal, moisture conditioning and compaction) of on-site soil materials or when amended with less permeable soil or other materials such as bentonite. Detailed specifications and requirements for construction of the impoundment lining shall be presented in the PDR and the construction documents including and quality control to assure the maximum seepage rates will be attained.

4. In lieu of seepage control as described in 2 and 3 above, a synthetic membrane material constructed of polyvinylchloride, high density polyethylene (HDPE), reinforced polypropylene, Hypalon® or ethylene propylene diene monomer (EPDM) or similar material may be considered. The membrane material shall have the following minimum thicknesses to best assure longevity and assurance of seepage control.

    - Polyvinylchloride: 60 mils.
    - Reinforced polypropylene: 45 mils.
    - HDPE: 60 mils.
    - Hypalon®: 45 mils.
    - EPDM: 45 mils.

f. Access provisions and control.

1. A waste stabilization pond DWWTW shall be constructed with a perimeter fence suitable for exclusion of livestock utilizing no less than 4 strands of barbed, smooth wire or woven wire with a height no less than 3.5 feet. Where wildlife is prevalent, an appropriate fence material, dimensions, and construction details to exclude wildlife must be included. Gates for operator access shall be constructed in a fashion to permit locking and exclusion of livestock and wildlife.

2. Operation and maintenance access to a waste stabilization pond DWWTW shall be provided with gates suitable for vehicular access, sized to accommodate trucks and construction equipment. Roadways with a driving surface no less than 10 feet in width shall be provided adjacent to each wastewater pond on all sides of each pond. The width of the roadway shall be expanded, where necessary, to accommodate site drainage conditions, provide for snow storage and accommodate other operation and maintenance requirements.

3. Signage shall be attached to the fence, fence posts or to freestanding posts at intervals no greater than 200 feet. The signage shall include, but may not necessarily be limited to stating, "No Trespassing."

4. Erosion control shall be accomplished to preserve the original design and constructed side slope and bottom configurations of the ponds. Erosion control shall 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 shall not be deemed to be suitable permanent erosion protection.

8.1.3 Design Criteria

a. Provisions for series and parallel operation shall be provided with distribution of organic loading on parallel cells or on a primary cell when operated as the first cell in series operation.

b. Yard piping or flow control structures shall allow for operation with one primary cell out of service.

c. Total BOD_5 loading shall not exceed 0.5 pounds per 1,000 square feet of water surface area per day based on the total water surface in the stabilization pond.

d. Total BOD_5 loading shall not exceed 1.0 pound per 1,000 square feet of water surface area per day with one primary cell out of service.

e. Settleable and suspended solids control shall be provided in the process design and construction documents including, but not necessarily limited to, pond volume allowance for settleable solids and outlet structure and piping to minimize suspended solids carryover from a pond. Suspended solids design criteria shall conform to the criteria and methodology of the *Principles of Design and Operations of Wastewater Treatment Pond Systems for Plant Operators, Engineers, and Managers*, EPA/600/R-11/088 August 2011 (or most recent version). This guidance is referred to hereinafter as *Principles of Design*. Design for suspended solids control shall provide for attainment of effluent limitations defined by the PELs and/or Regulation No. 62.

f. A waste stabilization pond DWWTW shall provide for a hydraulic detention time of no less than 180 days at average day design flow. The waste stabilization pond volume may be adjusted for the minimum evaporation loss which will occur in a 180 day period, generally the period of November through April.

8.1.4 Treated Wastewater Discharges to Groundwater

a. A DWWTW may be permitted for discharge to groundwater utilizing waste stabilization ponds as preliminary and primary treatment. The PELs shall establish the necessary quality requirements from the waste stabilization cells prior to discharge to groundwater.

b. Ponds, spreading basins or other constructed impoundments designed and constructed for the purpose of discharge to groundwater shall be considered on a case-by-case basis.

c. The point of compliance for a waste stabilization DWWTW discharging to groundwater and the manner of monitoring and reporting shall be determined in accordance with Regulations No. 41, 42 and 61.

8.2.0 MECHANICALLY AERATED PONDS

Aerated wastewater treatment pond systems shall provide mechanical aeration in one or more individual ponds or cells of a DWWTW. Mechanical aeration may involve submerged, diffused air or floating or fixed propeller or turbine-type mechanical aeration.

8.2.1 Pond Configuration and Geometry

a. Normal operating water depth shall be no less than 6.0 feet. Maximum operating depth shall be based on process design and selection of aeration equipment.

b. Length to width ratio shall be no less than 1:1 and no more than 5:1. The process design presented in the PDR shall be reflective of the pond geometry and flow regime (i.e., complete mix, partial mix, plug flow).

c. The side slope and corner configuration design criteria for mechanically aerated ponds shall be the same as those for stabilization ponds.

d. The freeboard requirements for mechanically aerated ponds shall be the same as those for stabilization ponds.

e. Mechanically aerated treatment ponds shall be designed and constructed with no less than 3 cells with interconnecting piping suitable for bypassing any single cell while maintaining the remaining two cells in operation. Raw wastewater shall be introduced to only two of the three cells in an aerated pond treatment facility with the third cell receiving treated effluent from either of the two influent cells.

f. Mechanical aeration shall be provided in no less than two ponds of an aerated pond DWWTW. The last pond in a series arrangement in an aerated pond DWWTW shall not be aerated. It shall be considered a final pond, cell or polishing pond designed to conform to "best waste stabilization pond technology" for suspended solids control and removal (e.g., 2 to 4 days).

8.2.2 Pond Appurtenances

a. Individual pond bypass shall be required for each pond.

b. Individual pond inlet and outlet piping configurations and criteria for mechanically aerated ponds shall be the same as for stabilization ponds. Pond inlet piping shall be configured with consideration to the impact of mixing and circulation effects of aeration equipment.

c. Criteria for the following appurtenances for mechanically aerated ponds shall be the same as for stabilization ponds:

1. Yard piping and flow control.
2. Flow measurement requirements.
3. Lining and seepage control.
4. Access provisions and controls.
5. Signage requirements.
6. Erosion control criteria.
7. Treated wastewater discharges to ground water.

8.2.3 Design Criteria

a. Maximum total BOD_5 loading to the primary pond shall not exceed the volumetric organic loading specified for an activated sludge extended aeration process at maximum month flow and loading.

b. Design review criteria for mechanically aerated ponds shall conform to the criteria and methodology in *Principles of Design*.

c. Analysis of multiple ponds shall utilize a first order reaction rate constant as provided in *Principles of Design*, Section 3.4.1.4, unless another value is justified in the PDR.

d. Process design relationships for a mechanically aerated pond DWWTW shall conform to *Principles of Design*, Section 3.4.

e. Mixing and aeration of a mechanically aerated pond DWWTW shall conform to *Principles of Design*, Section 3.4.2.9.

1. The firm capacity of the mechanical aeration system shall provide sufficient oxygen at a rate of no less than 1.3 pounds of oxygen to the pond per pound of applied total BOD_5 and a minimum DO concentration of 2.0 mg/L at maximum month flow and loading. If nitrification is intended, the mechanical aeration system shall provide sufficient oxygen for nitrification at a rate of no less than 4.6 pounds of oxygen to the pond per pound of applied TKN.
2. Should the mechanically aerated pond DWWTW receive waste from other than typical domestic waste contributions, the PDR shall include an evaluation of the relationship between ultimate biochemical oxygen demand and the minimum oxygen to be supplied to the treatment pond.
3. Oxygen delivery or transfer rates to pond contents shall be determined by the process relationships in Section 3.4.2.9 of *Principles of Design*.
4. The PDR shall provide background and supporting data for the oxygen transfer efficiency for the aeration system and/or devices proposed to be used in the aerated pond DWWTW.

8.3.0 ADVANCED INTEGRATED WASTEWATER POND SYSTEMS

a. Advanced integrated wastewater pond systems (AIWPS) and systems with anaerobic first cells will be evaluated on a case-by-case basis.

b. Design, construction and operation guidance shall be in accordance with guidance provided in *Principles of Design*.

8.4.0 EVAPORATIVE PONDS OR LAGOONS

Design criteria for evaporative ponds or lagoon are based on providing wastewater disposal without vector nuisances or discharge to surface or ground water.

a. Stabilization pond configuration and geometry criteria will govern these conditions for an evaporative pond system.

b. Maximum organic loading per unit surface area shall be no more than 0.5 pounds of BOD_5 per day per 1000 square feet.

c. Sizing to provide for disposal through evaporation with allowances for temporary storage and evaporation of design wastewater volume with 25-year return frequency, 24-hour precipitation event in any given year.

d. The PDR shall provide for confirmation that water supply rights are adjudicated and/or permitted for consumptive use through evaporative disposal system and no obligation exists for discharge to satisfy downstream water rights ownership.

e. Design criteria for site-specific evaporation and precipitation rates shall be based on site-specific records or records of nearby weather station(s) that are demonstrated to be representative of treatment facility site. Refer to information available at the Colorado Climate Center, Department of Atmospheric Science, Colorado State University and the Western Regional Climate Center, National Oceanic and Atmospheric Administration.

f. Lining and seepage control criteria for an evaporative pond system shall be the same as for stabilization ponds.

g. Pond appurtenances criteria for an evaporative pond system shall be the same as for stabilization ponds. Yard piping and controls shall distribute wastewater to control vector nuisances.

8.5.0 FREE SURFACE FLOW CONSTRUCTED WETLANDS

A free surface flow (FSF) system shall provide for wetland vegetation growth with wastewater flow substantially on the surface of substrate and through vegetative growth above the substrate surface. Substrate and wastewater conditions shall sustain wetland vegetation during growing seasons.

8.5.1 Design Criteria

a. The constructed wetland system must be preceded by a treatment process(es) that provides a minimum of primary treatment producing an effluent BOD_5 concentration of less than 150 mg/L, an effluent TSS concentration of less than 100 mg/L, and removal of floating material.

b. The HLR shall not exceed 1.5 gpd per square foot of substrate area.

c. The summer HRT shall not be less than 4 days.

d. The winter HRT shall be based on the necessary BOD reduction established using Equation 8.1, unless the PDR justifies an alternate method by identifying a peer-reviewed method, the sources of the method and all supporting calculations.

Equation 8.1 – Winter HRT for Free Surface Flow Wetlands

$$C_e/C_o = \exp\left[(-C)(K_T)(A_v)^{1.75}\,(HRT)\right]$$

Where:

C_e =	Design effluent BOD_5 concentration (mg/L)
C_o =	Design influent BOD_5 concentration (mg/L) to the wetlands
C =	Characteristic of the medium, design value to be 0.7
K_T =	Temperature dependent first order reaction rate constant ($days^{-1}$)
A_v =	Specific surface area for microbial activity (m^2/m^3), design value to be 15
HRT =	Hydraulic residence time (days) [Length x Width x Depth x Porosity / Flow]

Source: EPA 1988

e. The design influent BOD_5 concentration (C_o) shall be based on no more than a 75 percent reduction through the preceding treatment process(es) if a secondary treatment process precedes the wetland system and no more than a 20 percent reduction if only a primary treatment process precedes the wetland system.

f. The value of K_T shall be established using Equation 8.2, unless the PDR justifies an alternate method by identifying a peer-reviewed method, the sources of the method and all supporting calculations.

Equation 8.2 – Wetland Reaction Rate Constant

$$K_T = K_{20}\,(1.1)^{T-20}$$

Where:

K_{20} = 0.0057 day^{-1}

T = Wetland system effluent water temperature, °C

g. The minimum total wetland substrate surface area required shall be established using Equation 8.3, unless the PDR justifies an alternate method by identifying a peer-reviewed method, the sources of the method and all supporting calculations.

Equation 8.3 – Minimum Wetland Substrate Surface Area

$$A = (HRT)(Q)/(D)(N)$$

Where:

A = Total wetlands substrate surface area (ft^2)

HRT = Hydraulic retention time (days)

Q = Average wetlands hydraulic loading (ft^3/day)

D = Wetlands operating depth (ft)

N = Porosity of void fraction, design value to be 0.9

h. The average wetland hydraulic loading (Q) shall be the average of the wetland system influent hydraulic loading and the wetland system effluent flow based on a water balance that takes into consideration precipitation, seepage/exfiltration and evapotranspiration (ET).

i. The PDR must include water balance calculations documenting the potential effect that evaporation, precipitation and evapotranspiration will have on wetland system influent hydraulic loading and wetland system discharge flow.

j. Precipitation and evaporation data utilized in the water balance shall be from the monitoring station located closest to the treatment facility site that has a minimum period of record of 10 years. For winter conditions, the net ET shall not be greater than lake evaporation minus precipitation. For summer conditions, the net ET shall not be greater than 0.8 times Class A pan evaporation minus precipitation. This ratio includes an allowance for evapotranspiration from the wetland plants during the growing season.

k. The total wetland substrate surface area provided shall be greater than 15 acres per mgd based on average wetland hydraulic loading. The influent BOD_5 loading rate shall be less than 50 lbs BOD_5/acre/day based on the total wetland substrate surface area.

8.5.2 Wetland Cell Configuration

a. The constructed wetland system must consist of at least 2 cells that can be operated independently in parallel allowing an individual cell to be taken out of service.

b. The treatment process preceding the constructed wetland system must include provisions to exclude floating material and minimize the transfer of suspended solids, including algae, to the constructed wetland treatment system.

c. Constructed wetland cells must be lined in compliance with the requirements associated with lining of DWWTW ponds.

d. The shape of all wetland cells must encourage plug flow and limit short-circuiting. A minimum length to width ratio of 10:1 is required.

e. The lateral slope of the top of substrate shall be zero. The longitudinal slope from inlet to outlet shall not exceed 1 percent.

f. Normal design operating water depth shall be in the range of 4 inches to 24 inches.

g. The maximum operating depth measured from the top of substrate shall not be greater than 24 inches.

h. Cold weather operating depth shall be such that a minimum depth of flow under the ice cover of 6 inches can be maintained.

i. The design must include a minimum litter accumulation allowance of 15 inches when establishing the maximum wetland operating water surface elevation.

j. Dikes or berms enclosing a wetland cell shall be constructed to provide a minimum freeboard of 12 inches above the maximum design wetland water surface elevation taking into consideration the design litter accumulation allowance and the maximum normal design operating water depth.

k. Prior to construction of the wetland cell lining, the wetland area, bottom and dikes, must be stripped of all vegetation and organic material. No stripped vegetation or organic material can be used in the construction of embankments. Stripped organic material may be utilized for wetland substrate if it is compatible with the selected wetland vegetation.

l. Embankments and dikes must be constructed with suitable materials and compacted sufficiently to form a stable structure in keeping with standard embankment construction practices. The geotechnical information provided with the PDR shall specify the required embankment material and construction practices.

m. Dikes or berms surrounding the wetland cells shall have interior side slopes no steeper than 3:1 or flatter than 4:1. The top width of the dike shall be a minimum of 8 feet. The top of the dikes or berms enclosing the constructed wetland cells must be sloped to drain to the exterior of the cell at a minimum slope of 2 percent.

n. Constructed wetland systems must be enclosed with an adequate stock-tight fence complying with the requirements for fencing of pond treatment systems.

8.5.3 Inlets and Outlets

a. A flow control device or structure must be provided at the inlet to the constructed wetland system and be designed to provide positive flow control to each individual wetland cell, vary and monitor the flow to each wetland cell, stop flow to any individual wetland cell, dissipate the influent velocity, distribute the influent flow uniformly across the width of the wetland cell, minimize the potential for short-circuiting, and minimize the potential for freezing

b. Each inlet and outlet system must be adjustable to allow variation in the hydraulic loading placed on the wetland cell and the operating water depth and assure uniform

distribution of influent flow and uniform collection of effluent flow across the entire width of the wetland cell.

c. The design of inlet and outlet devices must provide for visual inspection of influent and withdrawal rates and cleaning of the device and located to minimize penetration of the wetland cell lining material.

d. Multiple inlets shall be spaced across the width of the wetland cell to facilitate uniform loading of the cell and must be located and discharge above the design maximum wetland cell operating water surface elevation. Inlet distributors must discharge into a minimum 18-inch layer of coarse aggregate (3 to 6 inch in diameter) or equivalent design.

e. Each wetland cell outlet must be equipped with an adjustable control structure or device to facilitate effective water level control in each individual wetland cell at increments not to exceed 2 inches from the top of substrate elevation to the maximum design operating water surface elevation.

f. Outlet collectors must be designed to collect flow at uniform intervals across the width of the wetland cell and limit velocity at the withdrawal point to less than 0.25 fps and preclude the discharge of floating material from the wetland cell.

g. Outlet collectors shall not be installed or enclosed in a berm of coarse aggregate or riprap (i.e., rock filters or similar outlet designs are not acceptable) and must be designed to allow for complete draining of the wetland cell to the top of the substrate.

h. Each wetland cell inlet and outlet flow control system must be designed such that a flow measuring device, such as a V-notch weir, can be installed to monitor the flow into and out of each individual wetland cell to aid in water balance calculations for verification of liner integrity.

8.5.4 Substrate and Vegetation/Plantings

a. Wetland substrate may consist of on-site soils, sands and/or gravels provided the gradation of the substrate material is suitable to support the root system of the selected wetland vegetation. A minimum of 6 inches and not more than 24 inches of substrate must be placed above the wetland cell liner material. The depth of substrate installed must not be greater than the anticipated root penetration of the wetland plants selected.

b. If the overall project includes the removal of sludge (biosolids) from the pond treatment system, 25 to 35 percent of the substrate material may consist of biosolids stabilized in accordance with state and federal regulations.

c. Wetland plants must be native species indigenous to the location of the facility and include one or a combination of only the following types:

1. Cattails (Typha).
2. Bullrushes (Scirpus).
3. Reeds (Phragmites).

d. Floating or aquatic plant species shall not be used in the design of a constructed wetlands.

e. The basis for wetland plant selection shall be documented in the PDR and must address the following, as a minimum:

1. Plant suitability for elevation of facility.

2. Plant suitability for design water depths in wetland cells.
3. Plant suitability for air and water temperature extremes at the project site.

f. Wetland vegetation shall be planted at no more than 2-foot centers throughout the length and width of each wetland cell.

8.5.5 Operation and Maintenance

The PDR must address the following items for a wetlands treatment system. The specifications shall indicate these items must also be addressed in the Operation and Maintenance Manual provided to the owner.

a. Vegetation maintenance, including removal of excess plant litter and debris.

b. Temporary storage and ultimate disposal of all materials removed from the constructed wetlands as part of operations and maintenance activities.

c. The use of herbicides, insecticides and fertilizers.

d. Any plant species that are to be actively managed for elimination as a noxious weed.

e. Changes in operating depth from cold weather to warm and warm to cold relative to the time period over which the changes are made and the increment of change to be made over a given time period.

8.6.0 SUBSURFACE FLOW CONSTRUCTED WETLANDS

Subsurface flow (SSF) constructed wetland systems shall provide for wastewater flow substantially through prepared substrate consisting of granular, porous material which can support root structure of and sustain wetland plantings on a seasonal basis.

8.6.1 Design Criteria

a. The constructed wetland system must be preceded by a treatment process(es) that provides a minimum of primary treatment producing an effluent BOD_5 concentration of less than 150 mg/L and removal of settleable solids and floating material.

b. The wetland system design influent BOD_5 concentration shall be based on no more than a 75 percent reduction through the preceding treatment process(es) if a secondary treatment process precedes the wetland system and no more than a 20 percent reduction if only a primary treatment process precedes the wetland system. If the anticipated wetland system influent BOD_5 concentration is greater than 100 mg/L, the design must provide for staged or step feeding of individual cells to more uniformly load the wetlands and improve process control.

c. The hydraulic conductivity of the wetland substrate utilized in the design must be based on laboratory testing of the actual substrate media being proposed for use on the project and presented in the PDR.

d. The average wetland hydraulic loading (Q) shall be the average of the wetland system influent hydraulic loading and the wetland system effluent flow based on a water balance that takes into consideration precipitation and evapotranspiration (ET). The PDR must include water balance calculations documenting the effect that evaporation, precipitation and evapotranspiration will have on wetland system influent hydraulic loading and wetland system discharge flow. Refer to FSF wetland criteria for precipitation and evaporation data requirements.

e. The design shall conform to the guidance provided in Section 5 of the *Manual-Constructed Wetlands Treatment of Municipal Wastewater*, US EPA Office of Research & Development, EPA/625/R-99-010, September 2000.

f. The total wetland substrate surface area provided shall be greater than 35 acres per mgd based on average wetland hydraulic loading. The influent BOD_5 loading rate shall be less than 50 lbs BOD_5/acre/day based on the total wetland substrate surface area.

8.6.2 Wetland Cell Configuration

a. Refer to criteria for FWS wetlands for wetland cell configuration requirements.

b. Refer to FWS wetland criteria for requirements for dikes and berms.

8.6.3 Inlets and Outlets

a. Refer to FWS wetlands criteria requirements for inlets and outlets.

b. The inlet distributors and outlet collectors located and discharging below the surface of the substrate media must be designed to limit inlet and outlet velocities to less than 1.0 fps to minimize the movement of substrate media.

c. Each wetland cell outlet must be equipped with an adjustable control structure or device to facilitate effective water level control in each individual wetland cell.

8.6.4 Substrate and Vegetation/Plantings

a. The maximum wetland substrate media depth shall not exceed the lesser of:

- 150 percent of maximum subsurface flow depth at design maximum monthly flow.
- The maximum normal root depth of the wetland plants selected.

b. The wetland cells must be designed to maintain the following depths of dry substrate media cover:

- Minimum of 6 inches at design flow.
- Maximum of 9 inches at design flow.
- Minimum of 2 inches at peak flow conditions.
- Maximum of 12 inches during diurnal low flow conditions.

c. The depth of substrate media must be at least 12 inches and not greater than 36 inches. The depth of substrate media installed must not be greater than the anticipated root penetration of the wetland plants selected.

d. If any portion of the substrate media will be larger than 1.5 inches in diameter, a top layer of small gravel, a minimum of 4 inches in depth, must be installed. The bottom of this gravel layer must be above the design saturated media zone. A transitional layer of medium gravel with a minimum depth of 4 inches must be provided between the small gravel layer and the coarse gravel substrate media to minimize migration of the small gravel into the lower void spaces.

e. The substrate media between the influent distribution zone and the effluent collection zone shall conform to the following:

1. Cleaned, washed or dry-screened gravel.
2. Ranging in size from ⅜-inch to ¾-inch in diameter.
3. Containing less than 2.0 percent by weight of clay, sand and other fine material less than No. 200 sieve size.
4. Mohs hardness of at least 5.0.

5. Resistant to acidic conditions.
6. Synthetic media is not acceptable.

f. Substrate media placed adjacent to the cell influent distributors must have ¾- to 3-inch sieve size to minimize the potential for clogging. Substrate media placed adjacent to the cell effluent collectors shall be coarse aggregate, 3 to 6 inches in diameter, or an equivalent design to promote balanced effluent collection.

g. Refer to FWS wetland criteria for wetland vegetation and/or planting requirements.

8.6.5 Operation and Maintenance

Refer to FWS wetland criteria for requirements of operation and maintenance to be addressed in the PDR and subsequent Operation and Maintenance Manual.

8.7.0 AQUATIC PLANT SYSTEM DWWTW

The Division will not consider aquatic plant systems for DWWTW in the State of Colorado.

CHAPTER 9
PATHOGEN REMOVAL AND DISINFECTION

The principal purpose of wastewater disinfection is to help prevent the outbreak of waterborne diseases in downstream receiving waters used for recreation and/or public water supply sources. The Division has selected the *E.coli* species of bacteria as its pathogen indicator organism. Not all strains of *E.coli* bacteria are pathogenic. However, epidemiological research indicates that when total *E.coli* levels are low, the chance of a waterborne disease outbreak is also low.

9.1.0 INTRODUCTION TO DISINFECTION TECHNIQUES

Pathogenic organisms, be they bacteria, protozoa, or viruses, are particles and disinfection can be accomplished by a combination of (1) supplemental particle removal beyond that achieved by secondary clarification and (2) inactivation by means of oxidants or ultraviolet (UV) light. The principal oxidants discussed herein are chlorine and ozone. As discussed at the end of this chapter, other forms of microorganism inactivation will be considered by the Division on a case-by-case basis.

9.2.0 GENERAL DESIGN CONSIDERATIONS

a. If supplemental filtration (i.e. after or in place of secondary clarification) is part of the disinfection process, the particle removal system must meet Division redundancy requirements (i.e. minimum of two units) and be designed to handle the design peak instantaneous wet weather effluent flow, taking into consideration any flow equalization facilities used at the plant in question.

b. The hydraulic capacity of the inactivation step must be sized to convey the design peak instantaneous wet weather effluent flow, without bypass, taking into account the presence of flow equalization at the plant. However, sizing of minimum inactivation capacity is to be based on the two conditions listed below:

   1. When regulatory compliance is based on monthly and weekly geometric means of multiple grab samples, inactivation capacity (i.e. oxidant feed rate or number of UV lamps) must be sized for at least the dry weather peak hour design flow expected during the high groundwater infiltration season, taking into account the presence of flow equalization.

   2. When a single sample maximum is specified or utilized by the discharger based on the number of samples analyzed per week, inactivation capacity shall be sized for the wet weather peak hour design flow expected during the high groundwater infiltration season, taking into account the presence of flow equalization.

c. Secondary clarifier effluents contain about 10^3 to 10^5 (1,000 to 100,000) *E.coli* organisms per 100 milliliters (mLs). Given that regulatory low flows are frequently small in Colorado, effluent limits are often close to the primary contact recreation stream standard, which is 1.26×10^2 (126) *E.coli* per 100 mLs. Therefore, required reductions are in the range of three orders of magnitude (i.e., log reduction of 3.0). Accordingly, the default assumption for these criteria assume unfiltered secondary effluent from all lagoons and all mechanical plants must achieve at least 3.0 logs of *E.coli* removal/inactivation, or a reduction of 99.9 percent.

9.2.1 Effect of Particle Removal

Tertiary filtration provided following secondary clarification, or membranes used for activated sludge solids separation in lieu of secondary clarification, can reduce the *E.coli* density for which inactivation is required. The level of reduction will depend upon the specific type of wastewater treatment and filtration technology used upstream of where

inactivation is to occur. The PDR must demonstrate the range of *E.coli* organisms in the filtered effluent after particle removal and a lower inactivation dosage and/or detention time will be sufficient to meet *E.coli* discharge requirements. Documentation must include statistically significant information for the plant in question, or existing analogous facilities, regarding the degree of *E.coli* reduction expected to occur due to the filtration step. Based on this information, the required level of inactivation (i.e., log removals) may be reduced at the discretion of the Division. The design must meet Division redundancy requirements (i.e. minimum of two units) to assure filtration is occurring at all times upstream of the inactivation step.

9.2.2 Primary and Supplemental Disinfection

a. If wastewater filtration is not provided, the inactivation step must be sufficient to serve as the primary and only means of disinfection. In that case, inactivation must provide 3.0 logs of *E.coli* reduction, unless the PDR includes statistically significant seasonal and multi-year data indicating that *E.coli* levels in the lagoon or secondary clarifier effluent are consistently and reliably less than 10^4 (10,000) and a lower dosage and/or detention time for the inactivation step is demonstrably sufficient to meet *E.coli* discharge requirements. The effluent *E.coli* information must come from the plant in question since unfiltered secondary effluent *E.coli* data can vary widely.

b. Should wastewater filtration be provided, the applicant may elect to provide statistically significant information regarding expected *E.coli* levels in the filtered effluent. If the anticipated *E.coli* level is at or above the effluent limit, the inactivation step will be considered as the primary means of disinfection and redundancy requirements will apply. If the anticipated *E.coli* level is below the effluent limit, the following shall apply:

1. The inactivation step shall be considered supplemental rather than primary.
2. Inactivation facilities shall be designed based on (1) the expected worst case performance of the filtration system and (2) producing a final disinfected effluent with one-half of the allowable *E.coli* density listed in the discharge permit or PELs. As a minimum, 1.0 log of supplemental *E.coli* inactivation (90 percent removal) shall be provided.
3. The supplemental inactivation system design may take into account the improved clarity and reduced organic content of the filtered effluent.
4. Reduced redundancy requirements will be considered on a case-by-case basis.

9.2.3 Concentration or Intensity X Contact Time

a. *E.coli* reductions in oxidant-based inactivation systems are dependent upon the residual concentration (C) times detention time (T), or CT. For UV inactivation systems, *E.coli* reductions are proportional to the delivered dosage (D), which is a function of the intensity (I) of UV light within the water column times T, or IT (i.e. D~IT).

b. When wastewater filtration is not provided, the applicant shall use the default design criteria listed herein for primary disinfection unless statistically significant CT (or IT) and *E.coli* reduction data is submitted for the specific plant in question.

c. When filtration is provided, the applicant may submit supporting information to size the inactivation step. Supporting information may need to include collimated beam studies to estimate the design D for UV reactor sizing, statistically significant UV transmittance data (UVT measured at 254 nanometers) for the specific effluent under

consideration, bench-scale testing of required CT levels for the oxidants being considered, and data from analogous existing plants.

9.3.0 CHLORINE DISINFECTION

This section covers the common forms of chlorination traditionally utilized for disinfection at WWTPs, including chlorine gas and both liquid and solid forms of hypochlorite.

9.3.1 Chlorine Type

Chlorine is available for disinfection in gas, liquid (hypochlorite solution), and solid (hypochlorite) form. The design must identify the selected type of chlorine based upon site conditions, safety and risk management considerations, capital and annual costs, and owner preference. Regardless of chlorine type, on site storage shall be provided for a minimum of 15 days usage at the design maximum month flow.

9.3.2 Dosage

The firm feed capacity shall be adequate to meet specified effluent *E.coli* limits, plus satisfy other potential in-plant demands, such as for odor control and wash down water. Calculations justifying equipment sizing and number of units shall be submitted for the expected range of flows and chlorine demands (considering both low and high requirements), from startup to design conditions. The firm chlorine feed design capacity must be capable of the dosages indicated in the following table.

Table 9.1 – Minimum Firm Chlorine Feed Capacity for Effluent Disinfection

Type of Treatment	Dosage Capacity as Cl_2 at Design Wet Weather Peak Hour Flow (mg/L)
Ponds and Wetlands Treatment	15
Trickling Filter Plant Effluent	10
Activated Sludge Plant Effluent	8
Tertiary Filtration Effluent	6
Nitrified Effluent	6

9.3.3 Mixing and Contact Time

a. After vigorous mixing of the chlorine with the effluent, a minimum contact time of 30 minutes shall be provided at the design peak hour flow (or maximum rate of pumpage). To reduce short-circuiting and promote plug flow detention time, the contact chambers must have the following features:

   1. A flow distribution chamber to enable equal distribution of flow among all contact chambers.
   2. An inlet baffle to dissipate inlet velocities and introduce the flow across the entire cross section of each contact basin.
   3. Over/under or end-around baffles.
   4. A minimum total length-to-width ratio of 40-to-1.
   5. A maximum depth -to-width ratio of 1-to-1.

b. Consideration should be given to providing a scum retention baffle and removal system at the effluent end of each contact chamber

c. The tank must be designed to facilitate maintenance and cleaning without reducing effectiveness of disinfection.

9.3.4 Gaseous Chlorination

Gaseous chlorine storage systems range from 150 pound cylinders, ton containers, and railroad tank cars. Chlorine storage containers contain a combination of liquid and gaseous chlorine. The rate of evaporation from liquid to gas is proportional to temperature and excessive gas withdrawal rates can cause freezing problems. Heating blankets for the containers and evaporators must be considered if high rates of withdrawal will be required. Automatic switchover shall be provided so there is no interruption of the disinfection process when a container becomes empty.

a. Containers:

1. One hundred fifty pound (68 kg) cylinders are typically used where chlorine gas consumption is less than 150 pounds per day (68 kg/d). Cylinders must be stored in an upright position with adequate non-corrosive support brackets and chains at 2/3 of cylinder height for each cylinder.

2. One-ton (907 kg) containers are typically used where the average daily chlorine consumption is over 150 pounds (68 kg).

3. Tank cars, generally accompanied by evaporators, are typically used at very large installations, where the number of ton containers would be excessive. Area wide public safety shall be evaluated. No interruption of chlorination shall be permitted during tank car switching.

b. Equipment:

1. Scales for weighing cylinders and containers shall be provided at all plants using chlorine gas. While at least a platform scale shall be provided, scales of the indicating and recording type are recommended. Scales shall be of corrosion-resistant material.

2. Evaporators must be considered to produce the quantity of gas required where manifolding of several cylinders or ton containers will be required to evaporate sufficient chlorine.

3. The disinfectant shall be positively mixed as rapidly as possible, with a complete mix being achieved in three seconds. This may be accomplished by either the use of turbulent flow regime or a mechanical flash mixer.

4. All chlorination systems must consider pacing chlorine dose according to flow and chlorine residual (compound loop control). If used, flow control must be from effluent flow meters and placement of residual analyzer probe must ensure appropriate lag time for residual analyzer control. Additionally, automatic gas cylinder or liquid chlorine tank changeover must be provided.

c. Piping and Connections.

1. Piping systems must be specifically selected and manufactured to be suitable for chlorine service. Piping must be well supported and protected against temperature extremes.

2. Due to the corrosiveness of wet chlorine, all lines designated to handle dry chlorine shall be protected from the entrance of water or air containing water. Low pressure lines made of hard rubber, saran-lined, rubber-lined,

polyethylene, polyvinylchloride (PVC), or other approved materials are satisfactory for wet chlorine or aqueous solutions of chlorine.

3. The chlorine system piping shall be color coded and labeled to distinguish it from other plant piping. Where sulfur dioxide is used, the piping and fittings for chlorine and sulfur dioxide systems shall be designed so that interconnection between the two systems cannot occur.

d. A sufficient supply of water shall be available for operating the chlorinator. Where a booster pump is utilized, firm capacity is required and all booster pumps shall be connected to the emergency power supply. Protection of a potable water supply shall conform to requirements for backflow prevention.

e. Housing:

1. If gas chlorination equipment or chlorine cylinders are to be in a building used for other purposes, a gas-tight room shall separate this equipment from any other portion of the building. Floor drains shall not be allowed in gas chlorine rooms unless properly trapped to prevent gas flow. Design must include provisions to replenish trap water (e.g., operating procedure, automatic water dose). Floor drains from the chlorine room, if any, must not be connected to floor drains from other rooms. Doors to this room shall open only to the outside of the building, and shall be equipped with panic hardware. Rooms shall be at ground level and should permit easy access to all equipment.

2. Storage areas for one-ton (907 kg) cylinders must be separated from the feed area. In addition, the storage area shall have designated areas for "full" and "empty" cylinders. Chlorination equipment should be situated as close to the application point as reasonably possible.

3. A clear glass, gas-tight, window shall be installed in an exterior door or interior wall of the chlorinator room to permit the units to be viewed without entering the room.

4. Rooms containing disinfection equipment shall be provided with a means of heating so that a temperature of at least 60°F (16 °C) can be maintained. The room must be protected from excess heat. If liquid hypochlorite solution is used, the containers may be located in an unheated area.

5. With chlorination systems, forced mechanical ventilation shall be installed that will provide one complete fresh air change per minute when the room is occupied. The entrance to the air exhaust duct from the room shall be no more than 12 inches off the floor. The point of discharge shall be located to not contaminate the air inlet to any buildings or present a hazard at the access to the chlorinator room or other inhabited areas. Air inlets shall be located to provide cross ventilation with air at a temperature that will not adversely affect the chlorination equipment. The outside air inlet shall be at least three feet above grade. The vent hose from the chlorinator shall discharge to the outside atmosphere above grade.

6. Switches for fans and lights shall be outside of the room at the entrance. A labeled signal light indicating fan operation shall be provided at each entrance, if the fan can be controlled from more than one point.

9.3.5 Liquid Sodium Hypochlorite

Liquid sodium hypochlorite systems range in size from barrels, to totes to bulk storage tanks.

a. Storage containers for hypochlorite solutions shall be of sturdy, non-metallic lined construction and shall be provided with secure tank tops and pressure relief and overflow piping. Storage tanks must be either located or vented outside. Provision shall be made for adequate protection from light and extreme temperatures. Tanks shall be located where leakage will not cause corrosion or damage to other equipment. A means of secondary containment shall be provided to contain spills and facilitate cleanup. Sodium hypochlorite will deteriorate in strength with time. Solution storage capacity must be based on the quantity used and the reliability of delivery. Automatic switchover (or refill) shall be provided so there is no interruption of the disinfection process when a container or tank becomes empty.

b. Equipment.

1. Mixing: See Section 9.3.4(b) above.
2. Control Equipment: See Section 9.3.4(b) above.
3. Piping and Connections: See Section 9.3.4(c) above.
4. Dilution/Mixing Water Supply: See Section 9.3.4(d) above.
5. Hypochlorite feeders shall be of the positive displacement type.

c. Housing.

1. Ventilation must follow normal industrial building requirements and maintain a room temperature no higher than 80°F (27°C).
2. A supply of water is required for dilution/mixing for sodium hypochlorite.
3. PVC, saran-lined steel, or polyethylene piping may be used with sodium hypochlorite. Valves may be made of PVC or other hypochlorite-resistant materials. PVC or polyethylene piping must be supported.

d. In addition to the required equipment above, on-site production will require a hypochlorite generator as well as ancillary equipment including:

1. Sodium chloride storage and equipment for feeding sodium chloride to the sodium hypochlorite generator
2. An adequate supply of dissolution water for the dry sodium chloride
3. An adequate supply of electricity (i.e., primary and emergency), which may need to be direct current depending on the hypochlorite generator.
4. Adequate venting of hydrogen gas produced from the on-site generation of sodium hypochlorite.

9.3.6 Calcium Hypochlorite

Calcium hypochlorite is commercial available as a liquid, but more typically as a dry powder, granules, tablets, and pellets.

a. Containers.

1. For dry forms, the design must consider the possibility of calcium hypochlorite reactions with certain organic compounds, which may result in fire or explosion, and the possibility of spontaneous combustion of dry calcium hypochlorite. Dry hypochlorite compounds must be kept in tightly closed containers and stored in a cool, dry location. Some means of dust control must be considered, as appropriate for the size of the facility and the quantity of compound used.

2. For liquid solutions, see Section 9.3.5(a) above. In addition, storage tanks must include provisions for cleaning as sludge deposits in liquid storage tanks and feed equipment reduce the reliability of calcium hypochlorite as a disinfectant.

b. Equipment.

1. Mixing: See Section 9.3.4(b) above.
2. Control Equipment: See Section 9.3.4(b) above.
3. Piping and Connections: See Section 9.3.4(c) above.
4. Dilution/Mixing Water Supply: See Section 9.3.4(d) above.
5. Hypochlorinators: See Section 9.3.5(b) above.

c. Housing.

1. Ventilation: See Section 9.3.5(c) above.
2. Ancillary Services: See Section 9.3.5(d) above.
3. Piping and Materials: See Section 9.3.5(c) above.

9.3.7 Safety Considerations

The design shall meet all applicable safety codes and owner requirements. The safety considerations mentioned here are just some of the issues unique to the handling of chlorine.

a. Design of gas chlorination systems must consider safety-related equipment such as:

1. At least two sets of respiratory air-pack protection equipment with a minimum capacity of 30 minutes that meets the requirements of the National Institute for Occupational Safety and Health
2. The appropriate cylinder repair kit as approved by the Chlorine Institute
3. A chlorine gas-leak detection system in both the chlorinator and chlorine storage rooms with a local alarm and a remote alarm that signals at a location maintained 24 hours a day.

b. Care must be taken with sodium hypochlorite and dissolved calcium hypochlorite solution because they are skin irritants and hazardous to the eyes. Designs of chlorination and dechlorination systems must consider safety-related equipment such as eye-washes and overhead showers in the storage and metering areas.

c. The design of facilities must consider the possibility of reactions of calcium hypochlorite with certain organic compounds, which may result in fire or explosion, and the possibility of spontaneous combustion of dry calcium hypochlorite.

9.3.8 Redundancy

a. The following equipment must be connected to the emergency power system:

1. All chlorine feed, mixing, and control equipment.
2. Water supply pumps for the chlorine gas injector or dilution/mixing systems.
3. Chlorinator and chlorine cylinder room ventilation and treatment system.
4. Chlorine leak detectors and alarms.

b. Firm capacity for the chlorine disinfection unit process must be capable of providing disinfection of the design peak hour flow.

c. For gas chlorination systems, a minimum of two booster pumps must be provided, each capable of providing the quantity and pressure of water necessary for the satisfactory operation of the chlorine injector. A public water supply with an appropriate backflow prevention system can be used as a backup.

9.3.9 Monitoring and Alarms

Provisions shall be made for measuring chlorine residuals using Division approved test procedures. For treatment facilities with rated maximum month capacities of 5.0 mgd or more, automatic effluent chlorine residual monitoring is required, with high and low chlorine residual alarms that sound at a place monitored 24 hours a day or that are tied into a discrete alarm using an automatic dialer or SCADA system.

9.3.10 Use of Other Chemical Disinfectants

Other chemical disinfectants such as bromine chloride, chlorine dioxide, and peracetic acid may be considered on a case by case basis. Design standards, operating data, and experience for this process are not well established. Therefore, design of these systems shall be based upon experience at similar full scale installations or thoroughly documented prototype testing with the particular wastewater.

9.4.0 DECHLORINATION

Dechlorination is required when using chlorine disinfection to remove the free and combined chlorine residual present in the effluent before it flows into the receiving body of water. Dechlorination feed capacity must be based on the wet weather design peak hour flow.

9.4.1 Types of Chemicals

The most common dechlorination chemicals are reduced sulfur compounds, particularly sulfur dioxide gas or aqueous solutions of sulfite or bisulfite. Pellet dechlorination systems are also available for small facilities. Other reducing agent chemicals maybe considered on a case-by-case basis. The type of dechlorination system must be carefully selected considering the type of chemical storage required, amount of chemical needed, ease of operation, compatibility with existing equipment, and safety.

9.4.2 Dosage Range

Firm dechlorination feed design capacity must be capable of the dosages listed in the following table:

Table 9.2 – Minimum Firm Feed Capacity for Dechlorination

Partial List of Reduced Sulfur Dechlorination Chemicals	Dosage Capacity at Design Wet Weather Peak Hour Flow (mg/L)
Sulfur Dioxide (SO_2)	2
Sodium Metabisulfite	3
Sodium Bisulfite	3
Sodium Sulfite	4

9.4.3 Mixing and Contact Time

The dechlorination chemical must be introduced at a point in the process where the hydraulic turbulence is adequate to assure thorough and complete mixing. If no such point exists, mechanical mixing shall be provided. A minimum of 30 seconds contact time at the design wet weather peak hour flow or maximum rate of pumping shall be provided.

9.4.4 Feed Systems

In general, the same type of booster pump/vacuum feed equipment used for chlorine gas may be used with minor modifications for sulfur dioxide gas. However, the manufacturer should be contacted for specific equipment recommendations. No equipment shall be alternately used for the two gases. Aqueous solutions of sodium sulfite and bisulfite must be fed using positive displacement chemical feed pumps. As with the chlorine, on site storage shall be provided for a minimum of 15 days usage at the design maximum month flow. Automatic switchover (or refill) must be provided for either gas or liquid storage tank systems so dechlorination will occur uninterrupted whenever the plant is discharging. Injection or mixing/dilution water must be provided, similar to (but likely smaller than) that required for chlorine feed.

9.4.5 Housing Requirements

Housing requirements for sulfur dioxide gas shall follow the same general guidelines as for chlorine gas. When using liquid dechlorination compounds, the solutions must be stored in a room that meets appropriate safety and handling requirements. The mixing, storage, and solution delivery areas must be designed to contain or route solution spillage or leakage away from traffic areas to an appropriate containment unit.

a. With gas dechlorination systems, both the sulfonator and sulfur dioxide gas storage rooms must have a mechanical ventilation system capable of providing a minimum of one complete air change per minute or 1 cubic foot of air per minute per square foot of floor area, whichever is greater.

b. The ventilation system must provide an inlet fan located near the ceiling and an air exhaust vent which must be located no more than 12 inches off the floor. The ventilation fan switch must be located outside of the room in an area that is not near the room ventilation exhausts.

c. All gas dechlorination systems must have a sulfur dioxide gas detection system in both the sulfonator and sulfur dioxide storage rooms.

d. System design must prevent chlorine compounds (chlorine gas or various forms of hypochlorite) from coming in contact with dechlorination compounds (sulfur dioxide gas or various forms of sulfite) in either storage or feed rooms. Separate rooms/areas must be provided to store these compounds until the dilute dechlorination chemical is finally fed to the effluent to remove the chlorine residual.

e. Chlorinators and sulfonators must be placed in separate rooms with separate vents and if applicable, separate drains.

f. The respiratory air-pac protection equipment is the same as for chlorine. See Section 9.3.7. Leak repair kits of the type used for chlorine gas that are equipped with gasket material suitable for service with sulfur dioxide gas may be used. (Refer to The Compressed Gas Association Publication CGA G-3-1995, "Sulfur Dioxide").

9.4.6 Redundancy and Spare Parts

The same requirements apply as for chlorination systems.

9.4.7 Potential Reaeration Requirements

Excess sulfur dioxide will consume DO at a ratio of approximately 1 mg of DO for every 4 mg SO_2. Provisions for effluent re-aeration must be included to assure that receiving water DO standards are met, particularly if the plant has an effluent DO limit.

9.4.8 Monitoring and Alarms

Provisions shall be made for (1) measuring the dechlorinated effluent for residual chlorine and DO using Division approved test procedures and (2) manual or automatic control of dechlorination agent feed rates based on chlorine residual and/or effluent flow. For treatment facilities with rated maximum month capacities of 5.0 mgd or more, automatic effluent chlorine residual monitoring is required, with high and low chlorine residual alarms that sound at a place monitored 24 hours a day or that are tied into a discrete alarm using an automatic dialer or SCADA system.

9.5.0 ULTRAVIOLET LIGHT DISINFECTION

This section summarizes the basic terms and technical factors associated with the design of UV disinfection systems for wastewater effluents.

The following definitions will be used throughout the rest of this section to identify UV system design requirements.

- Module: A grouping of ultraviolet lamps electrically and physically connected to each other.
- Bank: A grouping of modules that: 1) forms a complete unit capable of treating the full channel design width and depth, 2) light output can be automatically adjusted or turned on/off in relation to effluent flow variations; and 3) is electrically or physically connected together or physically adjacent to each other.
- Reactor: A combination of multiple banks in a series within a common channel, flow path, housing, or container.
- Closed Vessel: A fully enclosed unit of bulbs or modules in a conduit. For purposes of these criteria, a single closed UV vessel is equivalent to a bank.

9.5.1 UV Process Capacity

a. The UV system shall be designed to meet specified *E.coli* limitations and in accordance with Section 9.2.0.

b. Unless extensive site-specific, analogous, pilot, or collimated beam bench-scale data is presented to justify a lower value, the design delivered UV dosage for activated sludge secondary effluents shall be 30 mJ/cm^2 (30,000 microwatt seconds/cm^2). This dosage is to be delivered assuming an UVT of 65 percent. The applicant is encouraged to meet with Division staff at the beginning of the PDR phase (or before) to review the applicant's plan and safety factors for justifying the use of a lower design delivered UV dosage for the specific application under consideration.

c. Compared to activated sludge, other types of secondary effluent tend to have lower UVTs and higher suspended solids concentrations, both of which can increase the required UV dosage to meet specified *E.coli* limits. In these cases, a collimated beam study shall be performed to determine if a design dosage of more than 30 mJ/cm^2 shall be required. In addition, seasonal data extending over at least one year must be provided to determine if a lower design UVT shall be used. If not, the default criteria listed in 9.5.1(b) shall be utilized for design. The Division shall approve the plan to determine the required design delivered UV dosage and UVT before it is implemented by the applicant.

d. As noted above, special studies may be undertaken by the applicant to justify particle removal credits, lower design UV dosages, or higher UVTs, or a combination of all three. Based on collimated beam studies, the site-specific design delivered UV

dosage shall include a factor of safety of at least 2.0. The design UVT shall be the lower 90th percentile value of site-specific, analogous, bench, or pilot-scale data.

e. An independent, third party bioassay shall be used to verify that for the design UVT and peak flow per lamp, the UV system will deliver the target dosage based on the equipment derating factors described below. Before design approval will be granted, the bioassay reports for the specific equipment being considered must be on file with the Division, with specific sections marked confidential, if applicable. If needed, the UV equipment manufacturer shall verify that the scale up or scale down factor utilized in the design is appropriate for the specific application under consideration.

9.5.2 UV Systems Redundancy.

a. Each UV reactor shall consist of at least two banks in series and shall be capable of disinfecting the design peak hour flow. Each reactor shall also be capable of disinfecting its proportionate share of the design maximum month flow with one bank out of service or removed for maintenance (i.e., N+1 installed banks where N is the number of banks needed). If the specific application under consideration meets the requirements listed in Section 9.2.2 to qualify as supplemental disinfection, reduced redundancy requirements will be considered on a case-by-case basis.

b. The Division encourages each applicant to install parallel UV reactors (e.g., multiple channels) when the total number of required lamps makes this feasible. When multiple channels are included, the design shall electrically isolate the UV reactors in the different channels.

c. The UV equipment package must include the type and number of spare parts for one year of continuous, successful operation. The type of spare parts to be considered includes lamps, ballasts/ballast cards, power-related controls associated with modules or banks, quartz sleeves, sleeve wiper rings, and cleaning chemicals, and any other items recommended or required by the manufacturer, owner, or engineer. The design must identify the required type and minimum number of spare parts necessary to ensure continuous disinfection during maintenance and repair. For horizontal lamp arrays, at least one spare module shall be provided for each channel. For vertical lamp arrays, at least one spare module shall be provided for the total system.

9.5.3 UV Bioassay and Validation

a. Without exception, the basis for verifying the design delivered UV dose meets the requirements of Section 9.5.1 shall be an independent third party bioassay, signed and sealed by a licensed professional engineer with relevant experience. The bioassay procedure must conform to the applicable sections of one of the following protocols:

1. National Water Research Institute's Ultraviolet Disinfection Guidelines for Drinking Water and Water Reuse (May 2003).
2. NSF International, The Public Health and Safety Company, 40CFR35.6450 Environmental Technology Verification Protocol (October 2002).
3. USEPA Design Manual: Municipal Wastewater Disinfection, EPA/625/1-86/021 (1986).
4. USEPA Ultraviolet Disinfection Guidance Manual for the Final Long Term 2 Enhanced Surface Water Treatment Rule, 815-R-06-007 (November 2006).

b. The design equations provided by the validation report must be developed in accordance with a standardized bioassay protocol approved by the Division. The

design end of lamp life and quartz sleeve fouling factors used in the design shall be verified by an independent, third-party testing organization using current protocols issued or approved by the National Water Research Institute (NWRI).

9.5.4 UV Reactor Layout.

For open channel systems, the following design criteria apply.

a. Adequate stilling basin(s)/well(s) leading into UV channels shall be provided.

b. Inlet jet velocity of inlet pipes shall be restricted.

c. Inlet pipes shall be sized for a maximum velocity of 1.5 m/s to keep head loss, large scale turbulence and flow field distortions to manageable levels.

d. Inlet well shall be sized to adequately dissipate energy of inlet jet and avoid aiming directly into UV channel. Minimum criteria are listed below:

1. The depth shall be sufficient to locate the inlet pipe 1.5 to 2.5 pipe diameters below the floor of the UV channel.

2. The width shall be 1.5 times the UV channel width times the number of channels in parallel.

3. The length shall be the greater of the UV channel width or nominal depth.

4. Sharp turns/bends/edges within three hydraulic diameters of first UV bank shall be avoided.

5. The first UV bank shall be located with sufficient lead-in distance.

6. A lead-in distance of at least three hydraulic diameters downstream of the inlet well shall be provided to reduce the risk of UV banks being located with flow trips and/or recirculation zones.

7. Hydraulic diameter is defined as 4 x Rh where Rh = hydraulic radius = flow cross section divided by the wetted perimeter.

e. Inlet edges and bends/elbows shall be avoided. If possible, chamfer or round edges and corners approximately equal to Rh of the UV channel shall be used in the design (e.g. 8x8 to 12x12 inch chamfers and 12 inch rounding of inside corners helps to reduce distortion of velocity profiles leading into reactor). The intent of the above is to the keep velocity profiles leading into reactors to within adequate tolerances to eliminate hydraulic impacts on reactor performance.

f. A fluid level control device shall be provided.

g. For closed vessel UV systems, the approach and downstream conduits and flow conditions must be in accordance with manufacturer's recommendations and the associated bioassay test conditions.

9.5.5 UV Monitoring and Alarms

a. The plant SCADA system and/or the local UV control panel itself shall monitor, display, and provide alarms for the operational parameters that define the dose control strategy for that installation. Since equipment and features vary among UV equipment manufacturers, the design engineer shall be responsible for specifying the monitoring and alarm requirements that will assure continuous disinfection and permit compliance is provided. Common monitoring and alarm features to be considered in the UV system design include:

1. The operational UV dose (calculated or measured).

2. The flow rate in each disinfection channel/conduit (calculated or measured).
3. The UV intensity of a lamp in one bank/vessel of a disinfection reactor.
4. The effluent UV transmittance (or an adjustable default value).
5. The operational status and condition of each bank/vessel.
6. The on/off status of each lamp in the system.
7. The total number of hours of operation for each bank/vessel in the system.

b. Alarms are required to alert operators when the UV system operational control parameters extend beyond the validated operational envelope for the UV system.

c. The alarm(s) display can be locally at the equipment and/or at the operator input/display terminal and/or in the plant SCADA system

d. A facility that is not supervised 24 hours per day must have a notification system (e.g., telemetry with battery backup as part of the alarm system) to notify a facility operator in the event of a UV alarm.

e. The UV or plant alarm system must include the following minimum alarm conditions:

1. Failure of a lamp.
2. Low UV intensity.
3. Low UV transmittance if it is continuously measured and part of the dose control strategy.
4. Loss of flow signal, if applicable.
5. Multiple lamp failure.
6. Outage of any module or bank/vessel.

9.5.6 UV Disinfection System Cleaning and Maintenance

UV systems must be routinely and properly maintained to assure disinfection requirements are continuously met. Minimum requirements include the following:

a. The design must include provisions routine cleaning of the quartz sleeves and UV modules, and periodic draining/flushing of each UV disinfection channel/vessel.

b. Each UV disinfection system shall be equipped with a convenient method for cleaning all equipment surfaces over which the wastewater will pass.

c. Wiper-type cleaning systems must have provisions for supplementary acid cleaning.

d. If the disinfection system has an automatic cleaning system, it must be able to operate in a manual mode.

9.5.7 UV Disinfection System Safety

Design shall include provisions for appropriate protection of personnel within the immediate area where UV modules are in service (e.g., UV-rated face shield, safety glasses, goggles).

9.6.0 OZONE

Ozone (O_3) gas is a proven and acceptable means of wastewater disinfection. Historically, however, only limited use has been made of ozone for wastewater disinfection, both in Colorado and the United States as a whole. Therefore, requests to use ozone disinfection will be reviewed and approved on a case-by-case basis. The following provides some general guidance regarding the type of issues that

must be successfully considered and resolved for an ozone disinfection system to be approved by the Division.

9.6.1 Dosage Range

a. Ozone is strong and indiscriminant oxidant of organic matter, reduced metals, and other inorganics such as cyanide and nitrite. Ozone demand will vary widely depending upon the degree of treatment and the amount and type of organics and other oxidizable constituents remaining in the effluent to be disinfected. Unlike chlorine, there are no prescriptive "rules of thumb" regarding the design ozone dosage range. Once ozone is applied and transferred to the wastewater, a significant amount will be consumed in the oxidation of organic matter. The remaining ozone residual must be high enough, and maintained for a sufficiently long period of time, to provide the required degree of *E.coli* inactivation. That is, the total CT provided must be adequate to attain the required degree of disinfection.

b. The design must identify the total CT requirement upon which the design is based. The design must evaluate design ozone dose, potential ozone demand, plug flow contact time, and whether microflocculation of solids could cause compliance problems with other permits limits, such as effluent TSS or turbidity. These factors must be determined based on (1) bench or pilot-scale studies with the specific wastewater effluent to be treated or (2) at least three analogous projects that, in the opinion of the Division, have been thoroughly researched and documented. The analogous projects need not be limited to Colorado or the United States.

9.6.2 Ozone Generation

There are several methods by which ozone can be generated. These include corona discharge, ultraviolet light, cold plasma, and electrolytic, among others. The most widespread method of ozone generation method for water and wastewater disinfection is by means of a corona discharge. With this method, a feed gas containing O_2 is passed through two high voltage electrodes separated by an insulating dielectric. The feed gas becomes an energized plasma within with O_3 is generated. Either atmospheric air or pure oxygen can be used as the feed gas. However, at higher elevations, such as those found in Colorado, the use of pure oxygen becomes more cost competitive as the size of the ozone generation system increases.

a. If a corona discharge generation system is used, the feed gas must be both clean and dry, with a dew point of -60 °C for air and -30 °C for pure oxygen, to minimize the potential for sparking and nitric acid formation. Redundant air or oxygen supply must be provided to assure continuous generation of ozone and disinfection of the wastewater.

b. Special attention must be made to all aspects of the design to ensure that the feed gas is filtered; free of dust, oil, and other contamination; and dry. If dessicant dryers are used, it will be necessary to filter the air both before the compressors and after the dryers, immediately prior to the ozone generation equipment. In all cases, the design shall strictly adhere to the air handling recommendations of the ozone generator manufacturer.

c. Firm capacity shall be provided using a minimum of two generators. In addition, each generator shall be sized so it does not operate at full output for more than one hour at a time (i.e. link maximum output to the peak hourly design condition). Other ozone generator considerations include provision of a heat dissipation system, designing the electrical components for ozone service, and use of 316L stainless steel for the generator itself to prevent corrosion. A leak-proof check valve shall be

provided in the gas piping to prevent moisture from migrating back from the contactor to the generator. Note that all flexible connections in both the gas and liquid streams shall be made with ozone-resistant materials, such as Teflon or Hypalon®. Welding is preferred over screwed fittings, the latter of which tend to leak.

9.6.3 Mixing and Contact

a. Immediately after ozone is applied to the wastewater, the concentration will naturally start to decay as O_3 molecules recombine to form oxygen gas ($2\ O_3 \rightarrow 3\ O_2$). In addition, an ozone demand will be exerted as suspended solids and dissolved material are oxidized. Therefore, rapid and vigorous mixing of ozone with the effluent to be treated is recommended. Potential ozone gas transfer systems include fine bubble diffusers and those utilizing the venturi principle to draw the gas into a slipstream of the flow, which is subsequently injected into the main flow to be disinfected. Like an activated sludge aeration system, not all of the gas applied to the wastewater will be transferred into it. The ozone mixing and application system suppliers must submit documentation, from pilot studies or analogous water and wastewater disinfection projects, regarding demonstrated ozone transfer efficiencies.

b. Multi-stage plug flow contactors should be used to reduce the potential for short circuiting and provide a reasonably uniform exposure time of the effluent to the ozone residual. The Division does not require verification of actual CT provided, only compliance with the effluent limits specified for the pathogen indicator organism. However, it is recommended that CT be used as an operational control and tracking parameter by utilities utilizing ozone disinfection. Since the ozone residual will decay as the flow moves through the contactor, utilities may elect to integrate (i.e. add up) the product of the CT provided by each stage of the contactor rather than relying on a single CT measurement using the ozone residual at the end of the last stage and the overall contact time. Other considerations in the design of ozone contactors include:

1. Provide a minimum two plug flow contact chambers designed to minimize short circuiting.
2. Consider the potential for iron, manganese, and other precipitate formation, particularly when using fine bubble diffusers.
3. Full flow pipes provide good plug flow conditions and may be feasible and cost-effective depending upon total detention time requirements associated with the design CT for the specific project under consideration.
4. Contact chambers with an open water surface shall be covered and kept under negative pressure to protect worker safety. The materials of construction (concrete, fiberglass, 316L stainless steel, etc.) shall be designed to withstand the corrosive effects of ozone in the liquid and the off gas.
5. The off-gas shall be treated by an ozone destruct system before it is vented to the atmosphere. The maximum allowable concentration in the discharge shall be in accordance with air emission regulations, or whatever lower value may be required to protect worker and public health.
6. Provide adequate freeboard for foam accumulation and consider the installation of a spray water system to control foaming in the headspace above the contactor water surface level.

7. Provide a redundant means of injecting ozone into the flow. Diffusers shall be fully accessible for cleaning or replacement.

9.6.4 Off-Gas Ozone Destruction Requirements

A system must be provided to remove any ozone before the off gas from the ozone contact chambers is vented to the atmosphere. Typical methods for ozone gas destruction include thermal and thermal/catalytic destruction. Firm capacity shall be provided through the installation of at least two ozone gas destruction units. As noted above, the maximum allowable ozone concentration in the off gas vented to the atmosphere shall be in accordance with air emission regulations, or whatever lower value may be required to protect worker and public health. The ozone destruct units shall be designed to reduce the risk of fire and located where they can easily be reached for maintenance. Other considerations include how moisture and foam could negatively impact the performance of the ozone destruct system. Due to the severe conditions of service and need for reliable performance, low carbon 316L stainless steel is the recommended material of construction for the ozone destruct units.

9.6.5 Dissolved Ozone Residual Removal

Any ozone residual remaining in the disinfected effluent must be removed prior to discharge to the receiving stream. Unless sufficient storage time is provided to let the ozone residual naturally dissipate, a reducing agent must be injected into the flow, similar to the way in which chlorine residual is removed before discharge. The same reduced sulfur compounds used for dechlorination, as discussed in Section 9.4, can also be used for removal of ozone residuals. The applicant may select whether these or other suitable and commercially available chemicals are used for ozone residual removal. The feed system for removal of the ozone residual must be sized for the design peak hourly flow and maximum expect ozone residual. Note that residual removal dosage requirements will not be the same as for dechlorination.

9.6.6 Safety Considerations

The design shall meet all applicable safety codes and owner requirements.

9.6.7 Redundancy

As indicated above, firm capacity shall be provided for all feed gas supply and ozone generation, contact time, off-gas destruct, and residual removal facilities. As a minimum, the applicant shall maintain on site the spare parts inventory recommended by the manufacturer of each piece of equipment, including instrumentation and control components.

9.6.8 Monitoring and Alarms

a. Each manufacturer of ozone generation and off-gas destruct equipment will have recommendations for monitoring performance and sending alarm notifications to the operators.

b. In addition to adhering to manufacturer specific recommendations, the design must consider the need for the following continuous, on-line ozone system monitoring instruments connected to the plant control and alarm system(s).

1. Pressure gages at the inlet and outlet of the feed gas dryers, as well as the inlet to the ozone generators, contactors, and off-gas destruct units.
2. Electric power supply to the ozone generators, with an automatic shut off when power draw exceeds a preset level.
3. Dew point monitoring and automatic shut down if a preset value is exceeded.
4. Air flow monitoring through each dryer and ozone generator.

5. Temperature at the inlet and outlet of the ozone power supply/generator cooling water loop(s).
6. Water flow rate through the ozone power supply/generator cooling water loop(s).
7. Downstream of the generators, provide ozone monitors for the gas feed upstream of the injection point, the off-gas from the contactors, and the discharge from the ozone destruct units.
8. Monitor the ozone residual within the contactors in as many places as the applicant intends to take credit with respect to determining the total CT provided to the flow being disinfected. As a minimum, one on-line monitor must be provided at the outlet of the last stage of each contactor to determine the minimum CT provided and to help pace the chemical used to remove the ozone residual from the effluent.
9. Ambient ozone monitors shall be installed in any location where ozone gas may be expected to accumulate, such as within the generator room and in the vicinity of the contactors.

CHAPTER 10
OUTFALLS

Outfall sewers are the pipes discharging treated effluent into the receiving stream and typically include a single pipe (exposed or submerged) at the bank of the receiving stream or a multi-port diffuser in the receiving stream. This chapter presents design criteria for outfalls.

10.1.0 GENERAL

a. Outfalls shall be designed to discharge treated wastewater in a manner that results in dispersion of effluent into receiving waters to achieve in-stream water quality conditions consistent with the CDPS permit conditions and the findings of the water quality assessment for the CDPS permit.

b. The hydraulic capacity of the outfall must be sized to convey the design peak instantaneous wet weather effluent flow, taking into account the presence of flow equalization at the plant.

c. Hydraulic design of and pipe materials for an outfall pipe shall conform to the requirements for gravity pipe in Chapter 3 or for pressure pipelines in Chapter 4. Minimum discharge velocity through submerged side bank outfalls shall be no less than 3 fps at peak flow.

d. The PDR shall provide design details for the outfall to demonstrate compliance with the site location approval, PELs, and CDPS permit conditions (e.g., mixing zones, waters designated for threatened and endangered species).

e. The outfall shall be designed to minimize impacts of the discharge through appropriate site selection and erosion control. The design must provide protection from damage and adverse conditions as needed (e.g., trash racks, barrier screens, fences).

10.2.0 MULTI-PORT SUBMERGED DIFFUSERS

Multi-port submerged diffusers are intended to increase mixing and dispersion of discharged effluent in a stream. Diffusers can be an acceptable means of ensuring mixing zones will avoid or allow no more than a minor detrimental effect in waters designated as habitat for a threatened or endangered species. A multi-port diffuser consists of a header pipe containing two or more ports (with or without risers) discharging in any orientation and may include wyes and other atypical arrangements.

10.2.1 General Diffuser Considerations

a. Use of a diffuser must be negotiated with the Permits Section of the Division and diffuser-appropriate PELs issued before a diffuser design is considered.

b. Copies of the PDR and design drawings must be submitted to US Fish and Wildlife Service and US Army Corps of Engineers. Federal agencies have authority to disagree with PELs and draft and final permits. The system must demonstrate compliance with the requirements of all other regulating agencies. Installation of the diffuser will require notification and most likely an Army Corps of Engineers permit.

c. A zone of passage of at least 50 percent of the river cross section (i.e., river breadth) must be maintained outside the acute mixing zone. The diffuser header length (i.e., first port to last port) shall not be greater than 50 percent of the stream width (or lateral distance corresponding to 50 percent of the cross-sectional area). The mixing zone shall not encroach on a drinking water intake, recreation area, or sensitive habitat, overlap the next downstream outfall, or occlude a downstream tributary.

d. Computer dilution modeling (e.g., PLUMES, CORMIX) must be provided to justify that water quality standards will be met at the boundaries of acute and chronic mixing zones. The computer dilution models must be calibrated to actual conditions in the field and the analysis must include all critical flow and loading situations expected for the facility. For river discharges, the low flow must represent the low flow criteria as specified in Section 31.9 of 5 CCR 1002-31 The Basic Standards and Methodologies for Surface Water (Regulation 31).

e. The PDR shall include a description of construction methods for outfall installation in the water body (e.g., pipeline assembly, trench mechanics, slope stability, access restrictions, mitigation practices, permit requirements) and anticipated required installation permits (e.g., US Army Corps of Engineers)

f. The hydraulics of the diffuser must be tested to confirm modeling following installation (e.g., dye test). Upon completion of construction, a flow test using at least 80 percent of the design effluent flow shall be conducted to determine the hydraulic capacity of the system and confirm uniform exit velocity for each port. A record of actual flow and headloss shall be documented. This information is to be retained and used in the future to evaluate system performance and confirm the need for maintenance.

g. Adequate operation of the diffuser will depend upon development and implementation of a robust inspection and maintenance program for the diffuser. The PDR shall include written inspection and maintenance procedures and schedule to inspect the outfall line and diffuser to document its integrity and continued functioning.

h. For diffusers being installed at existing facilities, the existing outfall is to remain until the diffuser is installed and the existing outfall is to be removed once the diffuser is installed and operational.

10.2.2 Diffuser Design Criteria

a. Diffuser and Pipe Location

1. The pipeline shall be contained within approved property boundaries or easements. A shoreline marker shall identify the specific location of the submerged diffuser.

2. The feeder pipeline and diffuser header shall be located such that the pipeline can be accessed for monitoring and maintenance. Access points to the receiving water should be within close proximity to the diffuser, preferably upstream.

3. The diffusers must be designed to compensate for the geomorphology along the proposed outfall route and diffuser site including stability and mobility of the bottom, anticipated scour and deposition, flood conditions, and other potential hazards to the diffuser (e.g., dredging, recreation or commercial uses, seasonal debris loads).

b. The diffuser pipe and ports shall be constructed of a durable material that will provide a consistent cross section throughout its service life. The service life must be comparable to the life of the facility being served. Ports constructed of carbon steel, stainless steel, and high-density polypropylene have demonstrated suitable service for multi-port diffusers. When carbon steel is used, a coating or corrosion allowance must be provided.

c. The PDR shall document diffuser port size selection and diffuser capability to provide discharge with balanced flow from individual ports at all anticipated effluent flows. The PDR shall document sufficient head is provided to ensure discharge at the peak 100-year flood elevation with the head loss at peak flow.

d. The diffuser pipe velocity shall be at least 2 fps at peak flows. Individual port velocities shall exceed 2 fps at average dry weather flows. Maximum port velocity shall not exceed 15 fps.

e. The PDR shall include provisions for operators to remove accumulated material from the diffusers (e.g., manholes, cleanout ports) and to maintain diffuser capacity during low initial operating flows.

f. The design shall consider methods to adapt the diffuser for future WWTP capacity increases (e.g., spare fittings or ports, caps, plugs).

10.2.3 Submerged Pipe Design Criteria

a. The PDR shall document provisions to prevent trapped air in the submerged pipes (e.g., pipe profile, air and vacuum release valves, physical anchors).

b. Pipes must be properly anchored and armored for expected exposure to scour, debris and high currents during floods.

c. The PDR shall document provisions to control corrosion (e.g., coatings, pipe bonding, sacrificial anodes, impressed current system). Soil electrolytic conditions shall be tested for each application wherever metallic pipe materials are used.

CHAPTER 11
SOLIDS PROCESSING AND HANDLING

Wastewater treatment facilities shall develop management and operating plans for handling and treatment of raw sludge, biological process sludges, and ultimate use or disposal of biosolids. This chapter presents design criteria for solids processing and handling.

The following definitions apply to this chapter.

- Acid/gas two-phase anaerobic digestion: Sludge digestion process with separate acid-phase and methane-phase reactors operating in series.
- Biosolids: Stabilized primary sludge, humus, WAS, or combined sludges after digestion or chemical treatment.
- Humus: Material sloughed from trickling filters.
- Primary sludge: Suspended solids removed from raw sewage (primary sludge).
- Process unit: A treatment process basin (i.e clarifier, thickener, digester, etc.).
- Regulation 64 – Colorado Biosolids Regulation (5 CCR 1002-64) – State regulation that establishes requirements, prohibitions, standards and concentration limitations on the use of biosolids as a fertilizer and/or organic soil amendment in a manner so as to protect the public health and prevent the discharge of pollutants into state waters.
- Temperature phased anaerobic digestion (TPAD): Sludge digestion process with separate first phase thermophilic digestion followed by second phase mesophilic digestion.
- Waste Activated Sludge (WAS): Suspended solids removed from sewage after secondary treatment. For purposes of table values below, WAS term includes humus.
- 40 CFR Part 257: Federal regulatory requirements for classification of solid waste disposal facilities and practices.
- 40 CFR Part 503 ("503 Regulations"): Federal regulatory requirements for biosolids management.

11.1.0 GENERAL REQUIREMENTS

a. The design basis for sludge and biosolids handling and treatment systems shall be summarized in the PDR and must address at a minimum the criteria listed in Table 11.1.

b. If at least two process tanks are available for any sludge or biosolids systems, piping and pumping equipment shall be designed to allow: 1) transfer of solids and supernatant from one tank to another for maintenance, 2) continuous operation, and 3) operation in sequential primary-secondary digester, if desired.

c. Design of digester tanks (including aerobic, anaerobic and autothermal thermophilic aerobic digestion or ATAD) shall consider methods to retain heat in the biological process and control heat loss (e.g., insulation, below grade construction, etc.) from the system.

d. A biosolids sampling valve shall be installed at such a location that the biosolids can be sampled without drawing biosolids to the load out facilities. The valve and piping shall be at least 1-1/2 inches (4 cm) in diameter. Solids processes (e.g., thickening, dewatering) must have provisions for sampling before and after major components to allow periodic monitoring of process performance.

e. Provisions for draining and cleaning digester tanks shall be provided.

f. Adequate storage must be provided when solids processes are not operated continuously. Storage of un-dewatered solids must have adequate provisions to minimize nuisance odors (i.e. aeration, containment and off-gas odor treatment, or other odor control method).

g. During facility operation, classification of biosolids as Class A or B must comply with 40 CFR 503 and Colorado Biosolids Regulation 64. When digestion facilities are included in the design, the PDR must identify the design basis for the digestion process that is anticipated to enable the operations to meet the desired biosolids class.

h. Solids holding facilities (e.g., aerated sludge/scum holding tank or pond) shall be provided when digestion facilities are not included in the design. As a minimum, enough oxygenation capability shall be provided to maintain detectable dissolved oxygen within the tank contents. It shall also be designed to concentrate sludge and decant clear supernatant back to the aeration system. Sizing calculations, a description of how, where, and when final disposal of sludge will be accomplished shall be included in the PDR.

Table 11.1 – Minimum Criteria for Sludge and Biosolids Handling and Treatment Systems

Design criteria	Requirements
Solids loading	Maximum month and peak day sludge concentration and dry solids quantities.
Hydraulic loading	Maximum month and peak day liquid quantities.
Capacity	Design must accept the peak sludge liquid and dry solids quantities without overloading the sludge handling and treatment systems or adversely impacting the liquid stream processes. Treatment capacities listed herein indicate maximum application rates following attenuation/equalization.
Sludge quality	Volatile solids content and concentration of regulated nutrients, metals, and pathogen levels
Solids mass balance	Provide mathematically consistent calculations of solids quantities entering and exiting each sludge handling and treatment process, including recycle streams. Mass balance calculations must account for waste concentration, solids loading, solids retention time, sludge volatile solids reduction, tank volume, and decant or dewatering volumes, cycle time, storage volumes, and characteristics.
Assumptions	When actual sludge qualities or quantities are not known, document design assumptions that could affect performance of sludge handling and treatment processes.
Stabilization performance	Per 40 CFR 503 (e.g., pathogen and vector attraction reduction)
Disposal alternatives	Per 40 CFR 257
Redundancy	
Number of process units	Minimum of 2 process units except when an alternative method or operational procedure is described to provide reliable treatment and permit compliance during maintenance, repairs, or equipment failures.
Process unit capacity	Provide at least 50 percent of the total design loading when the largest process unit is out of service.
Equipment redundancy	Provide firm capacity for equipment (e.g., pumps, blowers, disinfection units) critical to maintain 100 percent of the design capacity for each process unit when the largest equipment unit is out of service.
Recycle streams	Identify and quantify the impact of recycle streams on upstream and downstream treatment processes. Recycle streams must be returned to the plant at a rate and location that will not adversely impact performance of upstream and downstream treatment processes.

11.2.0 SOLIDS THICKENING

a. If solids thickening is used, the criteria shown in Tables 11.2, 11.3, and 11.4 shall apply.

b. Gravity belt thickeners (GBTs) must have a polymer feed system as well as a filtrate drainage system of adequate size to remove the full hydraulic capacity of a gravity belt thickener without accumulation or ponding.

c. Other thickening methods (e.g., centrifuges, rotary drum thickeners) may be considered provided that the design basis is included in the PDR with the appropriate peer-reviewed design method references. Pilot or demonstration testing may be considered for equipment with less than 5 years operating experience under similar conditions (i.e., sludge type, loading rate) for other thickening methods.

Table 11.2 – Gravity Thickener Design Criteria

Parameter	Primary		WAS[a]		Primary + WAS[a]	
	Minimum	**Maximum**	**Minimum**	**Maximum**	**Minimum**	**Maximum**
Hydraulic loading, gpd/sf		760 *		200 *		300 *
Solids loading, ppd/sf		30^		8^		17*
Side water depth, feet	10					
Floor slope, ratio v:h	1:6					

[a]PDR must acknowledge biological reactions, generation of odors and floating sludge and justify adoption of gravity thickeners for WAS or for primary sludge + WAS.

Sources:
* = WEF, MOP 8, *Design of Municipal Wastewater Treatment Plants*, 2010, Chapter 23
^ = Metcalf & Eddy 2003, *Wastewater Engineering Treatment and Reuse*, 4th Edition, 2003.

Table 11.3 – Gravity Belt Thickener Design Criteria

Parameter	Primary		WAS		Primary + WAS	
	Minimum	**Maximum**	**Minimum**	**Maximum**	**Minimum**	**Maximum**
Hydraulic loading, gpm/m width				250 #		150
Solids loading, pph/m width				1,000*		
Polymer dose, lb/ton ds				8		10
Belt wash water						
Discharge rate, gpm/m width	20*#					
Discharge pressure, psi	60 #					

Sources:
* = WEF, MOP 8, *Design of Municipal Wastewater Treatment Plants*, 2010, Chapter 23
^ = Metcalf & Eddy 2003, *Wastewater Engineering Treatment and Reuse*, 4th Edition, 2003.
# = Texas Wastewater Design Criteria, Subchapter J – Sludge Treatment Units, §217.248 Sludge Thickening.

Table 11.4 – Dissolved Air Flotation (DAF) Thickener Design Criteria

Parameter	Primary		WAS		Primary + WAS	
	Minimum	Maximum	Minimum	Maximum	Minimum	Maximum
Hydraulic Loading, gpd/sf				2,880*		
Solids Loading						
No polymer, pph/sf				1.0*		1.0*
With polymer, pph/sf				2.0*		2.0*
Air to solids ratio, lb/lb	0.02^					
Side water depth, feet	10					

Sources:
* = WEF, MOP 8, *Design of Municipal Wastewater Treatment Plants*, 2010, Chapter 23
^ = Metcalf & Eddy 2003, *Wastewater Engineering Treatment and Reuse*, 4th Edition, 2003.

11.3.0 SOLIDS STABILIZATION

11.3.1 Solids Pretreatment

Prior to digestion, sludge pretreatment systems may be used (i.e., chemicals, heat, sonic energy, electric energy, or combinations). If used, sludge pretreatment benefits must be analyzed in the PDR. Pilot or demonstration testing may be considered for equipment with less than 5 years operating experience under similar conditions.

11.3.2 Anaerobic Digestion

a. If anaerobic digestion is used, the criteria shown in Tables 11.5, 11.6 and 11.7 shall apply.

Table 11.5 – Single Stage Anaerobic Digestion Process Design Criteria

Parameter	Mesophilic		Thermophilic	
	Minimum	Maximum	Minimum	Maximum
Process temperature, °C	35	38	50	60
Volatile solids loading, ppd VS/cf		0.20*		0.3 #
Solids retention time, days	15*^		10 &	

Sources:
* = WEF, MOP 8, *Design of Municipal Wastewater Treatment Plants*, 2010, Chapter 23
^ = Metcalf & Eddy 2003, *Wastewater Engineering Treatment and Reuse*, 4th Edition, 2003.
# = EPA *Biosolids Technology Fact Sheet, Multi-Stage Anaerobic Digestion*, EPA 832-F-06-031, 2006
& = CDPHE Design Criteria Workgroup consensus, 2012

Table 11.6 – Multi-Stage Anaerobic Digestion Process Design Criteria

Parameter	Acid/Gas Phased		Temperature phased (TPAD)	
	Minimum	Maximum	Minimum	Maximum
Process temperature, °C	35	60	35	60
Volatile solids loading, ppd VS/cf				
Acid-phase volume		2.5 *		
Initial TPAD phase volume – thermophilic				0.3 #
Initial TPAD phase volume – mesophilic				0.2 *
Solids retention time, days				
Acid-phase	1 *	2 *		
Methane phase	10 * (15 total)			
Thermophilic phase (55 °C)			4 *	
Mesophilic phase (35 °C)			7 ^ (total 15 ^)	

Sources:
* = WEF, MOP 8, *Design of Municipal Wastewater Treatment Plants*, 2010, Chapter 23
^ = Metcalf & Eddy 2003, *Wastewater Engineering Treatment and Reuse*, 4th Edition, 2003.
# = EPA *Biosolids Technology Fact Sheet, Multi-Stage Anaerobic Digestion*, EPA 832-F-06-031, 2006

Table 11.7 – Anaerobic Digestion General Design Criteria

Parameter	Minimum Criteria
Mixing	
Mechanical , hp/1,000 cf (unless manufacturer performance data are available)	0.2 *
Gas, scfm/1,000 cf	5 *
Velocity gradient, 1/s	50 *
Free board, feet	2 ^
Floor Slope, ratio v:h	1:4

Sources:
* = Metcalf & Eddy 2003, *Wastewater Engineering Treatment and Reuse*, 4th Edition, 2003.
^ = CDPHE Design Criteria Workgroup consensus, 2012

b. A WWTP with a hydraulic design capacity exceeding 1 mgd that utilizes anaerobic digestion must have at least two anaerobic digesters. A facility that has a single digester must have an emergency storage basin or other adequate means to allow the single digester to be taken out of service.

c. Mixing (i.e., either mechanical, hydraulic, or gas injection) shall be provided to minimize excessive temperature gradients, solids concentration, and grit and scum accumulation.

d. Provisions shall be made for the safe collection, handling, storage and use of gas generated in the anaerobic digestion process. The reuse of the gasses to supplement the heating requirements is encouraged.

e. A gas meter with bypass shall be provided to record total gas production for all digesters. Digester sludge feed rate and digested biosolids withdrawal shall be metered for process control and solids balancing.

f. The digester must have at least two access manholes in the cover and a separate sidewall manhole at ground level, every access manhole with a minimum diameter of 30 inches to permit personnel access and use of mechanical equipment for ventilation and cleaning during maintenance or repairs.

g. Digesters must have a minimum of two sludge inlets and two sludge withdrawal outlets (e.g., including mechanical mixing units) located to minimize short-circuiting or provide some means to prevent short-circuiting.

h. Each digester must have an un-valved, vented emergency overflow pipe.

i. A digester must maintain a minimum average daily sludge digestion temperature within +/-4 °C of the design temperature. Feed sludge must be heated as necessary to maintain digester temperature.

j. Gas Collection, Piping, and Storage.

1. The gas system must maintain positive gas pressure under all normal operating conditions, including sludge withdrawal. A gas system must include a pressure valve, vacuum relief valve, a flame trap, and an automatic safety shut-off valve. A gas pipe to each gas outlet must have a flame check or a flame trap. Each main gas pipe must have a flame trap with a fusible shut-off. Water seal equipment on gas pipe is prohibited.

2. Gas pipe must be pressure tested for leakage at 1.5 times the design pressure before a digester is placed into service. Gas pipe must slope at least 1/8 inch per foot to drain condensate. The main gas pipe from a digester must have a sediment trap and a condensation trap which must be accessible for servicing. If gas pipes from multiple digesters are manifolded, trap(s) must be adequate for independent operation of digesters. Float controlled condensate traps are prohibited. A drip trap must be located at each low point in the gas pipes.

3. Adequate storage for digester gas must be provided, depending on the use of the gas. Gas may be stored in specifically designed rigid covers or an engineered flexible membrane system. To minimize gas hazard potential, the storage volume for digester gas may be minimized if the digester gas utilization system is designed to consume the digester gas at the same or greater rate than the digester gas is generated.

k. Anaerobic digester gas piping must be equipped with gauges to measure pressure in the main pipe, pressure to gas-utilization equipment, and pressure to waste burners.

l. A gas pipe to a waste gas burner must have a pressure valve and a vacuum relief valve. A burner pilot must use natural or bottled gas. If placed at ground level, a waste gas burner must be accessible and must be located in accordance with NFPA 820relative to any structure. A waste gas burner must not be located on top of a digester but may be located on the roof of the control building.

m. Electrical equipment near digester pipe or tanks containing gas must be designed to prevent potentially explosive conditions per the NFPA 70 and NFPA 820.

n. An underground enclosure connected to an anaerobic digester tank, gas pipe, or sludge equipment must have forced ventilation and a tight-fitting, self-closing door to minimize gas hazards.

o. Digester heating capacity must be sufficient to maintain the required sludge stabilization temperature. Additional heating may be provided by circulating the

contents of the digester through an external heat exchanger. A sludge heating device with an open flame must be located above grade and in an area separate from gas production and any storage area. Digester heating systems must be designed to use an alternate source of fuel and have an alternate source of fuel available for emergency use.

p. Anaerobic digesters shall be equipped to control, suppress, or remove excessive foam. The design must consider provisions for the capture and control of foam outside the structure in the event of overflows or failure of equipment, seals, pipe penetrations, or access ports.

q. Supernatant liquor from an anaerobic digester may be returned directly to the facility for treatment or be chemically or biologically treated before being returned to the facility for treatment. Supernatant pipes must allow withdrawal from at least two draw-off levels. The minimum diameter for a supernatant pipe is 6.0 inches. A supernatant pipe must have sampling points at each supernatant draw-off level.

r. Digester covers must be gas tight with a gas collection chamber. Uncovered anaerobic digesters are prohibited.

s. For digesters with fixed covers, each digester must be equipped with two pressure and vacuum relief valves with flame traps for each digester. Isolation valves on pressure and vacuum relief valves shall be arranged such that one of the two sets of pressure relief valves and vacuum breakers remains in service at all times except when the entire digester is out of service. All anaerobic digester covers require vacuum relief valves. Pressure relief valves are not required for the following digester cover systems:

1. Floating covers
2. Fixed covers which are designed to lift or float to release the maximum internal design pressure
3. Fixed covers which have access covers or ports which are designed to lift or float to release the maximum internal design pressure.

<u>11.3.3 Aerobic Digestion</u>

a. If aerobic digestion is used, the criteria shown in Tables 11.8 and 11.9 shall apply.

Table 11.8 – Aerobic Digestion Process Design Criteria

Parameter	Conventional Aerobic Digestion		Autothermal Thermophilic Aerobic Digestion (ATAD)			
			First stage		Second stage	
	Minimum	Maximum	Minimum	Maximum	Minimum	Maximum
Process temperature, °C	15	20	35	50	50	70*
Feed solids concentration, percent	0.7*	2.5*	4	6	4	6
Volatile solids loading, ppd VS/cf	0.10 ^	0.30 ^				
Solids retention time, days			See section 11.1.0.g			
at 15 °C	60 #					
at 20 °C	40 #					
Number of stages			1		1	
Mixing						
Mechanical, hp/1,000 cf	0.5*	4.0*	3		3	
Air, scfm/1,000 cf	20 ^	40 ^	70		70	
Dissolved oxygen, mg/L						
At maximum oxygen demand	1.0 ^		1.0 ^		1.0 ^	
At average oxygen demand	2.0 ^		2.0 ^		2.0 ^	

Sources:
* = WEF, MOP 8, *Design of Municipal Wastewater Treatment Plants*, 2010, Chapter 23
^ = Metcalf & Eddy 2003, *Wastewater Engineering Treatment and Reuse*, 4th Edition, 2003.
# = 40 CFR 503

Table 11.9 – Aerobic Digestion General Design Criteria

Parameter	Minimum	Maximum
Side water depth, feet	10	
Free board, feet	1.5	
Sidewall depth to diameter ratio	0.3	0.7
Floor Slope, ratio v:h	1:12 *	1:3

Sources:
* = CDPHE Design Criteria Workgroup consensus, 2012

b. Aerobic digesters must have mechanical, hydraulic, or air mixing equipment.

c. The aerobic digester aeration diffuser design must consider prevention of plugging when the solids are periodically settled and thickened during operation. The PDR must include documentation of possible alternatives and maintenance requirements for the selected digester aeration diffusers (e.g., coarse bubble, fine bubble, or jet nozzle).

d. Aerobic digesters shall be equipped to control, suppress, or remove excessive foam. The design must consider provisions for the capture and control of foam outside the structure in the event of failure of equipment, seals, pipe penetrations, or access ports.

e. For an aerobic digester that concentrates waste sludge only by decanting a digester tank, the maximum solids concentration used to calculate the total retention time

must be 2.0 percent unless supporting data is submitted to increase the solids concentration up to 3.0 percent.

f. The ATAD process can be used to meet either Class A or Class B pathogen requirements. ATAD shall consist of two or more stages. The minimum DO level in the liquid (see design criteria table) shall be maintained to minimize odor potential.

g. If aerobic thermophilic pretreatment (ATP) is used prior to mesophilic anaerobic digestion, the aerobic thermophilic digester shall have a minimum solids residence time of 18 hours with a minimum reactor temperature of 55 °C.

11.3.4 Anaerobic Sludge Lagoons

a. If anaerobic sludge lagoon digestion is used for stabilization of primary sludge and/or biological sludge, the criteria shown in Table 11.10 shall apply.

Table 11.10 – Anaerobic Sludge Lagoon Design Criteria

Parameter	Minimum	Maximum
Solids retention time, days	180	
Organic loading rate, ppd/1000 cf		18.7 *
Surface loading rate, lb/100 ft^2		20 *
Water depth, feet	15 ^	
Freeboard, feet	3 ^	
Embankment slopes, vertical:horizontal		1:3 ^
Sub-drain soil liner	See requirements for lagoons (Chapter 8)	
Source: * = Ontario Ministry of the Environment Sewage Technical Working Group, *Design Guidelines for Sewage Works 2008*. ^ = CDPHE Design Criteria Workgroup consensus, 2012		

b. Anaerobic sludge lagoons must be lined in accordance with lagoon requirements identified in Chapter 8.

c. The design shall consider minimizing the surface area-to-volume ratio for heat retention.

d. Supernatant from anaerobic sludge lagoons shall be returned directly to the liquid stream treatment process.

e. The liquid volume of an anaerobic sludge lagoon shall be designed to provide adequate sludge storage for the minimum solids retention time accounting for supernatant return to the liquid stream, precipitation and lagoon surface evaporation.

f. Anaerobic sludge lagoons shall be covered or shall be designed to maintain an aerobic surface layer to minimize odors and methane gas emissions. Floating covers shall be gas tight and equipped with gas collection system. Gas may be beneficially used or be combusted in a waste gas burner. When mechanical surface aerators or submerged air diffusers are used to maintain an aerobic surface layer, the surface aeration system shall be designed to minimize mixing between the aerobic layer at the surface and and the anaerobic zone at the bottom of the lagoon.

11.4.0 BIOSOLIDS MANAGEMENT

Dewatered undigested and/or digested sludge must be properly stabilized to inactivate pathogens and reduce vector attraction (e.g., composting, alkaline stabilization, heat stabilization). Biosolids

management may be conducted at the WWTP or off-site by a contractor. All biosolids management including storage, reuse, or disposal methods shall conform with Federal Requirements 40 CFR 257 and 40 CFR 503, Colorado Biosolids Regulation 64, and with the requirements of the Colorado Regulations Pertaining to Solid Waste Disposal Sites and Facilities, as applicable. If biosolids management is intended at a WWTP, the PDR must provide a discussion of the intended biosolids management method(s) and provide adequate space and design features (e.g., liner, underdrain, stormwater control) in accordance with these regulations.

11.5.0 SOLIDS DEWATERING

11.5.1 Mechanical Dewatering Methods

Mechanical dewatering methods (e.g., centrifuges, belt presses, recessed-plate filter presses, rotary presses, screw presses) may be considered provided that the design basis is included in the PDR with the appropriate peer-reviewed design method references. Pilot or demonstration testing may be considered for equipment with less than 5 years operating experience under similar conditions (i.e., sludge type, loading rate) for other dewatering methods.

11.5.2 Drying Beds

a. If sludge drying beds are utilized, the criteria in Table 11.11 shall apply. The loading rates shall apply unless the PDR includes performance data from a similar facility in the same geographical area with the same influent sludge characteristics.

b. Drying beds must have at least two cells that can be isolated from one another and can be operated independently.

c. The bottom of a sludge drying bed must be lined. Where the groundwater table is 4.0 feet or more below the lining, the lining may consist of a layer of soil having low permeability (less than 10^{-6} centimeters per second) and minimum thickness of one foot. Where the groundwater table is within 4.0 feet of the bottom, an impermeable material (geomembrane, concrete, asphalt, etc.) must be installed over or in place of a soil liner. The drying bed design must consider preservation of the lining material when solids are periodically removed during operations. The PDR must include documentation of possible alternatives and maintenance requirements for the selected lining material.

d. The exterior walls of a sludge drying bed must be watertight and extend a minimum of 12 inches above the bed surface or ground elevation, whichever is higher. Interior walls of a sludge drying bed must be watertight and extend a minimum of 12 inches above and at least 6 inches below the bed surface.

e. Sludge pipe to the beds must terminate at least 12 inches above the surface of the media and drain to a sump to be returned to the headworks. Sludge must discharge onto a splash plate of sufficient area to prevent erosion or displacement of the drain media. Concrete drying beds without granular media are acceptable.

f. In addition to underdrains, a method of decanting supernatant may be installed on the perimeter of the drying bed.

Table 11.11 – Design Criteria for Sludge Drying Beds

Parameter	Minimum	Maximum
Number of cells	2	
Surface loading rate		
Anaerobic digested dry solids, lb/sf-yr		20.0 *
Aerobic digested dry solids, lb/sf-yr		15.0 *
Gravel drain media		
Media depth, inches	12 *	
Layers of gravel, number	2 *	
Top layer gravel diameter, inches	1/8 *	1/4 *
Top layer gravel depth, inches	3	
Sand drain media		
Media depth, inches	12 *	
Effective grain size, millimeters	0.3 *	75 *
Sand uniformity coefficient		4.0 *
Underdrains		
Drain piping diameter, inches	4.0 *	
Drain piping slope, percent	1.0 *	
Drain piping lateral spacing, feet		20 *
Drain piping depth below drain media surface, inches	6 *	
Sub-drain soil liner		
Thickness of soil lining material, inches	12 *	
Soil lining permeability, cm/sec		10^{-6}
Source: * = Texas Wastewater Design Criteria, Subchapter J – Sludge Treatment Units, §217.250 Sludge Dewatering.		

REFERENCES

ANSI/HI, 2010-2011, American National Standards Institute – Hydraulic Institute Pump Standards, www.pumps.org.

EPA 1988; *Design Manual Constructed Wetlands and Aquatic Plant Systems for Municipal Wastewater Treatment*; US Environmental Protection Agency, Office of Research and Development, Center for Environmental Research Information, Cincinnati, OH 45268, EPA/625/1-88/022, September 1988.

EPA 1993; *Manual - Nitrogen Control*, US Environmental Protection Agency, Office of Research & Development, Center for Environmental Research Information, Cincinnati, OH 45268, EPA/625/R-93/010, September 1993.

EPA 2000; *Manual - Constructed Wetlands Treatment of Municipal Wastewaters*, US Environmental Protection Agency, Office of Research & Development, National Risk Management Research Laboratory, Cincinnati, OH 45268, EPA/625/R-99-010, September 2000.

EPA 2006; *Biosolids Technology Fact Sheet, Multi-Stage Anaerobic Digestion*; US Environmental Protection Agency, Office of Water, EPA 832-F-06-031, September 2006.

EPA 2011; *Principles of Design and Operations of Wastewater Treatment Pond Systems for Plant Operators, Engineers, and Managers*; US Environmental Protection Agency, Office of Research and Development, National Risk Management Research Laboratory – Land Remediation and Pollution Control Division, Cincinnati, OH 45268, EPA/600/R-11/088, August 2011.

IWA 2012, *Guidelines for Using Activated Sludge Models*, IWA Task Group on Good Modeling Practice, International Water Association. www.iwahq.org, ISBN 978-1-8433-9174-6, www.iwapublishing.com, 2012.

Metcalf and Eddy 1981; *Wastewater Engineering: Collection and Pumping of Wastewater*; Metcalf & Eddy, Inc. with Dr. George Tchobanoglous, McGraw-Hill: New York, 1981.

Metcalf and Eddy 2003; *Wastewater Engineering: Treatment and Reuse*; 4th ed., Tchobangolous, G., Burton, F.L., Stensel, H.D. (Eds.); McGraw-Hill: New York, 2003.

NWRI 2003; *Ultraviolet Disinfection Guidelines for Drinking Water and Water Reuse*; Published by the National Water Research Institute in collaboration with American Water Works Association Research Foundation, Second Edition, May 2003, 10500 Ellis Avenue, PO Box 20865, Fountain Valley, CA 92728, 714-378-3278, Fax 714-378-3375, www.NWRI-USA.org.

Ontario 2008; *Design Guidelines for Sewage Works 2008*; Ontario Ministry of the Environment Sewage Technical Working Group, PIBS 6879, ISBN 978-1-4249-8438-1, 2008. [http://www.ene.gov.on.ca/stdprodconsume/groups/lr/@ene/@resources/documents/resource/std01_079496.pdf]

Pumping Station Design, 2008, Editor Garr M. Jones with Robert L. Sanks, George Tchobanoglous, and Bayard E. Bosserman II, published by Butterworth-Heinemann, ISBN 978-1-85617-513-5, 2008.

Texas Chapter 217; *Design Criteria for Domestic Wastewater Systems*; Part I Texas Commission on Environmental Quality; Title 30 Environmental Quality; Texas Administrative Code; ac@tceq.state.tx.us; http://www.tceq.texas.gov/rules/index.html

WEF FD-4, *Design of Wastewater and Stormwater Pumping Stations*; Water Environment Foundation (WEF), Manual of Practice (MOP) FD-4, 1993.

WEF FD-5, *Gravity Sanitary Sewer Design and Construction*; Water Environment Foundation (WEF), Manual of Practice (MOP) FD-5, 2007.

WEF MOP 8, *Design of Municipal Wastewater Treatment Plants*, Water Environment Federation (WEF), Manual of Practice (MOP) 8, 2010.

WEF MOP 31, *An Introduction to Process Modeling for Designers*, Water Environment Federation (WEF), Manual of Practice (MOP) 31, 2009 (2013 update in press).

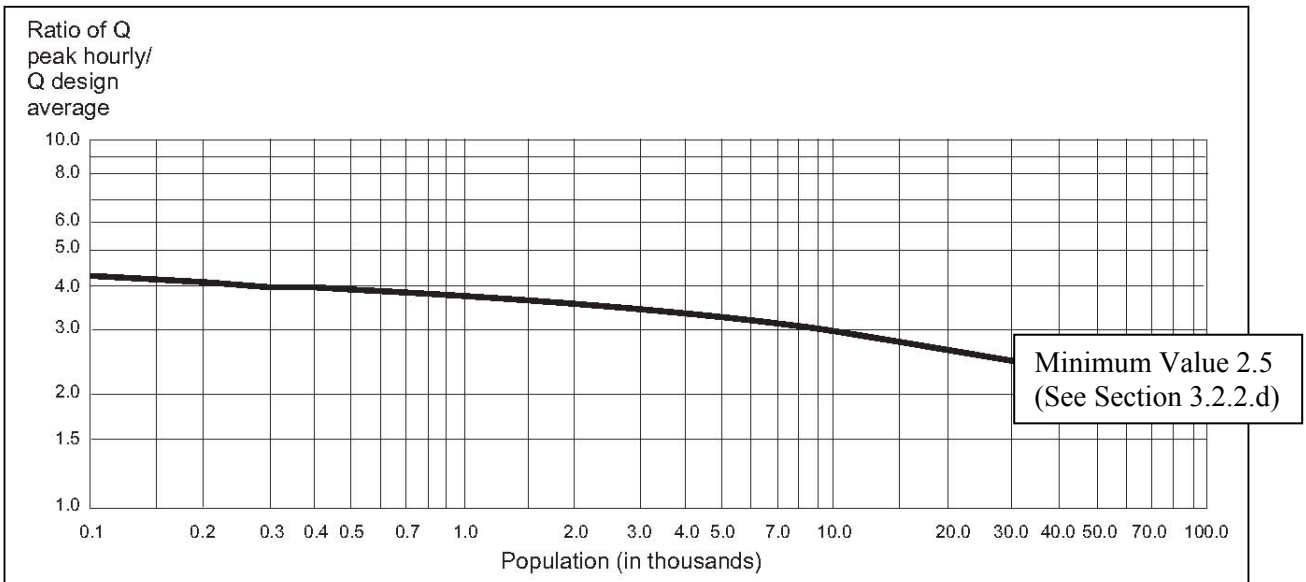
WEF MOP 34, *Nutrient Removal*, Water Environment Federation (WEF), Manual of Practice (MOP) 34, 2011.

WEF MOP 35, *Biofilm Reactors*, Water Environment Federation (WEF), Manual of Practice (MOP) 35, 2010.

APPENDIX I
FIGURES

Figure 3.1 Ratio of Peak Hourly Flow to Design Average Flow

[Source: Washington 98-37WQ, Figure C1-1 with note originally extracted from "Recommended Standards for Wastewater Facilities, 1990 Edition (10 States Standards)]



Source: Fair, G.M. and Gayer, J.C. *Water Supply and Wastewater Disposal*, First Ed., John Wiley and Sons, Inc., New York (1954), p. 136.

LEGEND

$$\frac{\text{Q peak hourly}}{\text{Q design average}} = \frac{18 + \sqrt{P}}{4 + \sqrt{P}}$$

Q peak hourly = Maximum rate of wastewater flow (peak hourly flow)
Q design average = Design average daily wastewater flow
P = Population in thousands

APPENDIX II
DESIGN REVIEW SUBMITTAL FORMS

Note: Forms may be modified occasionally. Current forms are available at the CDPHE-WQCD website under www.Colorado.gov. Due to website changes, if you need assistance finding a form, please email CDPHE.WQEngReview@state.co.us or call 303-692-6298.

- Wastewater Design Submittal Form
- PDR Checklist Form
- Capacity Evaluation Form and Examples
- Wastewater Alternative Technology Submittal Checklist
- Wastewater Alternative Technology Recognition Statement for Specific Project

Colorado Department of Public Health and Environment
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Wastewater Design Submittal Form

A. General Information				
Type of Submittal	Interceptor: Basis of Design Report	☐	Treatment Facility - Process Design Report (PDR)	☐
	Lift Station: Basis of Design Report	☐	Treatment Facility- Final Design Report	☐
System Name				
Project Title				
County				
Site Application Number				
Permit Number				
Date Fee Paid or payment attached			Invoice Number and Check Number	
B:System and Designer Information				
Design Company Name				
Design Engineer			CO License Number	
Address				
Email				
Phone			Fax	
Applicant / Entity				
Representative Name/Title				
Address				
Email				
Phone			Fax	

C. Project Information			
Location (existing or proposed site)		***Proposed Project Capacity***	
Brief location description		Maximum Month Average Hydraulic Capacity in million gallons per day (MGD)	MGD
Legal Description (e.g., Township, Range)		Peak Hour Hydraulic Capacity in million gallons per day (MGD)	MGD
County			
Latitude		Organic Capacity (lbs. BOD_5/day) – Treatment Facility Only	lbs. BOD_5/day
Longitude			

Funding Process	Will a State or Federal grant or loan be sought to finance any portion of the project (e.g., State Revolving Fund)?	No	☐	Yes	☐	If yes, please list project number	

Project Schedule and Cost Estimate	
Estimated Bid Opening Date	
Estimated Completion Date	
Estimated Project Cost	

D. Report Submittal Requirements	
DORA Compliance: Submittal prepared under the supervision and submitted with the seal and signature of a professional engineer licensed to practice engineering in the State of Colorado	☐
Report Copies: One copy of any submitted material and an electronic copy (PDF).	☐

E. Project Summary (description of proposed project scope)

Substantial Compliance Certification, Site-Specific Deviation Request Form, and Certification

I hereby certify that I was the engineer in responsible charge for (identify portions of work)

_____

_____

during the preparation of the submitted design document for the above-referenced project. I affirm that design is consistent with the approved site location approval and substantial compliance with all requirements of the most recent published version of *Colorado Design Criteria for Domestic Wastewater Treatment Works* with the exception of any declared site-specific deviation requests as outlined below. I affirm that all site-specific deviations of the most recent published version of *Colorado Design Criteria for Domestic Wastewater Treatment Works* are listed on this form. Furthermore, I affirm that based on my best professional judgment any listed site-specific deviation from the most recent published version of *Colorado Design Criteria for Domestic Wastewater Treatment Works* will not threaten public health and/or the environment.

_____ _____

Typed Name of Professional Engineer Date Signed

_____ _____

Signature of Professional Engineer License #

P.E. Stamp and Signature

Site-Specific Deviation Request Declarations

No.	**Design Criteria Requirement** (e.g., Section 4.2.1 "Wet Wells")	**Site-Specific Deviation Request** (attach additional information as needed per requirements of Part 1 of Design Criteria)	**Location in Submittal (section or page)**
1			
2			
3			
4			
5			
p7			

Please supplement the Site-Specific Deviation Request Declarations on additional sheets as necessary.

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Process Design Report (PDR) Submittal Checklist

In accordance with the *Colorado Design Criteria for Domestic Wastewater Treatment Works*, the design review process is a two step process that includes submittal of a process design report (PDR) for review and approval by the Division followed by submittal of the final design documents (plans and specifications) for review and approval by the Division. Please note that Process Design Reports are not required for interceptor sewers or lift stations.

A. Project and System Information			
System Name			
Project Title			
County			
Site Application Number			
Permit Number			
Date Fee Paid or payment attached		Invoice Number and Check Number	
Design Company Name			
Design Engineer		CO License Number	
Address			
Email			
Phone		Fax	
Applicant / Entity			
Representative Name/Title			
Address			
Email			
Phone		Fax	

B. Project Information			
Location (existing or proposed site)		***Proposed Project Capacity***	
Brief location description		Maximum Month Average Hydraulic Capacity in million gallons per day (MGD)	MGD
Legal Description (e.g., Township, Range)		Peak Hour Hydraulic Capacity in million gallons per day (MGD)	MGD
County			
Latitude		Organic Capacity (lbs. BOD_5/day) – Treatment Facility Only	lbs. BOD_5/day
Longitude			

Funding Process	Will a State or Federal grant or loan be sought to finance any portion of the project (e.g., State Revolving Fund)?	No	☐	Yes	☐	If yes, please list project number	
Streamline Review Request	Is the entity intending to pursue the streamline design review process?	No	☐	Yes	☐		

Project Schedule and Cost Estimate	
Estimated Bid Opening Date	
Estimated Completion Date	
Estimated Project Cost	

PDR Required Requirement Elements: Checklist must be filled out

Design Criteria Citation	Report Requirements	Applicant to fill out	
		Included/Addressed in Submittal? Yes/No	Location in Submittal (section or page)
1.2.2 Design Review Document Submittals			
1.2.2	**DORA Compliance:** Documents submitted for review shall be prepared under the supervision of and be submitted with the seal and signature of a professional engineer licensed to practice engineering in the State of Colorado.		
1.2.2	**Report Copies:** Two (2) hard copies of all documents (i.e., sealed and signed) and one (1) electronic copy (PDF) submitted. The design submittal must include a completed design submittal form.		
1.2.2	**General:** The report must demonstrate compliance with these criteria, or justify site-specific deviations from the criteria, and include supporting calculations, analyses, historical data, and technical assumptions.		
1.3.3 Process Design Report Elements			
1.3.3(a)	Description and purpose of the project, location and pertinent local environmental factors.		
1.3.3(b)	Description of existing plant, if applicable.		
1.3.3(c)	Description of contributing service areas.		
1.3.3(d)	Supporting calculations, analyses, historical data, and technical assumptions for each unit process.		
1.3.3(e)	PDR submittal checklist with identification of any deviations from these criteria.		
1.3.3(f)	Historical (to the extent available), present, and projected population.		
1.3.3(g)	Scaled site map showing the size and location of the proposed structures with the site topography.		
1.3.3(h)	Scaled site map showing the size and location of the proposed structures with the site topography.		
1.3.3(i)	Geotechnical report of the site, prepared by a Colorado licensed Geotechnical Engineer or Professional Geologist, if not previously provided with the site location application. The report must include soils testing results, identification of any geologic hazards, and a statement that the site will support the proposed facility.		
1.3.3(j)	Current and projected influent wastewater strength (i.e., BOD, TSS, TKN, alkalinity, pH, temperature, etc.), along with a discussion of infiltration and inflow and industrial and commercial wastes, if appropriate.		
1.3.3(k)	Flow and loading (e.g., organic, solids, nutrients) calculations (present and projected). Design flows and loads must be established for the facility as provided in Chapter 2. The design capacity (hydraulic and organic) must match the site location approval.		
1.3.3(l)	Current CDPS permit limits or preliminary effluent limits (PELs).		
1.3.3(m)	Discussion of the type of treatment process proposed, based upon the character of the wastewater to be handled, the method of disposal, and the degree of treatment required.		
1.3.3(n)	A process flow diagram and hydraulic profile. The process flow diagram must show all wastewater liquid and solids flow paths through various unit processes and include proposed sampling locations and bypasses. At a minimum, the hydraulic profile(s) must include hydraulic elevations associated with the high plant flow/high receiving water flow and low plant flow conditions.		
1.3.3(o)	Selected design flow rates for each unit process determined considering peak rates of flow and the impact on detention time and flow conduits, data from similar municipalities (e.g., new systems), wet weather flows, re-circulation and side stream flows.		
1.3.3(p)	Process and equipment design parameters for each treatment unit process referencing the applicable design criteria shall be provided in tabular form and shall consider reliability and redundancy requirements set forth in the design criteria.		
1.3.3(q)	Oxygen transfer calculations, including data used for oxygen transfer equations, blower or aerator sizing, basin volume, and air flow requirements for treatment and mixing.		

1.3.3(r)	A discussion of assumptions and appropriateness of the selected biological rate values used in the design. If modeling is used, biological process model inputs and outputs must be submitted, along with a discussion of the appropriateness of the model (i.e., calibration, validation, accuracy).		
1.3.3(s)	Where initial operating conditions will be significantly less than design capacity, PDR must document design flexibility allowing the system to operate until sufficiently loaded.		
1.3.3(t)	Flow and solids balances for appropriate unit treatment processes, including sidestreams.		
1.3.3(u)	Design basis for any odor control system including materials and equipment selection (e.g., type, capacity, loading).		
1.3.3(v)	Proposed influent and effluent flow metering and sampling locations to be used for permit compliance.		
1.3.4 OR 1.3.5 Discharge Method			
1.3.4	Outfall project requirements.		
1.3.5	Groundwater discharge project requirements.		
1.3.6 Preliminary Operating Plan			
1.3.6(a)	The expected basic operating configuration and process control procedures and associated staffing requirements for the facilities including anticipated staff needed for operation and maintenance, 24-hour notification, and Operator in Responsible Charge (ORC) certification requirements.		
1.3.6(b)	Residuals management considerations, including the expected solids generation quantities and quality, and a discussion of the method of final sludge disposal, if applicable.		
1.3.6(c)	Phased operation of existing facilities to maintain permit compliance during construction, if applicable.		
1.3.6(d)	Procedures to periodically inspect the outfall diffuser to document its integrity and continued functioning, if applicable.		
1.3.6(e)	Facility upset and/or emergency response preparedness and procedures, including telemetry, backup power supply, portable emergency pumping equipment, emergency storage/overflow protection, and operator emergency response time.		
1.3.6(f)	Safety issues for the wastewater treatment facility and individual components and equipment.		
1.3.6(g)	Facility security provisions.		

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Capacity Evaluation Form

Project and System Information	
Project Title	
System Name	
County	
Site Location Approval Number and Date	
Date of Process Design Report Submittal	
CDPS Permit No.	
Rated maximum month average hydraulic capacity in million gallons per day (MGD)	MGD
Peak hour hydraulic capacity in million gallons per day (MGD)	MGD
Rated organic capacity (lbs.BOD_5/day)	lbs BOD_5/day

Unit Processes (e.g., grit removal)	**Unit Process Description at Rated Capacity**

Unit Processes (e.g., grit removal)	**Unit Process Description at Rated Capacity**

Notes/Clarifications:

Example Capacity Evaluation Form

Unit Processes (e.g., grit removal)	**Unit Process Description at Rated Capacity**
Influent Lift Station	Number of pumps Type (e.g., screw, centrifugal) Instantaneous pumping rate Design average pumping rate Force main(s) number, material, size, length
Influent Flow Measuring	XX-inch Parshall Flume Ultrasonic sensor/recorder, Float probe with recorder XX-inch Magnetic Flowmeter
Preliminary Treatment	Number of units Type (e.g., bar, auger, fine screen) Bar screen w/ 0.XX-inch opening, mechanical or manual cleaning Velocity (average, peak flow) Fine screen – Manufacturer, Model w/ 0.XX inch opening Grit Removal System (type, size) Flow rate (average, peak) Detention Time (average) = XX hrs. @ XX MGD Detention Time (peak) = XX hrs. @ XX MGD Flow equalization – volume, mixing, aeration
Primary Treatment Facilities	Primary Sedimentation Volume = XXXX gallons Detention Time = XX.X hrs. @ XX MGD SWD = XX.X ft Surface Area = XXX sq. ft. Overflow Rate (average, peak) = XXX gpd/sq. ft. Solids Loading Rate = XXXX lb/day/sq. ft. Weir length = XX ft Weir Loading Rate = X,XXX g/Lft Number of clarifiers = X
Secondary Treatment	Flow Equalization Volume = XXXX gallons SWD = XXXX ft. Activated Sludge Process Type (e.g., extended aeration, oxidation ditch, step aeration, contact stabilization) Volume = XXXX gallons SWD = XXXX ft. Detention Time (average) = XX hrs. @ XX MGD Detention Time (peak) = XX hrs. @ XX MGD Organic Loading = XX lbs/1000 cu. ft/d. Horsepower = XXX HP (Blower w/fine bubble diffusers, etc.) Aeration Firm Capacity = XXX scfm Number basins, blowers Recycle Pumps (number, capacity) RAS pumps (number, capacity) WAS pumps (number, capacity) Secondary Sedimentation Volume = XXXX gallons Detention Time = XX hrs. @ XX MGD SWD = XX ft Surface Area = XXXX sq. ft. Overflow Rate (average, peak) = XXXX gpd/sq. ft Solids Loading Rate = XXXX lb/day/sq. ft. Weir length = XX ft

EXAMPLE

Unit Processes (e.g., grit removal)	**Unit Process Description at Rated Capacity**
	Weir Loading Rate = XXX g/Lft Number of clarifiers Chemically enhanced sedimentation (how, rates) MBR Volume = XXXX gallons SWD = XXXX ft. Detention Time (average) = XX hrs. @ XX MGD Detention Time (peak) = XX hrs. @ XX MGD Organic Loading = XX lbs/1000 cu. ft/d. Horsepower = XXX HP (Blower w/fine bubble diffusers, etc.) Aeration Firm Capacity = XXX scfm Membrane (style, area, manufacturer, model) Number of basins, blowers Recycle Pumps (number, capacity) SBR Number of basins, blowers Basin React Volume = XXXX gallons (each, total) Cycles (e.g., duration, number per day) Design average aeration time Decant Volume SWD = XXXX ft. Detention Time (average) = XX hrs. @ XX MGD Detention Time (peak) = XX hrs. @ XX MGD Organic Loading = XX lbs/1000 cu. ft/d. Horsepower = XXX HP (Blower w/fine bubble diffusers) Aeration Firm Capacity = XXX scfm WAS pumps (number, capacity) Fixed Film Type (e.g., Trickling Filter, Rotating Biological Contactor, Submerged Biological Contactor) Media type Media Surface Area = XXXX ft2 Hydraulic Loading Rate = XXXX Number units Diameter Media Depth Recirculation ratio Pump station (number, capacity each) Ponds Type (e.g., Aerated Lagoon, Facultative Lagoon, Stabilization Pond, Evaporative Lagoon) Volume = XXXX gallons SWD = XXXX ft. Detention Time (average) = XX hrs. @ XX MGD Detention Time (peak) = XX hrs. @ XX MGD Organic Loading = XX lbs/1000 cu. ft/d. Horsepower = XXX HP (Blower w/fine bubble diffusers, etc.) Aeration Firm Capacity = XXX scfm Number basins, blowers Liner type Constructed Wetlands (Free, Subsurface) Volume = XXXX gallons Detention Time (average) = XX hrs. @ XX MGD Detention Time (peak) = XX hrs. @ XX MGD Organic Loading = XX lbs/1000 cu. ft/d.

EXAMPLE

Unit Processes (e.g., grit removal)	**Unit Process Description at Rated Capacity**
Advanced Wastewater Treatment	Chemical addition (e.g., alum, polymers, alkalinity, carbon source, etc) Purpose (e.g., pH adjustment, enhanced sedimentation, phosphorus removal) Dosage rate XX:1 Chemical and concentration Selectors (Anaerobic, Anoxic) Volume = XXXX gallons SWD = XXXX ft. Detention Time (average) = XX hrs. @ XX MGD Detention Time (peak) = XX hrs. @ XX MGD Nitrification Volume = XXXX gallons SWD = XXXX ft. Detention Time (average) = XX hrs. @ XX MGD Detention Time (peak) = XX hrs. @ XX MGD TKN Loading = XX lbs/1000 cu. ft/d. Horsepower = XXX HP (Blower w/fine bubble diffusers, etc.) Aeration Firm Capacity = XXX scfm Number basins, blowers Nitrifying Fixed Film Type (e.g., Trickling Filter) Media Surface Area = XXXX ft2 Hydraulic Loading Rate = XXXX Number units Diameter Media Depth Recirculation ratio Pump station (number, capacity each) Denitrification Method Volume = XXXX gallons SWD = XXXX ft. Detention Time (average) = XX hrs. @ XX MGD Detention Time (peak) = XX hrs. @ XX MGD Nitrogen Loading = XX lbs/1000 cu. ft/d. Mixing Method and Capacity Number basins, mixers Phosphorus Removal Method Volume = XXXX gallons SWD = XXXX ft. Detention Time (average) = XX hrs. @ XX MGD Detention Time (peak) = XX hrs. @ XX MGD Loading = XX lbs/1000 cu. ft/d. Number basins, mixers Filtration Type (e.g., Single Media or Multimedia) Surface Area = XXXX sq. ft. Depth = X inches Flow rate = X.X gpm/sq. ft. Number of units Manufacturer, Model

EXAMPLE

Unit Processes (e.g., grit removal)	**Unit Process Description at Rated Capacity**
Pathogen Removal and Disinfection	Identify Primary and Backup Pathogen Removal Method Surface Area = XXXX sq. ft. Depth = X inches Flow rate = X.X gpm/sq. ft. Number of units Manufacturer, Model Chlorination w/ chlorine contact chamber Type (e.g., gas, liquid, tablet) Volume = XXXXX gallons Length/Width Ratio = XX:1 Detention Time = XX min. @ Peak Flow De-Chlorination – type, dose Ultraviolet Type (e.g., open channel, closed vessel) Manufacturer, model Configuration (e.g., number of banks, channels, etc.) Contact Time X.X seconds Minimum Design Dosage XX,XXX microwatts/cm2/sec
Effluent Flow Measuring Device and Recorder	XX-inch Parshall Flume Ultrasonic sensor/recorder, Float probe with recorder XX-inch Magnetic Flowmeter
Effluent Discharge (Outfall, Infiltration Beds)	Type (e.g., side bank, submerged, diffuser, infiltration) Size Diffuser details (e.g., number, description, capacity) Infiltration beds (e.g., pipe, chambers, number, size, capacity)
Solids (Sludge) Processing and Handling	Primary and biological solids handling Sludge Holding tank Digester Type (e.g., aerobic, anaerobic) Size Minimum solids retention time Design feed solids concentration (%) Solids loading rate Solids thickening processes (e.g., type, key variables)
Reclaim Storage	Volume = XXXX gallons Number basins Liner type
Septage Receiving	Holding tank volume Flow control provisions, mixing point
Odor Control	Type Size

EXAMPLE

Colorado Department of Public Health and Environment
Water Quality Control Division
4300 Cherry Creek Drive South, B2
Denver, Colorado 80246-1530
CDPHE.WQEngReview@state.co.us
303-692-6298

Wastewater Alternative Technology Submittal Checklist

In accordance with Section 1.8.0 of the *Colorado Design Criteria for Domestic Wastewater Treatment Works,* the request to review an alternative treatment technology not covered by the design criteria (or not previously accepted in the State) shall include the following administrative and technical documentation. Preference will be given to alternative technologies that have been thoroughly tested and installed with successful operating and compliance track records with operating conditions, effluent permit limits and sample collection requirements similar to the proposed application.

A. Alternative Technology Information			
Proposed Technology			
Basic description (e.g., grit removal)			
Technology Vendor			
Representative Name/Title			
Address			
Email			
Phone		Fax	

B. Alternative Technology Submittal Requirements		
Citation	**Design Criteria Submittal Requirements**	**Submittal Location**
Administrative Items		
1.8.0.a	Discussion of manufacturer's warranty and/or performance warranty. This discussion must include all exclusions or limitations on the warranty.	
1.8.0.b	A description of specific operator knowledge and skill that are needed to operate the proposed technology. This description must include an estimate of increased operator attention needed during startup and the first year of operation.	
1.8.0.c	Documentation of how operators will be trained to properly operate, control and maintain the facility.	
1.8.0.d	Full disclosure of any relationships between the owner, engineer, and manufacturer or vendor.	
Technical Elements		
1.8.0.e	Documentation of how the alternative technology functions. Proprietary information shall be marked as 'confidential' in the submittal and include an explanation regarding why the information is confidential. All assumptions must be clearly documented and explained. 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. For textbook references that are not widely available and common to the wastewater design field, a copy of the pertinent chapter(s) from the textbook must be included with the submittal.	
1.8.0.f	A discussion of actual, full-scale operating experience and/or pilot test work. For full-scale operating experience, the length of time that each installation has been in operation must be included. For pilot test work, a copy of the associated pilot test plan and final pilot test report must be included.	
1.8.0.g	Comparison of hydraulic capacity of other installations of the technology with the proposed application (within +/- 25% preferable).	
1.8.0.h	Comparison of organic and, if applicable, nutrient loading and loading variations of other installations of the technology with the proposed application (within +/- 25% preferable).	
1.8.0.i	Comparison of operating conditions (including temperature, altitude, daylight, darkness, etc.) of other installations of the technology with the proposed application (similar conditions preferable). Specific sensitivities of the proposed technology to any operating condition(s) must be discussed and viable means to address specifically included.	
1.8.0.j	Operating performance data of other installations for the technology for a continuous period of at least 12 months.	
1.8.0.k	Discussion of operational controls to provide flexibility for responding to varying influent characteristics and treatment conditions.	
1.8.0.l	Discussion of process control and effluent sampling and monitoring that is proposed to be performed to verify the performance of the alternative technology.	
1.8.0.m	Discussion of known and/or anticipated start-up issues and operational issues that have occurred or may occur during the first year of operation.	

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Wastewater Alternative Technology Recognition Statement for Specific Project

Owners/Districts and Design Engineers that proposed alternative treatment technology for a specific project in accordance with Section 1.8.0 of the *Colorado Design Criteria for Domestic Wastewater Treatment Works* must submit the recognition statement below.

A. Project and System Information			
System Name			
Project Title			
County			
Design Company Name			
Design Engineer		CO License Number	
Address			
Email			
Phone		Fax	
Applicant / Entity			
Representative Name/Title			
Address			
Email			
Phone		Fax	
B. Alternative Technology Information (need to submit Alternative Technology Checklist Form)			
Proposed Technology			
Technology Vendor			
Representative Name/Title			
Address			
Email			
Phone		Fax	

Owner/Facility: I hereby recognize as the representative for the above listed wastewater facility that system/facility/owner understands the proposed design includes a proposed alternative technology. I recognize that the owner/utility is responsible for repaying the full amount of any loans proposed for the alternative treatment technology and paying for additional treatment works if the proposed alternative technology does not meet permit limits.

Typed Name of Facility owner/representative

Job Title

Signature

Date Signed

Design Engineer: I hereby recognize as the design engineer that I understand the proposed design includes a proposed alternative technology which is not covered under the most recent version of the *Colorado Design Criteria for Domestic Wastewater Treatment Works*. I affirm that based on my best professional judgment, the use of the above-listed alternative technology will not threaten public health and/or the environment.

Typed Name of Professional Engineer

License #

Signature

Date Signed

P.E. Stamp and Signature

APPENDIX III
ALTERNATIVE TECHNOLOGY ACCEPTANCE LETTERS
(FUTURE)