

IOWA WASTEWATER FACILITIES DESIGN STANDARDS



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TABLE OF CONTENTS

Definitions and Abbreviations	1
Chapter 1: Project Submittals	3
1.1 General.....	3
1.2 Exemptions From a Permit.....	3
1.3 Engineering Services	4
1.4 Construction Permit Application.....	4
1.5 Engineering Reports and Facilities Plans	5
1.6 Construction Plans	10
1.7 Construction Specifications	12
1.8 Revisions to Approved Plans and Specifications (Addenda and Change Orders).....	13
1.9 Operation and Maintenance Manuals.....	13
Chapter 2: Iowa Standards for Sewer Systems	14
2.1 General.....	14
2.2 Design Period	14
2.3 Minimum Design Basis.....	14
2.4 Materials	15
2.5 Design Details.....	16
2.6 Construction Details.....	19
2.7 Testing.....	21
Appendix 2-A: Peak Ratio	23
Appendix 2-B: Kutter’s Formula.....	24
Chapter 3: Wastewater Pumping Stations and Force Mains.....	25
3.1 Applicability and Scope	25
3.2 General Requirements.....	25
3.3 Design.....	25
3.4 Pumps	26
3.5 Suction and Discharge Piping and Valves	27
3.6 Wet Wells.....	27
3.7 Ventilation.....	27
3.8 Special Details	28
3.9 Suction Lift Pumps	28
3.10 Submersible Pumps.....	29
3.11 Emergency Operation	30
3.12 Force Mains.....	30
Chapter 4: Wastewater Treatment Works.....	32
4.1 Applicability and Scope	32
4.2 Treatment Works Siting	32
4.3 Effluent Quality	32
4.4 Design.....	32
4.5 Treatment Facility Reliability Classes.....	37
4.6 Plant Outfall	40
4.7 Essential Facilities	41
4.8 Safety	42
4.9 Laboratory.....	42
Appendix 4-A: Recommended Process Piping Color Coding	44
Appendix 4-B: Laboratory Guidelines.....	45
Chapter 5: Screening and Grit Removal.....	47
5.1 Applicability and Scope	47
5.2 Screening Devices	47
5.3 Comminutors/Grinders.....	48

5.4 Grit Removal Facilities	49
Chapter 6: Settling	51
6.1 Applicability and Scope	51
6.2 General Considerations.....	51
6.3 Design Considerations	51
6.4 Sludge and Scum Removal	<u>5453</u>
6.5 Protective and Service Facilities.....	<u>5453</u>
Chapter 7: Sludge Handling and Disposal	5654
7.1 Applicability and Scope	<u>5654</u>
7.2 Design Considerations	<u>5654</u>
7.3 Sludge Thickening and Conditioning.....	<u>5654</u>
7.4 Sludge Stabilization and Holding	<u>5654</u>
7.5 Sludge Pumps and Piping	<u>6058</u>
7.6 Sludge Dewatering	<u>6159</u>
7.7 Final Disposal of Sludge	<u>6260</u>
Chapter 8A: Fixed Film Media Treatment.....	6361
8A.1 Applicability and Scope	<u>6361</u>
8A.2 Process Selection	<u>6361</u>
8A.3 Pretreatment.....	<u>6361</u>
8A.4 Industrial Wastes	<u>6361</u>
8A.5 Design Information	<u>6361</u>
8A.6 Trickling Filters	<u>6361</u>
8A.7 Rotating Biological Contractors	<u>6563</u>
Chapter 8B: Activated Sludge Biological Treatment.....	6866
8B.1 Applicability and Scope	<u>6866</u>
8B.2 Process Selection	<u>6866</u>
8B.3 Pretreatment.....	<u>6866</u>
8B.4 Aeration.....	<u>6866</u>
8B.5 Return Sludge Equipment	<u>7269</u>
Chapter 8C: Wastewater Treatment Lagoons (Ponds).....	7670
8C.1 Applicability and Scope	<u>7670</u>
8C.2 Supplement to Engineering Report.....	<u>7670</u>
8C.3 Location.....	<u>7771</u>
8C.4 Design Loadings.....	<u>7872</u>
8C.5 Controlled Discharge Lagoon Design	<u>7973</u>
8C.6 Aerated Facultative Lagoon Design.....	<u>8074</u>
8C.7 Lagoon Construction Details	<u>8478</u>
8C.8 Flow Measurement	<u>8882</u>
8C.9 Disinfection	<u>8882</u>
8C.10 Miscellaneous	<u>8983</u>
8C.11 Sludge Removal and Disposal	<u>8983</u>
Appendix 8C-A: Derivation of Reaction Formula (Aerated Facultative Lagoon).....	9084
Appendix 8C-B: Wastewater Treatment Lagoon Flow Schematics for Piping & Reliability	9185
Appendix 8C-C: Typical 2-Cell Controlled Discharge Lagoon	9286
Appendix 8C-D: Typical 3-Cell Controlled Discharge Lagoon.....	9387
Appendix 8C-E: Typical 4-Cell Controlled Discharge Lagoon	9488
Chapter 9: Supplemental Treatment Processes	9589
9.1 Applicability and Scope	<u>9589</u>
9.2 Phosphorus Removal by Chemical Treatment.....	<u>9589</u>
9.3 High Rate Effluent Filtration	<u>9690</u>
9.4 Other Supplemental Treatment Processes.....	<u>9892</u>
Chapter 10: Disinfection.....	9993

10.1	Applicability and Scope	<u>9993</u>
10.2	Process Selection	<u>9993</u>
10.3	Chlorine Feed Equipment.....	<u>9993</u>
10.4	Chlorine Supply	<u>10094</u>
10.5	Chlorine Piping and Connections	<u>10094</u>
10.6	Chlorine Housing.....	<u>10195</u>
10.7	Chlorine Respiratory Protection.....	<u>10296</u>
10.8	Chlorine Application.....	<u>10296</u>
10.9	Ozone	<u>10296</u>
10.10	Bromine.....	<u>10498</u>
10.11	Ultraviolet (UV) Radiation	<u>10498</u>
10.12	Dechlorination.....	<u>10498</u>
10.13	Evaluation of Effectiveness	<u>10498</u>
Chapter 11: Land Application of Wastewater		<u>106100</u>
11.1	Applicability and Scope	<u>106100</u>
11.2	General Site Considerations.....	<u>106100</u>
11.3	Responsibility	<u>106100</u>
11.4	Exclusions and Prohibitions	<u>106100</u>
11.5	General Land Application Site Information.....	<u>106100</u>
11.6	Site Design.....	<u>108102</u>
11.7	Wastewater Characterization and Treatment	<u>108102</u>
11.8	Land Application Rate Determination.....	<u>109103</u>
11.9	Storage Facility Design	<u>114108</u>
11.10	Monitoring Requirements.....	<u>115109</u>
11.11	Slow-Rate Land Application	<u>116110</u>
11.12	Overland Flow Land Application	<u>118112</u>
11.13	Vegetation Management	<u>118112</u>
11.14	Additional Storage Requirements.....	<u>119113</u>
11.15	Additional Application Restrictions.....	<u>119113</u>
11.16	Site Access.....	<u>119113</u>
11.17	Collection Ditches	<u>119113</u>
11.18	New Technology Disposal Option	<u>119113</u>

DEFINITIONS AND ABBREVIATIONS

The terms “shall” or “must” are used in these standards when it is required that the standard be used. Other terms such as “should” and “recommend” indicate desirable procedures or methods which should be considered but will not be required.

ADW means average dry weather (ADW flow).

Aerobic (or Oxidic) means a condition in which free oxygen is available in an aqueous environment.

Anaerobic means a condition in which neither dissolved free oxygen nor dissolved combined oxygen are available in an aqueous environment.

Anaerobic Lagoon -means a treatment process that involves retention in a lagoon under anoxic conditions.

Anoxic means a condition in which oxygen is only available in a combined form, such as nitrate (NO_3^-), nitrite (NO_2^-), or sulfate (SO_4^{2-}), in an aqueous environment.

ANSI means American National Standards Institute.

ASTM means “Annual Book of Standards, Section 11, Water and Environmental Technology”, published by ASTM International, www.astm.org.

ASCE means American Society of Civil Engineers.

AWW means average wet weather (AWW flow).

AWWA means American Water Works Association.

BOD₅ means five-day biochemical oxygen demand.

°C means degrees Celsius.

CBOD₅ means five-day carbonaceous biochemical oxygen demand.

cfm means cubic feet per minute.

CIPP means Cured in Place Pipe.

COD means chemical oxygen demand.

CWSRF means Clean Water State Revolving Fund.

Dry Weather Flow means a measure of total flows in the sanitary collection system when runoff is not occurring. It is the sum of the volume of wastewater discharges and the volume of groundwater infiltrating the collection system.

EPA means the United States Environmental Protection Agency.

°F means degrees Fahrenheit.

Final Effluent means the effluent from the final treatment unit of a wastewater treatment plant.

Flood Frequency means the percent frequency with which the maximum flood may be expected to occur at a site in any one year as determined by the department. Sometimes expressed in terms of years; for example, a 1% annual chance would be a 100-year flood (Q100); a 4% annual chance would be a 25-year flood (Q25).

fps means feet per second.

ft means feet; ft^2 means square feet, and ft^3 means cubic feet.

gpcd means gallons per capita per day (gallons/capita/day).

gpd means gallons per day.

gpm means gallons per minute.

lbs means pounds.

IAC means Iowa Administrative Code.

Innovative Technology means a technology that is developed, but it has not been proven effective and reliable in a substantial number of applications in the circumstances of its contemplated use.

Interceptor means a sewer used to transport the flows from two or more main (trunk) sewers to a central point for treatment and discharge.

IWFDS means the Iowa Wastewater Facility Design Standards.

Lateral means a sewer that discharges into a submain or other sewer and has no other common sewer tributary to it.

Main means the principal sewer to which two or more submains are tributary; also called trunk sewer.

mgd means million gallons per day.

mg/L means milligrams per liter.

mil or **mils** means one thousandth of an inch.

MLSS means mixed liquor suspended solids.

MLVSS means mixed liquor volatile suspended solids.

mm means millimeter.

$\mu W\text{-s}/cm^2$ means microwatt seconds per square centimeter

MWW means maximum wet weather (MWW flow).

MSDWW means maximum seven day wet weather (MSDWW flow).

NEC means National Electrical Code.

$NH_3\text{-N}$ means ammonia nitrogen.

NIOSH means National Institute for Occupational Safety and Health.

NEMA means National Electrical Manufacturer Association.

NOD means nitrogenous oxygen demand.

NFPA means National Fire Protection Association.

NRCS means Natural Resources Conservation Service.

O&M means operation and maintenance.

OSHA means Occupational Safety and Health Administration.

Outfall means a sewer that receives wastewater from a treatment plant and carries it to a point of final discharge.

PE means population equivalent.

PLC means programmable logic controller.

PHWW means peak hourly wet weather (PHWW flow).

Professional Engineer means a person engaged in the practice of engineering as defined in Iowa Code section 542B.2 who is issued a certificate of licensure as a professional engineer pursuant to Iowa Code section 542B.17.

psi means pounds per square inch.

Public Use Area means any of the following:

- A portion of land owned by the United States, the state, or a political subdivision with facilities which attract the public to congregate and remain in the area for significant periods of time.
- A cemetery.

PVC means polyvinyl chloride.

RBC means rotating biological contactor.

SAR means sodium adsorption ratio.

Service connection means any connection from a single property unit to an existing sanitary sewer.

Submain means a sewer into which the wastewater from two or more lateral sewers is discharged and which discharges into a main or trunk.

SUDAS means Iowa Statewide Urban Design Standard Specifications.

TDS means total dissolved solids.

Ten States Standards means the Recommended Standards for Wastewater Facilities, 2014 Edition, a report of the Great Lakes - Upper Mississippi Board of State and Provincial Public Health and Environmental Managers, available on their website at: www.health.state.mn.us/communities/environment/water/tenstates/standards.html.

TKN means total kjeldahl nitrogen.

TOC means total organic carbon

Treatment Works means any plant, disposal field, lagoon, holding or flow-regulating basin, pumping station, or other works installed for the purpose of treating, stabilizing, or disposing of sewage, industrial waste, or other wastes.

TSS means total suspended solids.

USDA means the United States Department of Agriculture.

UV means ultraviolet.

CHAPTER 1: PROJECT SUBMITTALS**1.1 GENERAL****1.1.1 Applicability and Scope**

1.1.1.1 A construction permit issued by the Iowa Department of Natural Resources (department) is required for the construction, installation, or modification of any disposal system or part thereof or any extension or addition thereto. A construction permit for minor sewer extensions may be obtained from a local public works department or rural water association when the department's permitting authority has been delegated to the local public works department or rural water association under Iowa Code section 455B.183. A construction permit may be obtained from the authorized local authority when the duties of the department have been delegated under Iowa Code section 455B.183 as they relate to the construction of semipublic sewage disposal systems.

1.1.1.2 A construction permit will not be issued until a complete application has been submitted to the department, in accordance with 567—subrule 60.2(3). Construction shall not be initiated until the department has issued a construction permit. The construction shall be completed in accordance with the approved plans and specifications. The construction permit shall expire if construction is not commenced within one year of the issuance date. The Director may grant an extension of time to commence construction when it is found necessary or justified.

1.1.1.3 Other local, state and federal agencies or authorities also have jurisdiction over proposed projects falling within the statutory authority of the department and must be contacted for the appropriate action as necessary.

1.1.2 Waiver

A request for a waiver to any design standard shall be submitted in writing pursuant to 567—Chapter 10. The contents of a petition for waiver shall include information pursuant to rule 561—10.9(17A,455A).

1.1.3 Electronic Submittals

All submittals shall be made by electronic means unless a paper copy is requested by the department or electronic submittal is infeasible for the applicant.

1.2 EXEMPTIONS FROM A PERMIT

A construction permit shall not be required for the following:

1. Storm sewers that transport only surface water runoff.
2. Any new disposal system or extension or addition to any existing disposal system that receives only domestic or sanitary sewage from a building or from housing occupied by fifteen persons or fewer.
3. Replacement of previously approved construction where the replacement is done with the same methods, materials, capacities and design considerations as the original construction.
4. Sanitary sewer service connections. However, where construction of a collection system is proposed that will serve multiple property units and use an alternative or innovative technology, rather than the public gravity sanitary sewers as described in IWFDS Chapter 2, the design for each sanitary sewer service connection will be reviewed for approval prior to department issuance of a construction permit for the sanitary sewer.
5. A pretreatment facility where a treatment unit(s) is owned and operated by a person or firm which provides partial reduction of the strength or toxicity of the waste stream prior to additional treatment and disposal by another person, firm, or municipality. However, the department may require that the design basis and construction drawings be filed for information purposes. This construction permit exception for pretreatment facilities shall not apply to earthen lagoons.
6. In-plant modifications of industrial or commercial installations, such as process changes, waste reductions, segregation and rerouting of wastes. However, the department should be informed of all such changes which result in significant process alterations or reductions in waste strength or volume.
7. Either holding tanks for the retention or storage of wastewater from a single property unit pending removal for further treatment or disposal by another person, firm, or municipality or wastewater transferred from other locations to a single property unit for temporary storage pending removal for further treatment by another person, firm, or municipality. Holding tanks shall be constructed in compliance with applicable standards for domestic septic tanks and shall be equipped with level monitoring equipment including a high level alarm.

Evidence of owner contracts or agreements with the licensed hauler and the receiving entity shall be provided to the department upon request. This construction permit exception shall not apply to earthen lagoons.

8. All wastewater facilities permitted by the department's Water Supply Engineering Section for process wastewater from a water works facility.
9. Where approved standard CIPP lining specifications from the governing agency or private engineering firm are used and on file with the department in accordance with Section 1.7.4, non-structural reconstruction of a partially deteriorated sanitary sewer (as determined by a professional engineer) using CIPP liners in accordance with ASTM F1216. This construction permit exception shall not apply to sanitary sewer reconstruction funded by a CWSRF loan.
10. Where approved standard cementitious lining specifications from the governing agency or private engineering firm are used and are on file with the department, in accordance with Section 1.7.4, reconstruction of a sanitary sewer manhole using a protective cementitious liner system in accordance with ASTM F2551. This construction permit exception shall not apply to sanitary sewer manhole reconstruction funded by a CWSRF loan.
11. Where approved standard spot sanitary sewer repair specifications from the governing agency or private engineering firm are used and are on file with the department, in accordance with Section 1.7.14, spot sanitary sewer repair by pipe replacement (generally less than 30 feet) in accordance with IWFDS Sections 2.4 (Materials), 2.5 (Details of Design) and 2.6 (Details of Construction). This construction permit exception shall not apply to spot sanitary sewer repair by pipe replacement funded by a CWSRF loan.
12. Alterations rectifying imminent public health or safety emergencies. Contact the local department field office within seven days of the start of such construction to report the incident. The department may require that "As Built" plans be submitted for information purposes. This construction permit exception shall not apply to sewer extensions.

1.3 ENGINEERING SERVICES

Engineering services to obtain a construction permit and complete the approved construction shall be performed in three stages:

1.3.1 Engineering report or facilities plan (not required for minor sewer extensions)

All engineering documents including reports, plans and specifications, addenda and change orders shall conform to Iowa Code chapter 542B and the rules of the Engineering and Land Surveying Examining Board (193C IAC). Engineering reports or facilities plans shall be submitted to the department at least 90 days prior to the date when action by the department is desired or in accordance with the Iowa Operation or NPDES Permit or other mandatory schedules.

1.3.2 Preparation of construction plans, specifications and contractual documents

The final plans and specifications should not be prepared until the engineering report has been approved by the department. After the engineering report has been approved, the final plans and specifications shall be submitted in accordance with 567—subrule 60.2(3) or in accordance with the Iowa Operation or NPDES Permit or other mandatory schedules. These plans and specifications shall be prepared in accordance with the approved engineering report or facilities plan. Any changes from the approved report must receive prior approval from the department before incorporation into the final plans and specifications.

1.3.3 Construction inspection, administration, compliance and acceptance

All engineering documents including addenda and change orders shall conform to Iowa Code chapter 542B and the rules of the Engineering and Land Surveying Examining Board (193C IAC).

1.4 CONSTRUCTION PERMIT APPLICATION

An application for a construction permit shall include all of the following:

1.4.1 Minor gravity sewer extensions

For minor gravity sewer extensions that do not include a lift station, an inverted siphon, a trunk or interceptor sewer or other major appurtenance:

- 1.4.1.1 One set of final plans and specifications and one copy of construction permit application Schedules A, B, and C.
- 1.4.1.2 Completed sewage treatment agreement form (DNR Form 542-3219), if applicable.
- 1.4.1.3 Application fee.

1.4.2 Projects other than minor sewer extensions

1.4.2.1 One copy of the engineering report or facilities plan and any supplements with one copy of construction permit application Schedules A, F, and G. A letter report with Schedule A may be accepted by the department on a case by case basis for minor improvements.

1.4.2.2 Application fee.

1.5 ENGINEERING REPORTS AND FACILITIES PLANS**1.5.1 General - Engineering Report or Facility Plan**

1.5.1.1 The engineering report or facilities plan assembles basic information; presents design criteria and assumptions; examines alternate projects with preliminary layouts and cost estimates; addresses duplication and power source reliability requirements; describes financing methods giving anticipated charges for users; reviews organizational and staffing requirements; offers a conclusion with a proposed project for applicant consideration; and outlines official actions and procedures to implement the project. The engineering report or facilities plan shall include sufficient detail to demonstrate that the proposed project will meet all applicable criteria.

1.5.1.2 The concept (including process description and sizing), factual data, and controlling assumptions and considerations for the functional planning of sewerage facilities shall be presented for each process unit and for the whole system. These data form the continuing technical basis for detailed design and preparation of construction plans and specifications.

1.5.1.3 Architectural, structural, mechanical, and electrical designs are usually excluded, but sketches may be desirable to aid in the presentation of a project. Outline specifications of process units, special equipment, may also be included.

1.5.1.4 Facilities plans for CWSRF projects shall meet the content and format requirements of 567—Chapter 90 and contain the items listed in Sections 1.5.3 and 1.5.4.

1.5.2 Submission Requirements - Engineering Report or Facility Plan

1.5.2.1 Engineering reports and facilities plans shall be submitted in accordance with Section 1.3. The criteria in this Section shall be used as a guideline for preparation of an engineering report or facilities plan. The listed items under this Section may not apply to all projects. Any listed item deemed necessary or appropriate by the department shall be included. For minor projects, a letter report that has been certified by a professional engineer may be submitted for review and approval.

1.5.2.2 The information required by IWFDS Section 8C.2 shall be submitted with the engineer's report for projects with earthen lagoons.

1.5.2.3 If necessary or appropriate, supplemental information in accordance with IWFDS Section 4.4.3 shall be included in the engineering report or facility plan.

1.5.2.4 All engineering reports or facilities plans shall be submitted in accordance with Section 1.3.

1.5.3 Minimum Information - Engineering Report or Facility Plan

Engineering reports and facilities plans shall include all of the following information:

1.5.3.1 Title of Project

1.5.3.2 Letter of Transmittal - A one page letter typed on the firm's letterhead and bound into the report or plan is preferred. The letter shall include a statement that this report or plan has been accepted by the applicant and a reference to the project as an outgrowth of an approved area-wide wastewater management plan, if appropriate. A statement regarding feasibility of the recommended project should be included.

1.5.3.3 Title Page - The title page shall include the project title; the municipality, county or other sponsoring agency; the name and address of the firm preparing the report; and a certification statement by a professional engineer, including signature, number and date in conformance with Iowa Code chapter 542B and the rules of the Engineering and Land Surveying Examining Board (193C IAC). Including the names of officials, managers and the wastewater superintendent is recommended.

1.5.3.4 Table of Contents - The table of contents shall include section headings, chapter headings, and subheadings and include lists of maps, graphs, abbreviations, illustrations, exhibits, diagrams, and appendices. Number all pages and cross reference by page number.

1.5.3.5 Engineering Report or Facility Plan Details - See Section 1.5.4.

1.5.3.6 Summary1.5.3.7 Findings - may include but are not limited to:

1. Population;
2. Land use and zoning;
3. Receiving waters;
4. Established effluent limitations and expected effluent quality;
5. Wastewater characteristics and concentrations;
6. Immediate and deferred collection system needs;
7. Selected treatment process and site description;
8. Environmental assessment of the selected process;
9. Proposed project cost;
10. Energy requirements;
11. Financing;
12. Administrative organization; and
13. Changes - discuss situations that could alter recommended projects.

1.5.3.8 Conclusion1.5.3.9 Recommendations - The recommendations shall include the appropriate step-by-step actions for the applicant to implement the conclusions. This may include, but is not limited to, the following:

1. Official acceptance report;
2. Adoption of recommended project;
3. Submission of report to appropriate agencies for review and approval;
4. Authorization of engineering services for approved projects;
5. Legal services;
6. Enabling ordinances or resolutions, as required;
7. Adoption of a sewer-use ordinance and rate structure;
8. Adoption of operating rules and regulations;
9. Financing program requirements;
10. Organization, administration and staffing requirements; and
11. Time schedules, including implementation, construction and completion dates which reflect applicable hearings, stipulations and abatement orders.

1.5.4 Details - Engineering Report or Facility Plan

As referenced in Section 1.5.1, the engineering report or facility plan details shall include all of the following:

1.5.4.1 **Purpose** - The reasons for the report or plan and the circumstances leading up to the report or plan.1.5.4.2 **Scope** - A definition of the project's extent and a discussion of the factors and limitations which were considered in determining the project scope.1.5.4.3 **Existing Conditions and Projections** - this section will include all of the following:

1. Planning Period - The planning period shall include the total period of time over which waste treatment is evaluated.
2. Land Use
 - a. Existing service area;
 - b. Expansion, annexation, and intermunicipal service;
 - c. Ultimate planning area;
 - d. Residential, commercial and industrial land use;
 - e. Zoning and population densities; and
 - f. Industrial types and concentrations.
3. Drainage Basin and Portion Covered
4. Demographic Data
 - a. Population growth, trends, and increase during design life of facility (graphs);
 - b. Employment from within and outside the service area; and
 - c. Transportation systems and effect of commuter influx.
5. Economic Data
 - a. Sources of funding and status of these sources;

- b. Recommended ordinance amendments, revisions, or cancellation and replacement;
- c. Sewer-use ordinance;
- d. Industrial wastewater surcharges;
- e. Existing contracts and agreements (including, but not limited to, intermunicipal or industrial agreements); and
- f. Enforcement provisions including, but not limited to, inspection, sampling, detection, or penalties.

1.5.4.4 Existing Facilities Evaluation - this section will include all of the following:

1. Existing Collection System
 - a. Inventory and map of existing sewers;
 - b. Isolation from water supply wells;
 - c. Adequacy to meet project needs (structural, condition and hydraulic capacity tabulation);
 - d. Flow monitoring and determination of the amounts of dry weather flow, infiltration and inflow fractions;
 - e. Overflows and required maintenance, repairs, improvements, and methods for elimination or control;
 - f. Repair, replacement, and stormwater separation requirements;
 - g. Sewer system rehabilitation priorities, if selected;
 - h. Recommended annual program to maintain the sewer system; and
 - i. Required annual expenditures.
2. Existing Treatment Plant Site
 - a. Area for expansion;
 - b. Terrain;
 - c. Subsurface conditions;
 - d. Isolation from habitation;
 - e. Isolation from water supply structures;
 - f. Enclosure of individual units, such as odor control;
 - g. Landscaping; and
 - h. Flooding (elevation of Q25, Q100 and Q500).
3. Existing Treatment Facilities
 - a. Capacities and adequacy of units (wastewater treatment, sludge processing, and sludge disposal);
 - b. Relationship and/or applicability to proposed project; consider present design standards;
 - c. Age and condition;
 - d. Adaptability to different usages;
 - e. Structures to be retained, modified, or demolished; and
 - f. Outfall line.
4. Existing Wastewater Characteristics - with all process return flows excluded.
 - a. Water consumption from records [total, residential (total and per capita), commercial, and industrial];
 - b. Wastewater flow data - ADW, AWW, maximum seven-day wet weather, MWW, and PHWW flows. Verify accuracy of installed metering equipment;
 - c. Physical, chemical, and biological characteristics, concentrations and mass loadings (pounds); and
 - d. Residential, commercial, industrial, infiltration and inflow fractions, considering different substances, including, but not limited to, organic, solids, toxic, and corrosive substances. Tabulate each fraction separately and summarize.

1.5.4.5 Proposed Facilities Evaluation - this section will include all of the following:

1. Proposed Collection System
 - a. Area of service;
 - b. Inventory and map of proposed additions and rehabilitation, including initial and projected loadings;
 - c. Isolation from water supply wells, reservoirs, or other facilities;
 - d. Unusual construction problems;
 - e. Utility interruption and traffic interference;
 - f. Restoration of surfaces, including, but not limited to, pavements and lawns; and

- g. Basement flooding prevention during power outage.
- 2. Design Wastewater Characteristics - with all process return flows excluded.
 - a. Design wastewater flows, including ADW, AWW, maximum seven day wet weather, MWW, and PHWW flows;
 - b. Design physical, chemical, and biological characteristics, concentrations, mass loadings (pounds), and design temperature; and
 - c. Design residential, commercial, industrial, infiltration and inflow fractions, considering different substances, including, but not limited to, organic, solids, toxic, and corrosive substances. Tabulate each fraction separately and summarize.
- 3. Character of wastewater - as necessary to ensure amenability to process selected.
- 4. Pretreatment evaluation - evaluation of the need for pretreatment of industrial wastewater before discharge to sewers.
 - a. Receiving stream considerations;
 - b. Downstream water uses, including, but not limited to, water supply, recreation, human health, aquatic life, agricultural, or industrial uses;
 - c. Impact of proposed discharge on receiving waters; and
 - d. Correlations of plant performance versus receiving water requirements.
- 5. Treatment Plant Site Requirements - All sites must comply with all applicable siting requirements in 567—subrule 60.2(2). Compare advantages and disadvantages relative to cost, hydraulic requirements, flood control, accessibility, enclosure of units, odor control, landscaping, and isolation with respect to potential nuisances and protection of water supply facilities. If the project lies in a flood plain, the department's Flood Plain Management and Dam Safety Section shall be contacted to determine if action related to construction in a flood plain is necessary.
- 6. Alternatives - All alternatives shall be conformed with the established effluent limitations. The effluent limitations shall be delineated. Alternatives shall consider such items as regional solutions, optimum operation of existing facilities, flow and waste reduction, location of facilities and outfalls, phased construction, necessary flexibility and reliability, enhanced nutrient control, sludge disposal, alternative treatment sites, alternative processes, and institutional arrangements. The evaluation of the alternative processes and sites shall include all of the following:
 - a. Describe and delineate each alternative (schematic diagrams);
 - b. Preliminary design for cost estimates;
 - c. Dated project cost estimates, including costs that are totaled, keyed to construction costs, indexed, and escalated;
 - d. Advantages and disadvantages of each;
 - e. Individual differences, requirements, and limitations;
 - f. Characteristics of process effluent for each;
 - g. Comparison of process performance;
 - h. Environmental assessment of each (including both primary and secondary impacts);
 - i. Operation and maintenance expenses and energy requirements; and
 - j. Annual expense requirements including tabulation of annual operation, maintenance, personnel, and debt of obligation for each alternative.
- 7. Selected Process and Site
 - a. Identify and justify the process and site selected;
 - b. Adaptability to future needs;
 - c. Environmental assessment;
 - d. Identify and justify outfall location;
 - e. Describe immediate and deferred construction; and
 - f. Describe method of providing treatment during construction.
- 8. Project Financing
 - a. Review applicable financing methods, including the effect of state and federal assistance.
 - b. Assessment by valuation, front foot, area unit, or other benefit;
 - c. Charges by connection, occupancy, readiness-to serve, water consumption, and industrial

- wastewater discharge;
 - d. Existing debt service requirements and bond retirement schedule;
 - e. Tabulate all expenses;
 - f. Show how representative properties and users are to be affected; and
 - g. Show anticipated typical annual charge to users and non-users.
- 1.5.4.6 Legal and Other Considerations**
1. Enabling legislation, ordinances, rules and regulations, including statutory requirements and limitations;
 2. Contractual considerations and intermunicipal cooperation; and
 3. Public information and education.
- 1.5.4.7 Combined Sewer Studies** - A study of the treatment and control of all combined sewer system flow is required in the engineering report or facilities planning stage, where applicable. A combined sewer is defined as a sewer designed and constructed with capacity to carry both stormwater and sanitary flow.
1. Scope of Combined Sewer Study - Prior approval of the scope must be obtained before initiation of the study. All of the following information shall be included in the scope of the combined sewer study and submitted for approval.
 - a. Description of the known or estimated extent of the combined sewers in the system;
 - b. Receiving stream characteristics and water quality criteria;
 - c. Potential health hazards;
 - d. The scope of work necessary to comply with the Combined Sewer Study Requirements; and
 - e. Cost of study.
 2. Combined Sewer Study Requirements - The study shall include a consideration of all of the following:
 - a. The controls and associated cost estimates needed to protect the beneficial use of the stream;
 - b. The alternative and associated general cost estimates for eliminating bypassing of sanitary wastes by installing a separate storm sewer system;
 - c. The alternative and associated general cost estimates for providing treatment to handle all excess flows and eliminating any bypassing. This may be accomplished by either building a stormwater retention lagoon and gradually returning the excess flow to the treatment plant during off-peak periods or providing a plant large enough to handle all flows. Either of these alternatives must provide treatment to meet the limitations of the Operation or NPDES permit. This evaluation should include duration, frequency and intensity data for rainfall;
 - d. Outline the methodology of arriving at treatment plant unit capacities and storage volumes, and describe the mode of plant operation during extended wet and dry periods and during the flow transition. Where the storage volume requirement must be minimized, a plant hydraulic capacity approaching the expected MWW flow is recommended;
 - e. The alternative and associated general cost estimates for segregating sanitary sewers from the area served by combined sewers. This alternative should include the rerouting of the present separate sewers and the prevention of any sewer extensions tributary to the existing combined sewers; and
 - f. A long range plan should be presented for segregation of combined sewers for those areas where neither elimination nor treatment are determined to be feasible.
- 1.5.4.8 Appendices: Technical Information and Design Criteria** - this section will include all of the following:
1. Collection system;
 2. Design tabulations, including flow, size, and velocities;
 3. Regulator or overflow design;
 4. Pump station calculations, including energy requirements and stand-by power;
 5. Special appurtenances;
 6. Stream crossings;
 7. System map;
 8. Process facilities;
 9. Influent hydraulic and organic loadings to wastewater and sludge processes - minimum, average, peak and effect of variability;
 10. Process selection and basis - flow equalization; preliminary (screening and grit removal), biological, and tertiary treatment processes; disinfection; and solids handling system;

11. Chemical addition and control facilities;
12. Physical control and flow metering facilities;
13. Recycle flows;
14. Unit dimensions;
15. Rates and velocities;
16. Detentions;
17. Loadings to and removal efficiencies through each unit operation; total removal efficiency and effluent quality (both concentrations and masses);
18. Energy requirements;
19. Flexibility;
20. Unit process reliability and power source reliability;
21. Process diagrams, including:
 - a. Wastewater flow diagram showing process configuration, interconnecting piping, reliability, flexibility, flow measurement, and sampling;
 - b. Solids handling flow diagram showing process configuration, interconnecting piping, reliability, flexibility, and sampling;
22. Collection system operation and maintenance;
23. Process facilities operation and maintenance;
24. Laboratory testing, personnel, space, and equipment requirements;
25. Office space for administrative personnel and records;
26. Personnel services - locker rooms and lunch rooms;
27. Support data;
28. Outline unusual specifications, construction materials, and construction methods; and
29. Maps, photographs, and diagrams.

1.6 CONSTRUCTION PLANS

1.6.1 General - Construction Plans

1.6.1.1 All construction plans for sewage works shall bear a suitable title showing the name of the municipality, sewer district, institution or other owner; and shall show a graphical scale using appropriate scaling, the north arrow, and the date and signed certification statement by a professional engineer, including signature, number and date in conformance with Iowa Code chapter 542B and the rules of the Engineering and Land Surveying Examining Board (193C IAC). A space should be provided for signature and approval stamp of the appropriate reviewing and approving officials and agencies.

1.6.1.2 The plans for the application shall comply with the legibility requirements of the Americans with Disability Act. They shall be drawn to a scale which will permit all necessary information to be plainly shown.

1.6.1.3 Detailed plans shall consist of plan views, elevations, sections, and supplementary views which, together with the specifications and general layouts, provide the working information for the contract and construction of the works. Dimensions, relative elevations of structures, location and outline form of equipment, location and size of piping, water levels, and ground elevations shall be included.

1.6.1.4 Plans for CWSRF projects shall meet the content and format requirements of 567—Chapter 90 and contain the items listed in Sections 1.6.3 to 1.6.5, as appropriate.

1.6.2 Submission Requirements - Construction Plans

All construction plans shall be submitted in accordance with Section 1.3.

1.6.3 Sewer System Plans

1.6.3.1 General Location Plans, Sewer Systems - A comprehensive plan of the existing and proposed sewers for projects involving new sewer systems and additions to or replacement of existing systems shall include all of the following:

1. Existing or proposed streets and all streams or water surfaces;
2. The boundary lines of the municipality or the sewer district and the area to be sewered; and
3. For new sewer systems, the location, size and direction of flow of all proposed sanitary sewers draining to the treatment works. For sewer extensions to existing systems, the location, size and direction of flow of all existing and proposed sewers in the adjacent area. Include an index listing the detail plan sheets.

1.6.3.2 Detail Plans, Sewer Systems - Profiles should have a horizontal scale of not more than 100 feet to the inch and a vertical scale of not more than 10 feet to the inch. Plan view should be drawn to a corresponding horizontal scale and be shown on the same sheet. Plans and profiles shall show all of the following:

1. Location of streets and sewers;
2. Line of ground surface; size of pipe; length between manholes; invert and surface elevation at each manhole; and grade of sewer between each two adjacent manholes. In addition,
 - a. All manholes shall be numbered on the profile;
 - b. Where there is any question of the sewer being sufficiently deep to serve any residence, the elevation and location of the basement floor shall be plotted on the profile of the sewer which is to serve the house in question; and
 - c. The engineer shall state that all sewers are at least two feet below adjacent basement floor elevations except where otherwise noted on the plans;
3. Locations of all special features such as inverted siphons, concrete encasements, and elevated sewers;
4. All known existing structures and utilities, both above and below ground, which might interfere with the proposed construction, particularly water mains, gas mains, storm drains, and telephone and power conduits; and
5. Special detail drawings, made to a scale to clearly show the nature of the design, that show all of the following:
 - a. All stream crossings and sewer outlets, with elevations of the stream bed and of normal and extreme high and low water levels;
 - b. Details of all special sewer joints and cross-sections; and
 - c. Details of all sewer appurtenances such as manholes, lampholes, inspection chambers, inverted siphons, regulators, and elevated sewers.

1.6.4 Wastewater Pumping Station Plans

1.6.4.1 General Location Plans, Pumping Stations - A location plan shall be submitted for projects involving construction or revision of pumping stations. This plan shall show the all of the following:

1. The location of the pumping station, force main, and downstream sewer;
2. The location and the extent of the tributary area; and
3. Any boundary lines of the municipality, sewer district or development within the tributary area.

1.6.4.2 Detail Plans, Pumping Stations - Detail plans shall be submitted showing the following, where applicable:

1. Site topography;
2. Existing pump station;
3. Proposed pumping station, including provisions for installation of future pumps or ejectors;
4. Elevation of high water at the site and maximum elevation of wastewater in the collection system upon occasion of power failure;
5. Maximum hydraulic gradient in downstream gravity sewers when all installed pumps are in operation; and
6. Soil borings and groundwater elevations.

1.6.5 Wastewater Treatment Plant Plans

1.6.5.1 General Location Plans, Wastewater Treatment Plants - A location plan shall be submitted which shows the wastewater treatment plant in relation to the remainder of the system. Sufficient topographic features shall be included to indicate its location with relation to streams and the point of discharge of treated effluent.

1.6.5.2 General Layouts, Wastewater Treatment Plants - Layouts of the proposed plant shall be submitted and include all of the following:

1. General plant layout showing the site topography, location of plant structures, location of utility systems serving the plant processes, location of soil borings, and areas for future expansion;
2. Schematic flow diagram showing the flow through various plant units;
3. Piping diagram, including any arrangements for bypassing individual units. Materials handled and direction of flow through pipes shall be shown; and
4. Minimum, average and peak hydraulic profiles showing the flow of wastewater, supernatant liquor, and

sludge.

1.6.5.3 Detail Plans, Wastewater Treatment Plants - Detailed plans shall be submitted which show all of the following:

1. Location, dimensions, and elevations of all existing and proposed plant facilities;
2. Detailed piping arrangement for wastewater and sludge streams;
3. Elevations of high and low water level of the body of water to which the plant effluent is to be discharged;
4. Adequate description of any features not otherwise covered by specifications or engineer's report;
5. Drainageways on treatment plant site and existing and proposed erosion controls; and
6. As necessary, existing and design sludge storage volumes.

1.7 CONSTRUCTION SPECIFICATIONS

1.7.1 General - Construction Specifications

1.7.1.1 Complete technical specifications for the construction of sewers, wastewater pumping stations, wastewater treatment plants, and all appurtenances shall accompany the plans.

1.7.1.2 Specifications for CWSRF projects shall meet the content and format requirements of 567—Chapter 90 and contain the items listed in Section 1.7.3.

1.7.2 Submission Requirements - Construction Specifications

Specifications shall be submitted in accordance with Section 1.3.

1.7.3 Content - Construction Specifications

1.7.3.1 Certification - The specifications shall include a certification statement by a professional engineer, including signature, number and date in conformance with Iowa Code chapter 542B and the rules of the Engineering and Land Surveying Examining Board (193C IAC).

1.7.3.2 Requirements - The specifications accompanying construction drawings shall include all construction information not shown on the drawings which is necessary to inform the builder in detail of the following:

1. Design requirements as to the quality of materials, workmanship, and fabrication of the project;
2. Type, size, strength, operating characteristics, and rating of equipment;
3. Allowable infiltration;
4. Complete requirements for all mechanical and electrical equipment, including machinery, valves, piping, and jointing of pipe; electrical apparatus, wiring, instrumentation, and meters;
5. Laboratory fixtures and equipment;
6. Operating tools;
7. Construction materials;
8. Special filter materials such as stone, sand, gravel, or slag;
9. Miscellaneous appurtenances;
10. Chemicals, when used;
11. Instructions for testing materials and equipment as necessary to meet design standards; and
12. Performance tests for the completed works and component units. It is suggested that these performance tests be conducted at design load conditions wherever practical.

1.7.3.3 Operation During Construction - Specifications shall contain a program for keeping existing treatment plant units in operation during construction of plant additions. Should it be necessary to take plant units out of operation, a shutdown schedule which will minimize negative effects from pollutants on the receiving stream shall be reviewed and approved in advance by the department and shall be adhered to.

1.7.4 Standard Specifications

1.7.4.1 Governing agencies and private engineering firms may file for approval of their standard sanitary sewer construction specifications with the department. One copy of the proposed standard specifications shall be submitted. The standard specifications shall contain:

1. A certification statement by a professional engineer, including signature, number and date in conformance with Iowa Code Chapter 542B and the rules of the Engineering and Land Surveying Examining Board (193C IAC); and
2. If the engineer preparing the specifications is not a permanent, full time employee of the agency submitting the specifications, then the governing body of the agency submitting the specifications must

also submit a resolution adopting the specifications as the official specifications of the agency.

1.7.4.2 Where standard specifications for sanitary sewer construction have been approved, the department will not require submission of specifications with the plans. When standard specifications are used, all plans must contain a statement that all construction shall be in accordance with the approved standard specifications currently on file with the department. Additional special provisions or amendments to the standard specifications for a particular project can also be utilized in conjunction with approved standard specifications. The applicant should submit one copy of the special provisions properly certified by an engineer. When a revision to an approved standard specification is required by revision of department standards or governing agency initiative, one copy of the revision, properly certified and adopted, shall be submitted.

1.7.4.3 Applicants may incorporate the SUDAS by reference without adoption by the applicant. To the extent of any conflict, the IWFDS standards shall prevail.

1.8 REVISIONS TO APPROVED PLANS AND SPECIFICATIONS (ADDENDA AND CHANGE ORDERS)

1.8.1 General - Revisions

1.8.1.1 Any deviations from approved plans or specifications affecting capacity, flow, operation of units, or point of discharge shall be approved in writing before such changes are made. Plans or specifications so revised should, therefore, be submitted well in advance of any construction work which will be affected by such changes, to allow sufficient time for review and approval. The applicant or a representative shall submit one copy of each revision. The submittal shall include any appropriate revised construction permit application schedules.

1.8.1.2 Structural revisions or other minor changes not affecting capacities, flows, or operation will be permitted during construction without approval. If requested, "As Built" plans clearly showing such alterations shall be submitted to the department.

1.8.1.3 Revisions for CWSRF projects shall meet the content and format requirements of 567—Chapter 90 and contain the appropriate items listed in Sections 1.6 and 1.7.

1.8.2 Submission - Revisions

Revisions shall be submitted in accordance with Section 1.3.

1.9 OPERATION AND MAINTENANCE MANUALS

1.9.1 O&M Manual - General

1.9.1.1 A complete operation and maintenance (O&M) manual shall be provided for each wastewater treatment facility with a design capacity larger than 15 PE prior to beginning operation of the facility.

1.9.1.2 Unless a longer period is required, the applicant or a representative shall submit a copy of the O&M manual to the appropriate local department field office, or, if appropriate, an amendment to an existing O&M manual no later than 12 months following the start of operation.

1.9.2 O&M Manual - Requirements

1.9.2.1 The manual shall be written in a manner easily understandable to the treatment plant operator and should have two distinct sections: operational section and maintenance section.

1.9.2.2 The manual should cover:

1. The Iowa Operation or NPDES permit for the facility and all reporting requirements contained therein;
2. Applicable operator education and experience qualifications; and
3. All O&M details for the wastewater treatment facility, including valve or gate settings, piping diagrams, lubrication schedules, safety, emergency operation, sludge disposal and other items of concern.

CHAPTER 2: IOWA STANDARDS FOR SEWER SYSTEMS**2.1 GENERAL****2.1.1 Applicability and Scope**

This chapter is applicable to the construction, installation, or modification of any disposal system required to obtain a construction permit from the department under Iowa Code section 455B.183 and rule 567—60.2(455B). This chapter applies to all sanitary sewers conveying raw wastewater required to obtain a construction permit. See IWFDS Section 1.2 for exceptions.

2.1.2 Electrical Equipment

Refer to IWFDS Section 3.4.7 for the requirements concerning electrical systems and components located in enclosed or partially enclosed spaces where hazardous concentrations of flammable gasses or vapors may be present.

2.1.3 Safety

It is the facility owner's responsibility to ensure that the OSHA, NFPA 70, NFPA 820, and other applicable building and construction codes and requirements are met during construction and subsequent operation. During construction this requirement may be met by including references to OSHA, NEC and other applicable building and construction codes in the contract documents.

2.1.4 Adoption by Reference Date

All standards adopted by reference in this chapter shall be those published most recently prior to the effective date of this chapter, unless otherwise the department in its sole discretion determines the use of a more recently published standard is required to adequately protect the public health or the environment.

2.2 DESIGN PERIOD

In general, sewer system design shall consider the estimated ultimate tributary population, except when considering parts of the system that can be readily increased in capacity. Similarly, consideration shall be given to the maximum anticipated capacity of developments such as institutions and industrial parks. Laterals and submains shall be designed for estimated ultimate development. The design of mains and interceptors shall take into consideration a reasonable planning period (50 years) and cost effectiveness. When the project does not provide for the ultimate capacity, a report detailing a plan for providing the ultimate capacity shall be developed.

2.3 MINIMUM DESIGN BASIS**2.3.1 Sewer Design Capacity**

Maximum hourly residential flow; additional maximum wastewater flow from non-residential municipal, commercial and industrial facilities; inflow; infiltration; and sewage pumping station capacity shall be considered in determining the required capacities of sanitary sewers.

2.3.2 Maximum Hourly Residential Flow

2.3.2.1 Determine the maximum hourly residential flow using 100 gallons/capita/day (gpcd) multiplied by the peaking factor found in Appendix 2-A. The 100 gpcd value, when used in conjunction with the peaking factor, is intended to cover normal extraneous flows for new sewers and new service connections built with modern construction techniques serving households with typical per capita wastewater flow rates. Additional extraneous flow allowances may be warranted where high groundwater levels, significant inflow sources, or higher than average per capita wastewater flow rates are anticipated to occur over the design life of the sewer.

2.3.2.2 If the sewer is to serve existing development, infiltration and inflow contributions from upstream sewers and service connections shall be evaluated and the design flow adjusted accordingly.

2.3.3 Minimum Design Equivalents2.3.3.1 Type of development:

1. Single family - 3-3.5 units/acre, 3 people/unit, or 10 people/acre
2. Multi-family (medium density) - 4.5 units/acre, 3 people/unit, or 15 people/acre
3. Multi-family (high density) - 6-12 units/acre, 2.5 people/unit, or 30 people/acre
4. Commercial - maximum hourly flow of 5,000 gpd/acre
5. Industrial - maximum hourly flow of 10,000 gpd/acre

2.3.3.2 Where the local jurisdiction has established planned population densities for the project service area, alternative residential equivalents may be approved. The minimum design equivalents for commercial and industrial development are expected peak flow rates for new sewers built with modern construction techniques where the specific types of commercial establishments or industrial facilities are unknown. Lower design values may be approved for proposed developments where specific types of establishments or industries are planned and adequate justification is provided for alternative equivalents.

2.3.4 Carrying Capacity of Pipe

Pipe sizes 15" and smaller shall carry the design flow at a depth of no more than two-thirds of the pipe diameter. Larger pipe sizes shall carry the design flow at a depth of no more than three-quarters of the pipe diameter.

2.4 MATERIALS

2.4.1 Material Selection

2.4.1.1 Pipe and joint materials shall be adapted to local conditions, including but not limited to the character of industrial wastes, possibility of septicity, soil and groundwater characteristics, exceptionally heavy external loadings, abrasion and corrosion.

2.4.1.2 All sewers shall be designed to prevent damage from superimposed live, dead, and frost induced loads. Soil conditions, bedding materials, potential groundwater levels and fluctuations, and the trench width and depth shall be considered. Where necessary, special pipe and joint materials, bedding, or installation methods shall be used to withstand potential superimposed loading, loss of trench wall stability, and soil or groundwater contamination.

2.4.1.3 Materials used shall be designed to minimize infiltration and prevent the entrance of roots throughout the life of the system.

2.4.2 Material Standards

The standards that shall be applied are listed below for the respective materials.

2.4.2.1

Rigid and Ductile Iron Pipes	Material Specifications	Joint Specifications
Clay	ASTM C700	ASTM C425
Non-reinforced Concrete	ASTM C14	ASTM C443
Reinforced Concrete	ASTM C76, ASTM C655	ASTM C443
Ductile Iron	ASTM A746, ASTM C151	ASTM A746, ASTM C111

2.4.2.2

Plastic Pipes	Material Specifications	Joint Specifications
Solid Wall PVC	ASTM D3034 (SDR \leq 35), ASTM F679	ASTM D3212
Open Profile PVC	ASTM F794	ASTM D3212
Closed Profile PVC	ASTM F1803	ASTM D3212
Corrugated PVC	ASTM F949	ASTM D3212, ASTM D2855
Polyethylene	ASTM D2239, ASTM D3035	ASTM D3261

2.4.2.3

Composite Pipes	Material Specifications	Joint Specifications
ABS and PVC Composite	ASTM D2680	ASTM D2680

2.4.2.4 Sewers Constructed of Water Main Materials - All sewers constructed of water main materials shall be rated for a minimum of 150 psi and conform to applicable requirements of 567—Chapter 43.

2.4.2.5 Other Materials - All other sewer pipe and joint materials shall conform with the appropriate ANSI, AWWA, or ASTM specifications. For new pipe or joint materials for which ANSI, AWWA, or ASTM standards

have not been established, the design engineer shall submit to the department for approval complete specifications developed on the basis of criteria adequately documented and certified in writing by the pipe manufacturer to be satisfactory for the application.

2.5 DESIGN DETAILS

2.5.1 Diameter

No public gravity sanitary sewer conveying raw wastewater shall be less than eight inches in diameter, with the following exception. For unsewered communities, six-inch diameter sewers may be used for laterals and submains, provided the six-inch sewers have sufficient hydraulic capacity.

2.5.2 Depth

Sewers should be sufficiently deep so as to receive sewage from basements and to prevent freezing. Precautions such as insulation and increased slope shall be provided for sewers that cannot be placed at a depth sufficient to prevent freezing.

2.5.3 Slope

2.5.3.1 All sewers shall be designed and constructed to give average velocities when flowing full of not less than 2.0 fps based on Kutter's Formula using an "n" value of 0.013. The following minimum slopes shall be provided.

Sewer Size	Minimum Slope (ft./100 ft.)
8"	0.400
10"	0.280
12"	0.220
15"	0.150
18"	0.120
21"	0.100
24"	0.080
27"	0.067
30"	0.058
36"	0.046
39"	0.041
42"	0.037

2.5.3.2 Sewers 48 inches or larger should be designed and constructed to give average velocities when flowing full of not less than 3.0 fps based on Kutter's Formula using an "n" value of 0.013.

2.5.3.3 Self-cleansing velocities necessary for transport of particles, initial and ultimate flow rate variations and recurrence intervals, wastewater constituents and particle sizes, anticipated maintenance requirements, and the sewer cleaning capabilities of the operating authority should all be considered in determining minimum sewer slopes. Calculated slopes associated with self-cleansing velocities should be based on a regularly recurring peak flow, which will be less than the design peak flow used to determine required pipe capacity.

2.5.3.4 Full-flow velocities of not less than 1.5 fps may be accepted for deep or continuous rock excavation, when a lift station can be eliminated or where elevations are fixed such that meeting the minimum slope requirement would require deepening extensive sections of the existing sewer system. In such instances, the design engineer shall submit to the department a present worth comparison of all available alternatives demonstrating a minimum cost ratio of 5 to 1. Estimated costs shall be based on alternatives designed to meet no more than the minimum department standards over a common design period not to exceed 50 years.

2.5.3.5 The slope shall be the maximum feasible where calculated full-flow velocities are less than 2.0 fps. Increased maintenance requirements due to lesser velocities shall be considered. Oversizing of sewers will

not be approved to justify using flatter slopes where a smaller pipe diameter can accommodate the design flow at the proposed slope based on Kutter's Formula using an "n" value of 0.013 and the requirements of Section 2.3.4.

2.5.3.6 The following exceptions to the above requirements in this section shall apply to unsewered communities only.

2.5.3.7 A minimum velocity of 2.0 fps when flowing full should be maintained in all sewer mains. However, in specific cases where savings in sewer costs are possible or a lift station could be eliminated, a minimum sewer velocity of 1.5 fps when flowing full using an "n" value of 0.013 will be permitted.

1. Minimum slopes for eight-inch sewers flowing full at 2.0 fps and 1.5 fps shall be 0.40 ft. per 100 ft. and 0.22 ft. per 100 ft.
2. Minimum slopes for six-inch sewers flowing full at 2.0 fps and 1.5 fps shall be 0.60 ft. per 100 ft. and 0.34 ft. per 100 ft.
3. In cases where a minimum sewer design velocity of less than 2.0 fps is used, the operating authority of the sewer system will be required to submit written assurance to the department that any additional sewer maintenance required by reduced slopes and velocities will be provided.

2.5.4 Horizontal Alignment

2.5.4.1 Sewers 24 inches or less shall be laid with straight alignment between manholes.

2.5.4.2 Curvilinear alignment of sewers larger than 24 inches may be considered provided ASTM or specific pipe manufacturers' maximum allowable pipe joint deflection limits are not exceeded. Curvilinear sewers shall be limited to simple curves which start and end at manholes. When curvilinear sewers are proposed, the minimum slopes required by Section 2.5.3 must be increased accordingly to provide average full flow velocities equivalent to sewers with straight alignment.

2.5.5 Changes in Pipe Size

2.5.5.1 When a smaller sewer joins a larger receiving sewer, the invert of the larger sewer should be lowered sufficiently to maintain the same energy gradient. An approximate method for securing these results is to place the 0.8 depth point of both sewers at the same elevation.

2.5.5.2 Sewer extensions shall be designed for projected flows even when the diameter of the receiving sewer is less than the diameter of the proposed extension at a manhole constructed in accordance with Section 2.5.7 with special consideration of an appropriate flow channel to minimize turbulence when there is a change in sewer size. The department may require a schedule for construction of future downstream sewer relief.

2.5.6 High Velocity and Steep Slope Protection

2.5.6.1 Where velocities greater than 15 fps are attained, special provisions shall be made to protect against displacement by erosion and impact.

2.5.6.2 Sewers on 20% slopes or greater shall be anchored securely with concrete, or equal, anchors spaced as follows:

1. Not over 36 feet center to center on grades of 20% up to 35%;
2. Not over 24 feet center to center on grades of 35% up to 50%; and
3. Not over 16 feet center to center on grades of 50% or greater.

2.5.7 Manholes

2.5.7.1 Location - Manholes shall be installed:

1. At the end of each sewer line;
2. At all changes in pipe size, grade or alignment except for curvilinear sewers constructed in accordance with Section 2.5.4;
3. At all sewer pipe intersections; and
4. At intervals not exceeding 400 feet for sewers 15 inches or less or at intervals not exceeding 500 feet for sewers 16 inches to 30 inches.

2.5.7.2 Spacing - Spacing of manholes up to 600 feet for sewers 30 inches or less or greater spacing for sewers larger than 30 inches may be approved if the operating authority submits written assurance that it has access to cleaning equipment adequate for such spacing.

2.5.7.3 Cleanouts - Cleanouts may be permitted in place of manholes at the end of lines. Terminal cleanouts shall be constructed so that flexible cleaning equipment can be passed through them. Cleanout lids should

be bolted down to prevent entry of foreign objects. If the sewer is ever extended, the cleanout must be removed and a manhole constructed at that point if the maximum distance between manholes has been reached. When the distance between a terminal cleanout and the nearest downstream manhole exceeds 150 feet, the operating authority will be required to submit written assurance that it has access to cleaning equipment adequate for such spacing.

2.5.7.4 Drop Type

1. A drop pipe should be provided for a sewer entering a manhole at an invert elevation of greater than 24 inches above the manhole invert. Where the difference in elevation between the incoming sewer invert and the manhole invert is less than or equal to 24 inches, the invert should be filleted to prevent solids deposition.
2. Outside drop connections shall be encased in concrete or other material that will prevent displacement that would result from the backfilling operation in the vicinity of the manhole. Designs incorporating outside drop connections should consider extension of the drop pipe to the ground surface with a suitable cover or other provisions that will facilitate cleaning of the drop pipe. Inside drop connections shall be secured to the interior of the manhole wall and provide adequate access for cleaning the drop.

2.5.7.5 Diameter - The minimum diameter of manholes shall be 48 inches. The minimum diameter of manhole openings shall be 24 inches. Larger diameters should be considered for manholes including an inside drop connection.

2.5.7.6 Watertightness

1. Manholes shall be precast or poured in place concrete. Manhole lift holes, grade adjustment rings, precast section joints and any additional areas potentially subject to infiltration shall be sealed watertight.
2. Inlet and outlet pipes shall be joined to the manhole with a gasketed flexible watertight connection or any watertight connection arrangement that allows differential settlement of the pipe and manhole wall to occur.

2.5.7.7 Frame and Cover Assembly

1. Manhole covers shall be non-vented; however, covers with pickholes are acceptable. Frame and cover assemblies shall be of adequate strength to withstand anticipated live loads.
2. Watertight cover assemblies shall be required wherever the manhole tops may be flooded by street runoff or high water. Bolt-down cover assemblies shall be required on manholes subject to inundation on a floodplain or displacement by sewer surcharging. Locked manhole covers should be considered in locations where unauthorized access or vandalism may be a problem.

2.5.7.8 Flow Channel

1. Flow channels through manholes should be made to conform as closely as possible in shape and slope to that of the connecting sewers. The channel walls should be formed or shaped to the full height of the crown of the outlet sewer in such a manner as to not obstruct maintenance, inspection or flow in the sewers.
2. When curved flow channels are specified in manholes, including branch inlets, the minimum slopes indicated in Section 2.5.3 should be increased to maintain acceptable velocities.

2.5.7.9 Bench - A bench shall be provided on each side of any manhole channel when the pipe diameter(s) are less than the manhole diameter. The bench should be sloped no less than ½ inch/ft. For new manholes, no lateral sewer, service connection, or drop manhole pipe shall discharge onto the bench surface.

2.5.8 Protection of Water Supplies

2.5.8.1 Cross Connections - The sewer and other conveyance SDs are specified in Table A in 567—subparagraph 43.3(7)"d," and specific narrative SDs for conveyances are provided in 567—subparagraphs 43.3(2)"a"(3) and (4). There shall be no physical connection between a public or private potable water supply system and a sewer, or appurtenance thereto, which would permit the passage of any sewage into the potable water supply.

2.5.9 Connection of Dissimilar Pipe

Suitable couplings complying with ASTM specifications shall be used for joining dissimilar materials. The leakage limitations on these joints shall be in accordance with Section 2.7.

2.5.10 Inverted Siphons

2.5.10.1 Use of inverted siphons is discouraged where initial average flows will not be sufficient to secure adequate velocities to prevent deposition of suspended solids and where other practical alternatives exist.

1. Inverted siphons shall have not less than two barrels, each with a minimum pipe size of six inches and shall be provided with necessary appurtenances for convenient flushing and maintenance.
2. The manholes shall have adequate clearance for cleaning equipment.
3. In general, sufficient head shall be provided and pipe sizes selected to secure velocities of at least 3.0 fps for design average flows.

2.5.10.2 The inlet and outlet details shall be arranged so that the normal flow is diverted to one barrel, and so that either barrel may be cut out of service for cleaning. The vertical alignment should permit cleaning and maintenance. Ventilation and odor control measures should be considered due to the headspace blockage created by a siphon unless an air jumper is used.

2.5.11 Sewer Crossing Under a Waterbody

2.5.11.1 The top of all sewers entering or crossing waterbodies shall be at a depth below the natural bottom of the bed sufficient to protect the line. One foot is required where the sewer is located in rock or cased and three feet is required in other material. In major streams, more than three feet may be required.

2.5.11.2 In paved channels, the top of the sewer line should be placed below the bottom of the channel pavement.

2.5.11.3 Sewer structures and appurtenances shall be so located that they do not interfere with the free discharge of flood flows.

2.5.11.4 Sewers located along waterbodies shall be located outside of the bed.

2.5.11.5 Sewers entering or crossing waterbodies shall be constructed of ductile iron pipe with restrained joints or shall be so otherwise constructed that they will remain water tight and free from changes in alignment or grade.

2.5.11.6 Sewer systems shall be designed to minimize the number of waterbody crossings. Stream crossings shall be designed to cross the stream as nearly perpendicular to the stream flow as possible.

2.5.11.7 Construction methods that will minimize siltation shall be employed. Material used to backfill the trench shall be stone, coarse aggregate, washed gravel, or other materials which will not cause siltation.

2.5.11.8 Upon completion of construction, the waterbody shall be returned as near as possible to its original condition. The banks shall be seeded and planted, or other methods employed to prevent erosion.

2.5.11.9 The design engineer shall include in the project specifications the method or methods to be employed in the construction of sewers in or near waterbodies to provide adequate control of siltation.

2.5.12 Aerial Crossings

2.5.12.1 Support shall be provided at all joints in pipes utilized for aerial crossings. The supports shall be designed to prevent frost heave, overturning and settlement.

2.5.12.2 Precautions against freezing, such as insulation and increased slope, shall be provided. Expansion jointing shall be provided between above-ground and below-ground sewers. Where buried sewers change to aerial sewers, special construction techniques shall be used to minimize frost heaving.

2.5.12.3 For aerial stream crossings, the impact of flood waters and debris shall be considered. The bottom of the pipe should be placed no lower than the elevation of the Q50 (50-year flood). Greater elevations may be required.

2.5.13 Storm Sewer Crossings

Adequate support shall be provided where sanitary sewers cross storm sewers. A minimum vertical clearance of six inches should be provided. Special structural support should be considered if there is less than 18 inches of clearance.

2.6 CONSTRUCTION DETAILS**2.6.1 Excavation**

2.6.1.1 Trench Bottom - Trenches shall be excavated to line and grade. Bell holes shall be the minimum size that will permit construction of satisfactory joints and ensure uniform bearing of the barrel on the trench bottom, while avoiding bearing on the bells. If the material encountered at the bottom of the trench is not

satisfactory for bedding pipe, the unsatisfactory material shall be removed and replaced by material that will give proper support and compaction.

2.6.1.2 Trench Width - Trenches shall be wide enough to allow the pipe to be laid and jointed properly and to allow the bedding and haunching to be placed and compacted to adequately support the pipe. The trench sides shall be kept as nearly vertical as possible. When wider trenches are specified, appropriate bedding class and pipe strength shall be used.

2.6.1.3 Rock Removal - Ledge rock, boulders and large stones shall be removed to provide a minimum clearance of four inches below and on each side of all pipe.

2.6.1.4 Dewatering - All water entering the excavations or other parts of the work shall be removed until all the work has been completed. No sanitary sewer shall be used for the disposal of trench water, unless specifically approved by the engineer and then only if the trench water does not ultimately arrive at existing pumping or sewage treatment facilities.

2.6.2 Bedding, Haunching and Initial Backfill

2.6.2.1 Rigid Pipe - Bedding Classes A, B, C, or crushed stone as described in ASTM C12 shall be used for all rigid pipe provided the proper strength pipe is used with the specified bedding to support anticipated loads, based on the soil type(s) encountered and potential groundwater conditions.

2.6.2.2 Ductile Iron Pipe - Embedment materials for bedding and initial backfill as described in ASTM A746 for Type 1 through Type 5 laying conditions shall be used for ductile iron pipe provided the proper strength pipe is used with the specified bedding to support anticipated loads, based on the soil type(s) encountered and potential groundwater conditions.

2.6.2.3 Plastic Pipe - Embedment materials for bedding, haunching and initial backfill, Classes I, II, or III, as described in ASTM D2321 shall be used and carefully compacted for all plastic pipe provided the proper strength pipe is used with the specified bedding to support anticipated loads, based on the soil type(s) encountered and potential groundwater conditions.

2.6.2.4 Composite Pipe - Except as described in ASTM D2680, the bedding, haunching and initial backfill requirements for composite pipe shall be the same as for plastic pipe.

2.6.3 Installation

2.6.3.1 Rigid Pipe - Installation procedures as described in ASTM C12 shall be used for all rigid pipe provided the proper strength of pipe is used.

2.6.3.2 Ductile Iron Pipe - Installation procedures as described in ASTM A746 for Type 1 through Type 5 laying conditions and applicable installation procedures as described in ANSI/AWWA C600 shall be used for ductile iron pipe provided the proper strength of pipe is used.

2.6.3.3 Plastic Pipe - Installation procedures as described in ASTM D2321 shall be used for all plastic pipe provided the proper strength pipe is used.

2.6.3.4 Composite Pipe - Installation procedures for composite pipe shall be the same as for plastic pipe except as specified in ASTM D2680.

2.6.4 Final Backfill

2.6.4.1 Final backfill shall be of suitable material removed from excavation except where other suitable material is specified. Debris, frozen materials, large clods or stones, organic matter, or other unstable materials shall not be used for backfill within two feet of the top of the pipe.

2.6.4.2 Final backfill shall be placed in such a manner as not to disturb the alignment of the pipe.

2.6.5 Alternative Installation Methods (Trenchless Technologies)

2.6.5.1 Alternative installation methods may be considered where minimal surface disturbance is desirable or where significant cost savings can be realized using trenchless construction or pipe renewal technologies. Where trenchless installation methods are proposed, grade control including maximum specified elevation tolerances shall be sufficient to meet the requirements of Section 2.5.3.

2.6.5.2 For new construction, subsurface conditions shall be adequately characterized and verified along the bore path. The proper strength pipe and joining system shall be used to withstand anticipated installation and in situ loads, based on the installation method, soil type(s) encountered, potential groundwater conditions and, for pipe renewal methods, the structural condition of the existing pipe. The possibility of prism loading on the pipe shall be considered where live loads, fluctuating groundwater levels, unconsolidated soils or other conditions may cause borehole collapse during the design life of the sewer.

2.6.5.3 For flexible pipe, the design engineer shall consider the ability of the selected pipe material and pipe wall thickness to maintain long-term ring deflections within ASTM or the pipe manufacturer's recommended design deflection limits under all anticipated loads using the pipe material 50-year modulus. All plastic pipes installed using trenchless methods shall comply with Section 2.7.1.

2.7 TESTING

2.7.1 Deflection Test

2.7.1.1 Deflection tests shall be performed on all plastic and composite pipes. The deflection test shall be conducted after the final backfill has been in place at least 30 days.

2.7.1.2 No pipe shall exceed a deflection of 5%.

2.7.1.3 If the deflection test is to be run using a rigid ball or mandrel, it shall have a diameter not less than 95% of the pipe's base inside diameter or average inside diameter, depending on which is specified in the ASTM specification (including appendices), to which the pipe is manufactured. The tests shall be performed without mechanical pulling devices.

2.7.2 Allowable Leakage

Leakage tests shall be specified and may include appropriate hydrostatic or air pressure testing. The testing methods selected should consider the range in groundwater elevations during the test and anticipated during the life of the sewer. The maximum allowable infiltration or exfiltration as determined by hydrostatic testing for any new gravity sewer section, including all manholes, is 100 gallons/inch of diameter per mile of pipe per day. Manholes may be tested separately.

2.7.3 Leakage Tests

2.7.3.1 Line Infiltration Test Using a Weir

1. The crown of the pipe shall be covered with not less than two feet of water at the highest point in the section tested. The test head shall be maintained for not less than 24 hours before a leakage measurement is made.
2. The infiltration should be measured by means of a V-notch weir located in the downstream manhole. All service connections and stubs shall be capped or plugged to prevent the entrance of groundwater into the line at these connections.

2.7.3.2 Line Exfiltration Test

1. The inlet of the upstream manhole and test section outlet shall be closed with watertight bulkheads. Then, the sewer and the upstream manhole shall be filled with water until the elevation of water in the upstream manhole is two feet higher than the top of the pipe in the line being tested, or two feet above the existing groundwater in the trench, whichever is the higher elevation.
2. Measure the exfiltration by determining the amount of water required to maintain the initial water elevation for one hour from the start of the test.
3. If the average head above the section being tested exceeds two ft, then allowable leakage can be increased by 5% for each additional foot of head.
4. This test is preferable for dry areas where groundwater head over the pipe does not exist at the time of the test.

2.7.3.3 Line Air Pressure Test - At a minimum, air testing shall conform to the test procedures described in ASTM C828 for clay pipe, ASTM C1214 for concrete pipe, and ASTM F1417 for plastic, composite, and ductile iron pipes.

2.7.3.4 Manhole Exfiltration Test

1. The manhole inlet and outlet shall be plugged and the manhole filled to at least the depth that is used in testing the line. Allow the water to stand one hour and refill to the original elevation. After a specific time, usually 15 minutes to one hour, record the difference in elevation and convert into volume lost per unit time through manhole leakage.
2. To get actual line exfiltration, subtract manhole loss from loss determined during line exfiltration test.

2.7.3.5 Manhole Air Test - Air testing shall conform to the test procedures described in ASTM C1244.

2.7.3.6 Exceptions - Replacement of existing sewers which have service connections may be exempted from the leakage testing requirements.

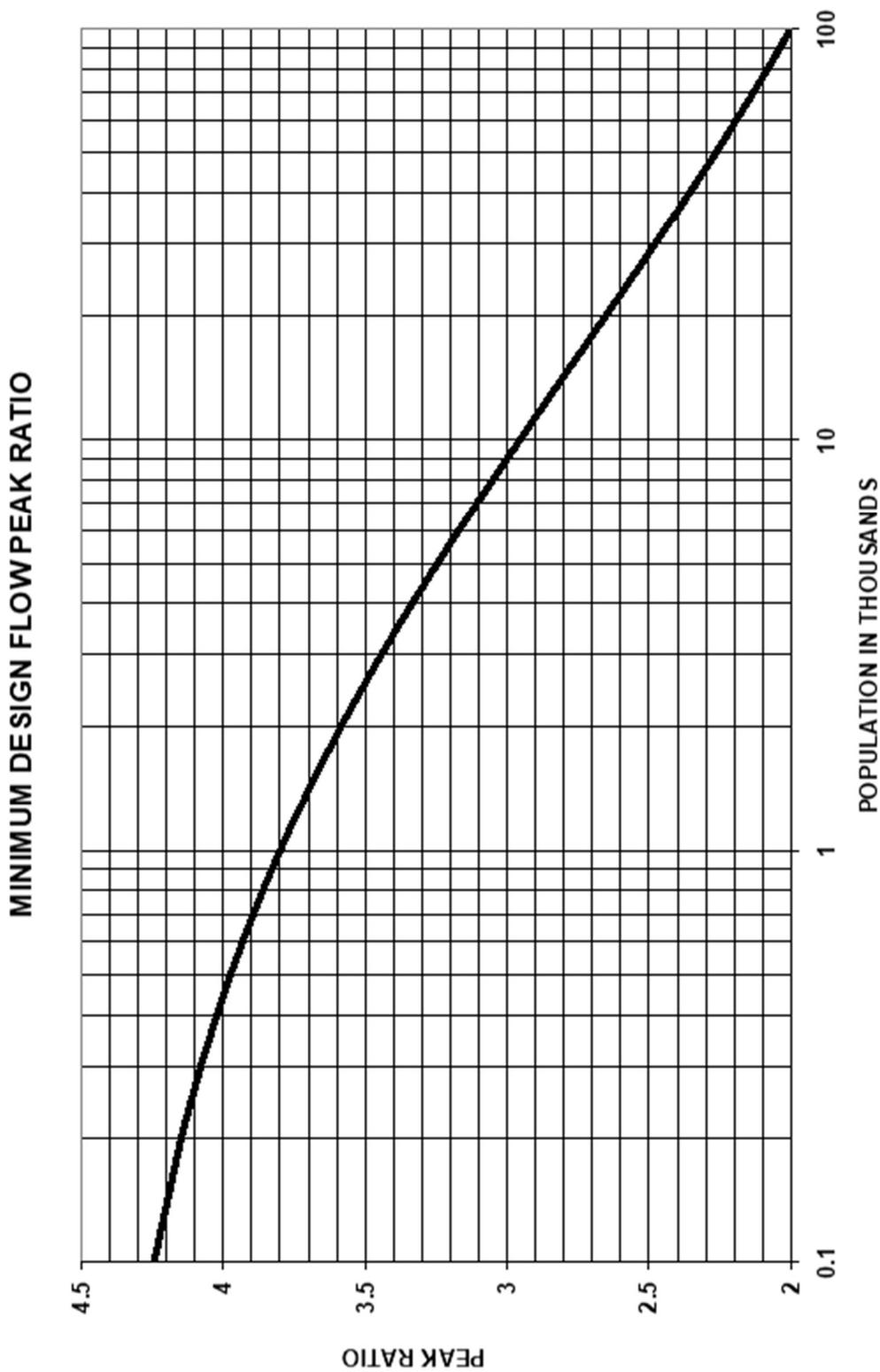
2.7.4 Alignment Test

Sewers shall be checked for alignment by either using a laser beam or lamping. The light should be visible through the section of pipe lamped. The alignment test results shall be evaluated by the design engineer.

2.7.5 Video Inspection

Video inspection of all new and rehabilitated sewers after installation is recommended.

APPENDIX 2-A: PEAK RATIO



Curve Equation: Peak Ratio = $[(18 + P^{0.15}) / (4 + P^{0.15})]$ where P = population in thousands
 Source: Fair, G.M. and Geyer, J.C. "Water Supply and Wastewater Disposal"
 1st Ed., John Wiley & Sons, Inc., New York (1954), p. 136

APPENDIX 2-B: KUTTER'S FORMULA

$$V = \left[\frac{\frac{1.811}{n} + 41.66 + \frac{0.00281}{S}}{1 + \frac{n}{\sqrt{R}} \left(41.66 + \frac{0.00281}{S} \right)} \right] \sqrt{RS}$$

V = pipe velocity, feet per second

n = coefficient of roughness

S = slope, (unitless, e.g., ft/ft)

R = hydraulic radius, feet

CHAPTER 3: WASTEWATER PUMPING STATIONS AND FORCE MAINS

3.1 APPLICABILITY AND SCOPE

This chapter is applicable to the construction, installation, or modification of any wastewater disposal system required to obtain a construction permit from the department under Iowa Code section 455B.183 and rule 567—60.2(455B). This chapter shall apply to all raw wastewater pumping stations, whether located in the collection system or at the wastewater treatment works.

3.2 GENERAL REQUIREMENTS

The design for wastewater pumping stations and force mains shall meet all applicable requirements in IWFDS Chapter 4.

3.2.1 Flood Protection

IWFDS Section 4.2.4 describes flood protection. In the absence of official records to establish the Q100 and Q25 (100-year and 25-year flood elevations), the best available local information shall be used.

3.2.2 Accessibility

Access to all wastewater pumping stations by maintenance vehicles shall be provided in accordance with IWFDS Section 4.2.54.

3.2.3 Siting

3.2.3.1 The engineering report or facilities plan required by IWFDS Chapter 1 shall address site selection. The design for pumping stations shall comply with the separation requirements in IWFDS Section 4.2.

3.2.3.2 Adjacent land use, noise control, odor control, geotechnical investigations, station architectural design, and other aesthetic items shall be taken into consideration. Sites for stations should be of sufficient size for maintenance, future expansion, or addition, if applicable.

3.2.4 Safety

It is the facility owner's responsibility to ensure that the OSHA, NFPA 70, NFPA 820, and other applicable building and construction codes and requirements are met during construction and subsequent operation. During construction, this requirement may be met by including references to OSHA, NEC, and other applicable building and construction codes in the contract documents.

3.2.5 Security and Fencing

Pumping stations shall be designed to discourage vandalism and the entrance of animals or unauthorized personnel. Fencing should be provided when appropriate. All access gates, control panels and access hatches should be lockable.

3.3 DESIGN

3.3.1 Type

This section covers wet well/dry well pumping stations.

3.3.2 Structures

3.3.2.1 Separation - Dry wells, including their superstructures, shall be separated from wet wells. Where common wall construction is proposed, all penetrations shall be water and gas tight.

3.3.2.2 Equipment Removal - Provisions shall be made to facilitate removal of pumps, motors, and other mechanical and electrical equipment.

3.3.2.3 Access - Suitable and safe means of access shall be provided to dry wells and to wet wells containing screens, bar racks, or other mechanical equipment requiring inspection or maintenance.

3.3.2.4 Construction Materials - Materials shall be selected that are appropriate under conditions of exposure to hydrogen sulfide and other corrosive gasses, as well as fats, oils, greases, and other constituents frequently present in wastewater.

3.3.2.5 Grit Protection - The wet well and pumping station piping should be designed to avoid operational problems from the accumulation of grit.

3.3.2.6 Odor Control - Design of the pumping station and force main should minimize odor potential. Where the pumping station is expected to operate at a rate less than ½ the ADW flow for longer than 12 hours at a time, handle high organic strength wastewater, or pump wastewater with excessive sulfate, the design should include measures necessary to minimize or prevent septicity due to holding times in the wet well and/or retention times in the force main.

3.4 PUMPS

3.4.1 Pumping Rate and Number of Units

3.4.1.1 A minimum of two pumps shall be installed. Pumping units shall have capacity such that with any unit out of service, the remaining unit or units will have the capacity to handle the expected PHWW flow.

3.4.1.2 All pumps should be tested by the manufacturer. These tests should include a hydrostatic test and an operating test.

3.4.1.3 Consideration shall be given to the use of variable-speed pumps, particularly when the pumping station delivers flow directly to a treatment plant, so that wastewater will be delivered at approximately the same rate as it is received at the pumping station.

3.4.2 Provisions for Screening

3.4.2.1 Trash baskets constructed of a corrosion resistant material and easily removable for cleaning should be considered for small pumping stations.

3.4.2.2 Where the size of the installation warrants, mechanically cleaned and/or duplicate bar racks should be considered. The design for screening devices, if used, shall meet the applicable provisions in IWFDS Section 5.2.

3.4.2.3 Where the removal of screenings is provided, the design shall address storage and disposal of screened material. Hoists should be provided for removing screenings containers from facilities located below ground. Where disposal of screenings at a landfill is recommended, the design shall be in accordance with 567—subrule 109.11(3).

3.4.3 Pump Openings

Unless grinder or chopper pumps are used, pumps shall be capable of passing solid spheres at least three inches in diameter. Pump suction and discharge openings shall be at least four inches in diameter. An exception to the requirement for passing solid spheres of at least three inches in diameter may be made on a case by case basis when the design includes equivalent protection from clogging.

3.4.4 Priming

Pumps should be placed so that they will operate under a positive suction head under all operating conditions (except for suction lift pumps).

3.4.5 Intakes

Each pump shall have individual intake piping. The wet well shall be designed to avoid turbulence near the intake and to minimize air entrainment resulting from proximity of the flow entering the wet well and the pump intakes. Intake piping shall be as straight and short as practical and designed to avoid air entrapment. Use of the current Hydraulic Institute Standards is recommended.

3.4.6 Reverse Rotation Protection

Consideration should be given to protect against runaway pumps on installations with high flows, high discharge heads, long force mains or combinations of these which could contribute to excessive backflows in the event of check valve failure.

3.4.7 Electrical Equipment and Controls

3.4.7.1 Electrical systems and components (including motors, lights, cables, conduits, switchboxes, and control circuits) in raw wastewater wet wells, or in enclosed or partially enclosed spaces where hazardous concentrations of flammable gasses or vapors may be present, shall comply with the NFPA 820 requirements for Class I, Division 1, Group D locations. Electrical classification may be downgraded to Class I, Division 2, Group D if the space is continuously ventilated with at least 12 fresh air changes per hour. If the pump room is above grade and physically separated from the raw wastewater wet well by a gas tight partition, it may be unclassified.

3.4.7.2 Equipment located in the wet well shall be suitable for use under corrosive conditions. Each flexible cable shall be provided with a watertight seal and separate strain relief. A fused disconnect switch located above ground shall be provided for the main power feed for all pumping stations. When such equipment is exposed to weather, it shall meet the requirements of NEMA 3R or 4, at a minimum. Lightning and surge protection systems shall be considered.

3.4.7.3 Pumping station control panels located outdoors shall be provided with a 110-volt power receptacle inside the control panel to facilitate maintenance. Ground Fault Circuit Interrupter (GFCI) protection shall be provided for all outdoor power receptacles.

3.4.7.4 Sensing devices for level controls in wet wells shall be located to minimize the effects of turbulence from entering flows or pump suction. Provisions shall be made to alternate the pumps in use.

3.4.8 Dry Well Dewatering

A separate sump pump shall be provided in the dry well to remove leakage or drainage, with the discharge equipped with dual check valves and located above the maximum liquid level in the wet well. All floor and walkway surfaces shall have an adequate slope to a point of drainage. Pump seal water shall not discharge on the floor of the pumping station. Sump pumps shall be placed to allow access for removal and maintenance.

3.5 SUCTION AND DISCHARGE PIPING AND VALVES

3.5.1 Pipe Size

Pump suction and discharge piping shall not be less than four inches in diameter, except where design of specialized equipment allows. Maximum recommended velocities are six fps in the suction line and eight fps in the discharge line. Minimum velocity shall not be less than two fps in the discharge line.

3.5.2 Valves

3.5.2.1 Suction Line - Suitable shutoff valves shall be placed on the suction line of each dry well pump.

3.5.2.2 Discharge Line

1. Suitable shutoff and check valves shall be placed on the discharge line of each pump. The check valve shall be located between the shutoff valve and the pump. Check valves shall be suitable for the material being handled and shall be placed on the horizontal portion of discharge piping. Ball checks may be placed in the vertical run where a wastewater pumping station is upgraded and no horizontal option exists. Valves shall be capable of withstanding normal pressure and water hammer.
2. All shutoff and check valves shall be operable from the floor level and accessible for maintenance. Outside levers are recommended on swing check valves.
3. Where limited pump backspin will not damage the pump and low discharge head conditions exist, short individual force mains for each pump may be considered in lieu of discharge valves.
4. Suitable provisions shall be made on installations using screw pumps to prevent backflow down the trough of a pump that is out of service.

3.6 WET WELLS

3.6.1 Wet Well Size

The wet well size and control setting shall be appropriate to avoid heat buildup in the pump motor due to frequent starting. Manufacturers should be consulted to determine allowable cycle times. Detention times for initial and ultimate flow conditions shall be evaluated. For constant speed pumps, the minimum wet well volume shall be based on the following formula:

$$V = \frac{TQ}{4}$$

V = Storage Volume (gallons)

T = Required Time between Starts (minutes)

Q = Pump Discharge Capacity (gallons/minute)

3.6.2 Floor Slope

The wet well fillets shall have a minimum slope of one to one to the hopper bottom. The horizontal area of the hopper bottom shall be kept as small as possible while providing for proper installation and function of the inlet.

3.7 VENTILATION

3.7.1 General

3.7.1.1 Adequate ventilation shall be provided for all pumping stations.

3.7.1.2 Where the dry well is below the ground surface, mechanical ventilation is required. The wet well shall be independently ventilated if screens or mechanical equipment requiring maintenance or inspection are

located in the wet well. There shall be no interconnection between the wet well and dry well ventilation systems.

3.7.1.3 Multiple inlets and outlets for ventilation are desirable for large installations.

3.7.1.4 Fine screens or other obstructions in air ducts should be avoided to prevent clogging.

3.7.1.5 Switches for operation of ventilation equipment shall be marked and conveniently located.

3.7.1.6 All intermittently operated ventilating equipment shall be interconnected with the respective wet well or dry well lighting system.

3.7.1.7 Consideration shall be given to automatic controls where intermittent operation is used.

3.7.1.8 The fan wheel shall be fabricated from non-sparking material.

3.7.1.9 Consideration should be given to installation of automatic heating and/or dehumidification equipment.

3.7.2 Wet Wells

Ventilation in wet wells may be either continuous, intermittent, or static. Continuous ventilation shall provide at least 12 complete fresh air changes per hour. Intermittent ventilation shall provide for at least 30 complete fresh air changes per hour. Fresh air changes shall be provided through mechanical force other than exhausting stale air. Submersible pump wet wells shall be provided with static vents if mechanical ventilation is not provided.

3.7.3 Dry Wells

Ventilation in dry wells may be either continuous or intermittent. Continuous ventilation shall provide at least six complete fresh air changes per hour. Intermittent ventilation shall provide for at least 30 complete fresh air changes per hour. This requirement does not apply to the upper or grade level operating room of a wet well/dry well type pumping station.

3.8 SPECIAL DETAILS

3.8.1 Flow Measurement

3.8.1.1 Pumping stations with a PHWW flow capacity more than 0.5 million gpd shall be equipped with flow metering equipment. All flow meters should be capable of recording the maximum hourly flow during any 24-hour period.

3.8.1.2 Elapsed time meters shall be installed for every combination of simultaneous pump operation.

3.8.1.3 Pumping stations with a PHWW flow less than 0.5 million gpd may use the elapsed time meters instead of a flow meter to measure total flow rate.

3.8.2 Water Supply

There shall be no physical connection between any potable water supply and a wastewater pumping station which might cause contamination of the potable water supply. If a potable water supply is brought to the station, it shall comply with IWFDS Section 4.7.1.

3.8.3 Alarm Systems

3.8.3.1 Alarm systems shall be provided for pumping stations. The alarm shall be activated in cases of power failure, pump failure, high water level, or any cause of pumping station malfunction.

3.8.3.2 Pumping station alarms shall be transmitted to a municipal facility that is manned 24 hours a day. If such a facility is not available, the alarm shall be transmitted to city offices during normal working hours and to the homes and mobile phones of the person(s) in responsible charge of the pumping station during off-duty hours.

3.8.3.3 Audio-visual alarm systems with a self-contained power supply may be acceptable in some cases in lieu of the transmitting system outlined above, depending upon location, station holding capacity, and inspection frequency.

3.8.4 Lighting

Adequate lighting shall be provided for the pumping station. Where the wet well is lighted, electrical luminaires shall be rated for the classified area in accordance with Section 3.4.7.

3.9 SUCTION LIFT PUMPS

3.9.1 General

Suction lift pumps shall be of the vacuum-priming or self-priming type. All suction lift pumps shall meet the applicable requirements in Sections 3.3 and 3.4. The maximum lift for suction lift pumps shall not exceed 15

feet. Higher lifts may be permitted if detailed calculations are submitted indicating satisfactory pump performance under the proposed operating conditions. Such detailed calculations must include static suction lift as measured from the elevation that turns the lead pump off to the centerline of pump suction, friction and other hydraulic losses of the suction piping, vapor pressure of the liquid, altitude correction, net positive suction head required (NPSHR), and a safety factor of at least six feet.

3.9.2 Equipment Compartment and Wet Well

The pump equipment compartment shall be above grade or offset and shall be effectively isolated from the wet well to prevent the humid and corrosive sewer atmosphere from entering the equipment compartment. Wet well access shall not be through the equipment compartment. Valves shall not be located in the wet well.

3.9.3 Self-Priming Pumps

3.9.3.1 Self-priming pumps shall be capable of rapid priming and re-priming at the elevation that turns the lead pump on. Such self-priming and repriming shall be accomplished automatically under design operating conditions.

3.9.3.2 Suction piping shall not exceed the size of the pump suction and shall not exceed 25 feet in total length.

3.9.3.3 Priming lift at the elevation that turns the lead pump on shall include a safety factor of at least four feet from the maximum allowable priming lift for the specific equipment at design operating conditions.

3.9.3.4 The combined total of the dynamic suction-lift at the elevation that turns the pump off and the required net positive suction head at design operating conditions shall not exceed 22 feet.

3.9.4 Vacuum-Priming Pumps

Vacuum-priming pumping stations shall be equipped with dual vacuum pumps capable of automatically and completely removing air from the suction lift pump. The vacuum pumps shall be adequately protected from damage due to wastewater. The combined total of the dynamic suction lift at the elevation that turns the pump off and the required net positive suction head at design operating conditions shall not exceed 22 feet.

3.10 SUBMERSIBLE PUMPS

Submersible pumping stations shall meet all applicable requirements under Sections 3.3 and 3.4.

3.10.1 Construction

Submersible pumps and motors shall be designed specifically for wastewater use, including totally submerged operation during a portion of each pumping cycle. An effective method to detect shaft seal failure or potential seal failure shall be provided, and the motor shall be of the type without brushes or other arc-producing mechanisms.

3.10.2 Pump Removal

Submersible pumps shall be readily removable and replaceable without dewatering the wet well or disconnecting any piping in the wet well.

3.10.3 Electrical

3.10.3.1 Power Supply and Control - Electrical supply, control and alarm circuits shall be designed to provide strain relief and to allow disconnection from outside the wet well. Terminals and connectors shall be located outside the wet well or protected from corrosion through use of watertight seals. If located outside, weatherproof equipment shall be used.

3.10.3.2 Control Center - The motor control center shall be located outside the wet well and be protected by a conduit seal or other appropriate measures meeting the requirements of the NEC to prevent the atmosphere of the wet well from gaining access to the control center. The conduit seal shall be located such that the motor may be removed and electrically disconnected without disturbing the seal.

3.10.3.3 Power Cord - Pump motor power cords shall be designed for flexibility and serviceability under conditions of extra hard usage. Ground fault interruption (GFI) protection shall be used to de-energize the circuit in the event of any failure in the electrical integrity of the cable.

3.10.3.4 Valves - Valves for submersible pumps required under Section 3.5 shall be located in a separate valve chamber. Accumulated water shall be drained to the wet well. An effective method shall be provided to prevent wastewater and gas from entering the valve chamber.

3.11 EMERGENCY OPERATION

3.11.1 General

3.11.1.1 Pumping stations and collection systems shall be designed to prevent or minimize bypassing of wastewater and sanitary sewer overflows. An emergency means of operation shall be provided for use during possible periods of extensive power outages, mandatory power reductions, or uncontrolled storm events; such as a second, independent power source connected to the station, an engine-driven generator, engine-driven standby pumps, portable pumps, or a portable generator. Portable standby units must be capable of being placed in operation at the site within 30 minutes of the onset of the emergency condition.

3.11.1.2 Where portable standby units may be used at multiple locations, the design shall evaluate for adequacy the total number and size of required portable standby units necessary to prevent backup of wastewater into basements and/or prohibited discharges during a power outage.

3.11.1.3 Engine-driven pumps shall comply with Section 3.4. Provisions for backup power sources shall comply with IWFDS Section 4.5.3.

3.11.2 In-Place Equipment

Where in-place internal combustion equipment is utilized, all of the following guidelines shall be followed.

3.11.2.1 Placement - The unit shall be bolted in place. Facilities shall be provided for unit removal for purposes of major repair or routine maintenance.

3.11.2.2 Controls - Consideration should be given to provisions for automatic and manual startup and cut-in. The transfer switch shall comply with the NEC, Article 700.

3.11.2.3 Size - Unit size shall be adequate to provide power for lighting and ventilating systems in addition to pumping requirements.

3.11.2.4 Engine Location - The unit internal combustion engine shall be located at or above grade, with suitable and adequate provisions for heat dissipation and ventilation of exhaust gasses.

3.11.2.5 Air Emissions - Provisions shall be included to comply with federal, state, and local air emission requirements.

3.11.3 Portable Equipment

Where portable equipment is used, all of the following guidelines shall be followed:

3.11.3.1 Pumping units shall have capability to operate between the wet well and the discharge side of the station and the station shall be provided with permanent fixtures that will facilitate rapid and easy connection of lines.

3.11.3.2 Electrical energy generating units shall be protected against burnout when normal utility services are restored, and shall have sufficient capacity to provide power for lighting and ventilating systems in addition to the pumping units.

3.12 FORCE MAINS

3.12.1 Size

Minimum size force mains shall be not less than four inches in diameter, except for grinder pumps or other specialized applications.

3.12.2 Velocity

The minimum self-scouring velocity shall not be less than two fps. Recommended maximum velocity is eight fps.

3.12.3 Air Relief and Vacuum Valves

An air relief valve or air vacuum valve shall be placed at high points in the force main to relieve air locking. Force main configuration and head conditions should be evaluated as to the need for placement of additional air relief and vacuum valves.

3.12.4 Termination

3.12.4.1 The force main shall enter the receiving manhole with an invert elevation that will ensure a smooth flow transition to the gravity flow section; but in no case shall the force main enter the gravity sewer system at a point more than one foot above the flow line of the receiving manhole. The design shall minimize turbulence and scouring at the point of discharge.

3.12.4.2 Consideration shall be given to the use of inert materials or protective coatings for the receiving manhole to prevent deterioration as a result of exposure to hydrogen sulfide or other chemicals where such chemicals are present or suspected to be present because of industrial discharges or long force mains.

3.12.5 Materials of Construction

3.12.5.1 Pipe and joints shall be equal to the water main strength materials described in IWFDS Section 2.4 and shall be suitable for local conditions, such as character of industrial wastes, soil characteristics, exceptionally heavy external loadings, internal erosion, corrosion, and similar problems.

3.12.5.2 Installation specifications shall contain appropriate requirements based on the criteria, standards, and requirements established by the industry in its technical publications. Requirements shall be set forth in the specifications for the pipe and methods of bedding and backfilling thereof so as not to damage the pipe or its joints, impede cleaning operations, create excessive side fill pressures, or seriously impair flow capacity.

3.12.5.3 All pipes shall be designed to prevent damage from superimposed loads. Proper allowance for loads on the pipe shall be provided due to the width and depth of trench.

3.12.6 Pressure Tests

All force mains shall be tested at a minimum pressure of at least 50% above the design operating pressure, but not less than 50 psi, for at least two hours at the low point in the line. Leakage shall not exceed the amount given by the following formula:

$$L = \frac{ND\sqrt{P}}{7,400}$$

L = allowable leakage (gallons/hour)

N = number of joints in section tested

D = pipe diameter (inches)

P = test pressure (pounds/square inch)

3.12.7 Special Construction

Force main construction near streams or used for aerial crossings shall comply with IWFDS Sections 2.5.11 and 2.5.12.

3.12.8 Protection of Water Supplies

Force main construction shall comply with IWFDS Section 2.5.8 for the protection of public and private water supplies.

3.12.9 Anchoring

Force mains shall be sufficiently anchored within the pumping station and throughout the line length. The number of bends shall be as few as possible. Thrust blocks, restrained joints, and/or tie rods shall be provided where restraint is needed.

3.12.10 Surge Protection

Consideration shall be given to the use of surge anticipation valves, surge tanks, or other suitable means to protect the force main against severe pressure changes due to the starting or stopping of large capacity pumps, particularly when such pumps are required to run against high discharge heads.

3.12.11 Design Friction Losses

3.12.11.1 Friction losses through force mains shall be based on the Hazen and Williams Formula or other acceptable method. When the Hazen and Williams Formula is used, the following values for "C" shall be used for design.

- Unlined iron or steel - 100
- All other materials - 120

3.12.11.2 When initially installed, force mains will have a significantly higher "C" factor than shown. The effect of the higher "C" factor shall be used in designing for the discharge forces at receiving or splitting structures at the discharge end of force mains, in calculating maximum power requirements, and in evaluating the initial operating conditions of the pumps.

3.12.12 Identification

Where force mains are constructed of material which might cause the force main to be confused with potable water mains, the force mains shall be appropriately identified. Generally, tracer wire is desirable, but it should not be the sole means of piping identification.

3.12.13 Cleaning

Provisions should be provided to facilitate cleaning of the force main, such as pigging or periodically operating at a resuspension velocity of three to five fps.

CHAPTER 4: WASTEWATER TREATMENT WORKS**4.1 APPLICABILITY AND SCOPE**

This chapter is applicable to the construction, installation, or modification of any disposal system required to obtain a construction permit from the department under Iowa Code section 455B.183 and rule 567—60.2(455B).

4.2 TREATMENT WORKS SITING**4.2.1 General**

The engineering report or facilities plan required by IWFDS Chapter 1 shall address site selection. All sites must comply with all applicable siting requirements of the department and other state and local agencies.

4.2.2 Site Survey

The applicant's engineer shall submit the following information for a site survey, in accordance with 567—paragraph 60.2(3)"c":

1. Engineering Report, Facilities Plan, or a cover letter which contains a brief description of the proposed treatment process and assurance that the project will conform with the long-range planning for the area.
2. Completed Schedule A - General Information
3. Completed Schedule F - Treatment Project Site Selection
4. Completed Schedule G - Treatment Project Design Data

4.2.3 Separation Distance Requirements

Separation distances are specified in 567—paragraph 60.2(2)"c."

4.2.4 Flood Protection

4.2.4.1 Protection from physical damage by the Q500 (500-year flood) plus one foot shall be considered in the evaluation of alternatives under IWFDS Subsection 1.5.2.5. At a minimum, the treatment works structures, electrical, and mechanical equipment shall be protected from physical damage by the Q100 (one-hundred-year flood plus one foot).

4.2.4.2 Treatment works should remain fully operational and accessible during the Q100 (100-year flood), if practicable. Lesser flood levels may be used dependent on local situations, but in no case shall less than a Q25 (25-year flood) be used. This applies to new construction and should be considered for existing facilities undergoing major modifications.

4.2.4.3 Wastewater treatment facilities shall not be located to conflict with encroachment limits on the floodway. The establishment of these encroachment limits is described in rule 567—75.4(455B).

4.2.4.4 It is recommended that structures be offset 100 feet or twice the width of the river or stream measured from top of bank to top of bank, whichever distance is less, unless a greater distance is required under rule 567—72.6(455B).

4.3 EFFLUENT QUALITY

The department establishes the effluent limitations for each wastewater discharger. Effluent limitations for existing wastewater dischargers are available from the department. The effluent limitations for new dischargers or significantly modified dischargers are established by the department upon request. The minimum degree of treatment shall be standard secondary treatment for municipal facilities and the industrial effluent guidelines, as defined by department rules and Federal regulations, for industrial facilities. If the minimum degree of treatment requirements would violate state water quality standards, a higher degree of treatment will be required. Prior to preparation of an engineering report or facilities plan, design engineers must obtain effluent limitations and any other self-monitoring requirements from the department. All facilities shall be designed to meet average effluent limitations in the operation permit during any 30-day period and to not exceed maximum and seven-day average effluent limitations.

4.4 DESIGN**4.4.1 General**

4.4.1.1 Type of Treatment - Careful consideration shall be given to the type of treatment selected in the engineering report or facilities plan as required by IWFDS Subsection 1.5.2.5.

4.4.1.2 Industrial Wastes - Consideration shall be given to the type and effects of industrial wastes on the treatment process. It may be necessary to pretreat industrial wastes prior to discharge to the sanitary sewer system.

4.4.1.3 Prohibited Wastes - The following wastes shall not be discharged to treatment facilities without assessment of their effects upon the treatment process or discharge requirements in accordance with state and federal law:

1. Any toxic chemicals which may inhibit biological or bacteriological processes;
2. Any strong oxidizing agents or disinfectants in quantities sufficient to inhibit the growth of microorganisms;
3. Metal plating wastes or other toxic wastes containing heavy metals and/or toxic or noxious inorganic chemicals;
4. Detergent wastes or other wastes containing excessive phosphorous or surfactants;
5. Plastics, pharmaceutical wastes and/or other synthetic organic chemicals not amenable to biological treatment;
6. Any wastes containing excessive amounts of nonbiodegradable oil and grease or tar;
7. Any acidic or alkaline wastes which because of quantity, strength or unequalized flow may upset biological processes;
8. Any wastes containing in excess of one mg/L phenols;
9. Any wastes containing radioactive chemicals;
10. Nutrient deficient wastes which cannot meet the normal ratio of 100 BOD₅: 5 Nitrogen: 1 Phosphorus that is necessary for the maintenance of the biomass;
11. Any wastes that might cause excessive physical deterioration of the equipment, piping or structures;
12. Any wastes with a closed cup flashpoint of less than 140°F; and
13. Any other waste which may be defined as an incompatible pollutant.

4.4.2 Pre-Design Meeting

For treatment works projects, it is recommended that a pre-design meeting be held with the applicant, design engineer, and the department in attendance. The purposes of this meeting include:

- Discussion of changes subsequent to engineering report or facilities plan approval;
- Deviations from design standards, if any;
- Schedule of submittal and review; and
- Facility reliability requirements determination.

4.4.3 New Process, Equipment and Application Evaluation, Project Coordination Meetings, and Project Performance Standards

4.4.3.1 Department policy is to encourage rather than obstruct the development of any new methods or equipment for treatment of wastewater. The lack of inclusion in the design standards of some types of wastewater treatment processes or equipment should not be construed as precluding their use. The department may approve applications for construction permits accommodating other types of wastewater treatment processes and equipment under the condition that the operational reliability and effectiveness of the process or device shall have been demonstrated with one or more suitably-sized prototype unit operating at its design load conditions. The specific information required by the department to demonstrate operational reliability and effectiveness will depend upon the process or device under consideration.

Engineering reports assembling technical information or presenting design criteria and assumptions shall include a certification statement by a professional engineer. Information which may be required includes:

1. Monitoring observations, including test results (calibrated data) and engineering evaluations, demonstrating the efficiency of such processes or equipment;
2. Detailed description of the test methods;
3. Testing, including appropriately composited samples, under various ranges of strength and flow rates (including diurnal variations) and waste temperatures over a sufficient length of time to demonstrate adequate performance under climatic and other conditions which may be encountered in the area of the proposed installations. A control group may be required to demonstrate effectiveness; or
4. Other appropriate information deemed necessary by the department.

The department may require that appropriate testing be conducted and evaluations be made under the supervision of a professional engineer other than the one employed by the manufacturer, patent holder, or developer.

4.4.3.2 A proposal for testing and engineering evaluation, as a minimum, should include the following:

1. Goals, objectives, and benefits with an explanation as to why a pilot study or field demonstration project is needed to obtain additional engineering data;
2. Literature search identifying key design parameters and related experience;
3. A proposal description with schematic diagrams, pictures, drawings, or any other important information
4. Environmental assessment, including both primary and secondary impacts;
5. Sampling and testing protocol;
6. Cost for testing study and closure; and
7. Complete schedule for testing and evaluation, including start, completion, and submittal of summary report.

4.4.3.3 Project Coordination Meetings - Coordination meetings are recommended and should be held with the applicant, design engineer, and the department in attendance.

4.4.3.4 Standards of Performance - Where an innovative technology is recommended, the department may require the permit holder to conduct additional monitoring and sampling following the initiation of operation, provide a contingency plan in the event that such technology fails to meet the expected performance, and/or submit a certification by a professional engineer that the project meets the project performance standards.

4.4.4 Design Period

4.4.4.1 The design period shall be clearly identified in the engineering report or facility plan.

4.4.4.2 The normal design period for municipal wastewater facilities shall be 20 years beyond the date of completion of construction.

4.4.4.3 The department may approve the use of a shorter design period on a case-by-case basis and contingent on the submission of a schedule of actions which identifies future improvements to avoid effluent quality violations caused by municipal growth.

4.4.4.4 Industrial facilities shall, as a minimum, be sized to adequately treat wastewater produced during the maximum projected production period.

4.4.5 Hydraulic Design

4.4.5.1 General

1. Flow modeling should be considered for disposal systems impacted by infiltration and inflow from ordinary storms. The hydraulic design may be adjusted to account for infiltration and inflow which is eliminated by sewer system rehabilitation.
2. The peak hourly wet weather flow shall be used to evaluate the effect of hydraulic peaks on the design of pumps, piping, clarifiers, and any other flow sensitive aspects.
3. Initial low flow conditions must be evaluated in the design to minimize operation problems with freezing, septicity, flow measurements and solids dropout.

4.4.5.2 Critical Flow Conditions, Municipal - The following five flow conditions are critical to the design of the treatment plant:

1. Average Dry Weather (ADW) flow - The daily average flow when the groundwater is at or near normal and runoff is not occurring. The period of measurement for this flow should extend for as long as favorable conditions exist up to 30 days, if possible.
2. Average Wet Weather (AWW) flow - The daily average flow for the wettest 30 consecutive days for mechanical plants or for the wettest 180 consecutive days for controlled discharge lagoons.
3. Maximum Seven Day Wet Weather (MSDWW) flow - The daily average flow for the wettest seven consecutive days.
4. Maximum Wet Weather (MWW) flow - the total maximum flow received during any 24-hour period when the groundwater is high and runoff is occurring.
5. Peak Hourly Wet Weather (PHWW) flow - the total maximum flow received during one hour when the groundwater is high, runoff is occurring, and the domestic, commercial and industrial flows are at their peak. The domestic/commercial peak hour flow shall be based on actual monitoring information or the

use of a peaking factor as determined by IWFDS Appendix 2-A. The runoff flow component shall be adjusted to the storm event of two inches of rainfall in one hour.

4.4.5.3 Existing Systems, Municipal - Where there is an existing system, the volume and strength of existing flows shall be determined. The flow determination shall include, but not be limited to, all five flow conditions listed in Subsection 4.4.5.2. The strength determination shall include both dry weather and wet weather conditions. Composite 24-hour samples proportional to flow shall be taken to be accurately representative of the strength of the wastewater. The flow conditions of the system should be determined using hydrographs prepared with at least three years of flow data. Eight to ten years of flow data is recommended. The increment of design flow for projected population growth shall be based upon the same criteria listed below for new systems.

4.4.5.4 New Systems, Municipal - The design for wastewater treatment plants to serve new collection systems shall be based on an AWW flow of 100 gpcd for residential and commercial flow, plus 20 gpcd for out-of-town students, plus industrial flow, plus any large commercial operation. Exceptions may be made on a case-by-case basis where there is an existing water supply with adequate available water use data. If adequate water use data from a water supply does not exist, exceptions may also be made where there is data from similar existing wastewater systems that can be utilized for new collection systems. However, in such cases, thorough investigation and adequate documentation shall be provided to establish the reliability and applicability of such data.

4.4.5.5 Critical Flow Conditions, Industrial

1. Flow and loads from industrial sources may vary significantly during a day, a week or a month due to production patterns. In designing a facility, the flow rate which occurs during the time period of discharge shall be considered. This flow rate is defined as the rated flow.
2. The following flow conditions shall be considered in the design of a treatment facility:
 - a. Average Rated Flow (30-Day) - The average rated flow which is expected to occur during production days in a 30 consecutive day period;
 - b. Maximum Day Rated Flow - The maximum rated flow expected to occur during a single 24-hour period; and
 - c. Peak Hour Flow - The maximum flow which is expected to occur during a one-hour period.
3. Other flows shall be considered when they are critical to the sizing and operation of a treatment process. When determining the critical flow conditions, all of the following components shall be considered:
 - a. Production Flows - for existing facilities, a minimum of one year of flow data shall be used for determining critical flows. This data shall be correlated with production data. For new facilities, the design flows shall be based on similar operating facilities, proposed operation mode, federal development documents for effluent limitations, and new source performance data;
 - b. Sanitary Flows - A minimum of 10 gallons/worker/shift/day shall be utilized. Higher values with suitable documentation shall be used if shower and/or cafeteria facilities are present; and
 - c. Contaminated Storm Runoff - If direct treatment of contaminated stormwater runoff is to be included, critical flows shall be estimated using a rational method.
4. A treatment plant must be designed to meet the effluent limitations discussed in Section 4.3.

4.4.5.6 Flow and Load Equalization

1. Measures creating uniform organic loadings to biological processes tend to reduce the probability of upsets.
2. Facilities for the equalization of flows and organic shock load shall be considered when the ratio of PHWW flow to MSDWW flow is 2.5 or more. If flow equalization is not employed under these circumstances, an explanation must be included, outlining how the plant will handle transitions from MSDWW flow to PHWW flow.
3. Where flow equalization is employed, the excess flow retained by the holding basin shall be returned to the treatment plant in a timely manner during off-peak periods. The hydraulic capacity of the plant should be in the range of the MSDWW flow to the MWW flow. Individual circumstances may dictate higher capacities. In no case shall the hydraulic capacity of the treatment plant be less than the AWW-30

flow. As necessary, any organic under loadings that may occur when excess flows are returned to the plant must be carefully addressed.

4. The maximum cumulative storage volume for flow equalization should be based on incoming sewers designed for unrestricted flow.
5. Where the ratio of PHWW flow to MSDWW is 2.5 or more, the maximum cumulative storage volume that must be provided for flow equalization at municipal facilities will typically be in the range of two to three days based upon the AWW-30 flow.

4.4.6 Organic Design

4.4.6.1 Domestic Loadings

1. When an existing treatment works is to be upgraded or expanded, the organic design loadings shall be based upon the actual strength of the wastewater as determined from the measurements taken in accordance with Subsection 4.4.5.3, with an increment for growth. This growth increment shall be based on the design criteria for new systems stated in paragraph 2. below. A loading rate of 0.17 pounds BOD₅/capita/day and 0.036 pounds TKN/capita/day may be used in lieu of actual loading rates whenever the loading rates are less than 0.17 pounds BOD₅/capita/day and 0.036 pounds TKN/capita/day, respectively.
2. Domestic waste treatment design to serve new collection systems shall be based on at least 0.17 pounds of BOD₅/capita/day, 0.036 pounds TKN/capita/day, and 0.20 pounds of suspended solids/capita/day, plus 0.05 pounds of BOD₅/capita/day, 0.01 pounds of TKN/capita/day, and 0.05 pounds of suspended solids per out-of-town student per day.
3. When garbage grinders are used in areas tributary to a domestic treatment plant, the design basis should be increased to 0.22 pounds of BOD₅/capita/day, 0.06 pounds TKN/capita/day, and 0.25 pounds of suspended solids/capita/day.
4. Domestic waste treatment plants that will receive industrial wastewater flows shall be designed with additional capacity for these industrial waste loads.

4.4.6.2 Industrial Loadings

1. The design loadings of industrial wastewater treatment works shall be based on actual sampling in accordance with Subsection 4.4.5.4, data from similar industrial facilities, or federal development documents for effluent limitation guidelines and new source performance requirements.
2. The treatment facility must be designed to meet the effluent limitations discussed in Section 4.3. In addition, diurnal peaks of organic loads shall be addressed if such peaks adversely affect a unit process.

4.4.6.3 Septage Loadings - The waste loadings from other sources shall include, but not be limited to, the amount and rate of septage, if any, that will be accepted by the wastewater treatment plant above collection system loadings.

4.4.7 Conduits

All piping and channels shall be designed to carry the maximum expected flows into these conduits or channels without flooding. Bottom corners of the channels, except final effluent channels, must be filleted. Conduits shall be designed to avoid creation of pockets and corners where solids can accumulate. The use of shear gates, stop plates or stop planks is permitted where they can be used in place of gate valves or sluice gates. Corrosion resistant materials shall be used for valves, plates and gates. Pipes subject to clogging shall be provided with means for mechanical cleaning and flushing.

4.4.8 Design Details

4.4.8.1 Unit Bypass During Construction - Final plan and specification documents shall identify or require a construction sequence for uninterrupted operation of the existing plant during construction so as to minimize temporary water quality degradation.

4.4.8.2 Drains - A means shall be provided to dewater each unit in the process. This shall be accomplished by means of gravity drains or pumping. The drainage must receive a degree of treatment which will allow for discharge in compliance with the facilities' permit limitation.

4.4.8.3 Buoyancy - Suitable methods shall be included in the design to prevent flotation of structures in areas subject to high groundwater.

4.4.8.4 Pipe Identification - In order to facilitate identification of piping, it is required that process piping be clearly identified by labeling or color coding. Appendix 4-A presents a recommended color scheme for purposes of standardization.

4.4.8.5 Operating Equipment - A complete outfit of tools, accessories, and spare parts necessary for the plant operator's use should be provided. Readily-accessible storage space and workbench facilities should be provided in non-lagoon facilities.

4.4.8.6 Erosion Control During Construction - Effective site erosion and sediment control shall be provided during construction. All temporary erosion and sediment control measures shall be removed or replaced with permanent measures after construction.

4.4.8.7 Grading and Landscaping - Upon completion of plant construction, the ground shall be graded and seeded or sodded. Surface water shall not be permitted to drain into any unit.

4.4.8.8 Sludge Disposal During Construction - Sludge removal may be required when upgrading an existing disposal system. The approved sludge processing, storage and disposal plan may be implemented by inclusion in the final plan and specification documents to be bid for the project. Transferring sludge from an existing lagoon cell into any new lagoon cell for disposal is prohibited.

4.4.9 Plant Operability

4.4.9.1 Unit Operation Bypassing

1. Bypassing shall be provided around each unit operation, except as follows. Unit operations with two or more units and involving open basins shall not be required to have provisions for bypassing if the peak wastewater flow can be handled hydraulically with the largest unit out of service. The comminution facility shall be provided with means for gravity bypassing regardless of the number and flow capacity of the comminutors.
2. The actuation of all bypasses shall require manual action by operating personnel. All power actuated bypasses shall be designed to permit manual operation in the event of power failure and shall be designed so that the valve will fail as is, upon failure of the power operator.
3. A fixed high-water level bypass overflow should be provided in addition to a manually or power actuated bypass to prevent flooding in case the operator bypass fails to function or is unattended at times.

4.4.9.2 Flexibility - Where duplicate units are provided, a central collection and distribution point including proportional flow splitting shall be provided for the wastewater flows before each unit operation. Exceptions to this requirement may be made, on a case-by-case basis, when the design incorporates more than one unit process in the same physical structure.

4.4.9.3 Flow Division Control - Flow division control facilities shall be provided as necessary to ensure positive, adjustable control of organic and hydraulic loading to the individual process units and shall be designed for easy operator access, change, observation, and maintenance. Where duplicate units are provided, a flow division control facility shall be designed to properly proportion flow to each unit operation so that proportioned flows are measurable.

4.5 TREATMENT FACILITY RELIABILITY CLASSES

4.5.1 Facility Reliability Classes

The department shall establish reliability classes for all new facilities and facilities undergoing major modification in accordance with one of the following classes listed in this Section. Designated uses are described in 567—Chapter 61, Water Quality Standards.

4.5.1.1 Facility Reliability Class I - Includes all facilities which discharge into waters that could be permanently or unacceptably damaged by a reduction in effluent quality for a few hours. This includes those facilities discharging into Outstanding Iowa Waters or into waters designated as: Class A1 - primary contact recreational use; Class A3 - children's recreational use; Type 1 Class B(CW1) - cold water aquatic life; Type 2 Class B(CW2) - cold water aquatic life; Type 1 Class B(WW-1) - warm water; Class HH - human health; or Class C - drinking water supply.

4.5.1.2 Facility Reliability Class II - Includes all facilities which are not included in Reliability Class I where a reduction in effluent quality for several days would cause a violation of the water quality standards in the

receiving waterbody. This includes waters designated as: Class A2 - secondary contact recreational use; Type 2 Class B(WW-2) - warm water; Type 3 Class B(WW-3) - warm water; or Class B(LW) - lakes and wetlands.

4.5.1.3 Facility Reliability Class III - Includes all facilities which are not included in Reliability Classes I or II. This includes controlled discharge lagoons, treatment prior to land application, and facilities which discharge into undesignated use waters that do not fall under the rebuttable presumption where the effluent limits are governed by the protection of undesignated use waters.

4.5.2 Unit Process Reliability Criteria

The requirements for system reliability are normally achieved by providing duplicate or multiple units for each treatment process, but reliability can also be achieved through flexibility in the design and operation of systems and components. As used in these criteria, a unit operation is a single physical, chemical, or biological process.

4.5.2.1 Unit Process Reliability Criteria A - The following reliability is required for any mechanical treatment facility that is Facility Reliability Class II or III and is required to provide secondary treatment.

1. Duplication of major treatment units is not required. If provided, duplication for any unit process or operation shall, as a minimum, be in accordance with the appropriate part of Process Reliability Criteria B.
2. When duplicate units are not provided, the facility shall include a holding pond with both five days storage capacity for the AWW flow and the capability to bypass the pond when effluent limitations are being met.
 - a. This holding pond may also be used for flow equalization. Provisions for returning the holding pond contents to the treatment process are required.
 - b. A holding pond shall be constructed in accordance with IWFDS Section 8C.7, particularly Section 8C.7.3 pertaining to sealing of the pond bottom and maximum percolation rate.
 - c. Separate volumes shall be provided in the pond for the five days storage capacity for the AWW flow and for flow equalization if it is planned to use the pond for both purposes.
 - d. A minimum water level of two feet shall be maintained at all times.
 - e. Adequate provisions shall be made for the necessary valving, piping, pumping, metering, aeration, and sludge removal capabilities to permit the pond to be maintained and operated in a manner to effectively perform its intended functions.
3. Sludge wasting, sludge stabilization (as defined by process) and holding, and a final sludge disposal site are required.

4.5.2.2 Unit Process Reliability Criteria B - The following reliability is required for any mechanical treatment facility providing either two-stage nitrification (which includes intermediate clarification) or standard secondary treatment with no required nitrification, and that is not regulated by Process Reliability Criteria A:

1. If primary screens are used, duplication shall be of a sufficient number of units of a size such that, with the largest flow capacity unit out of service, the remaining units shall have a peak flow capacity of at least 100% of the PHWW flow (or industrial peak hour flow) to that unit operation.
2. Duplication of all primary clarifiers (if used), aeration basins, and fixed film reactors shall be of a sufficient number of units of a size such that, with the largest unit out of service, the remaining units shall have a design load capacity of at least 50% of the total design loading to that unit operation.
3. Duplication of all final clarifiers shall be of a sufficient number of units of a size such that with the largest unit out of service, the remaining units shall have a design load capacity of at least 75% of the total design loading to that unit operation for Facility Reliability Class I and 50% for Facility Reliability Class II or III.
4. Sludge wasting, sludge stabilization (as defined by process) and holding, and a final sludge disposal site are required.

4.5.2.3 Unit Process Reliability Criteria C - The following reliability is required for any mechanical treatment facility providing single stage combined carbonaceous oxidation and nitrification:

1. If screens are used in lieu of primary clarifiers, duplication shall be of a sufficient number of units of a size such that, with the largest flow capacity unit out of service, the remaining units shall have a peak flow capacity of at least 100% of the PHWW flow (or industrial peak hour flow) to that unit operation.

2. Duplication of all primary clarifiers (if used), aeration basins, and fixed film reactors shall be of a sufficient number of units of a size such that, with the largest unit out of service, the remaining units shall have a design load capacity of at least 50% of the total design loading to that unit operation.
3. Duplication of all final clarifiers, except for facilities with no nitrification requirement other than enhanced nutrient control, shall be of a sufficient number of units of a size such that, with the largest unit out of service, the remaining units shall have a design load capacity of at least 75% of the total design loading to that unit operation. Duplication of all final clarifiers for treatment facilities with no nitrification requirement other than enhanced nutrient control shall be of a sufficient number of units of a size such that with the largest unit out of service, the remaining units shall have a design load capacity of at least 75% of the total design loading to that unit operation for Facility Reliability Class I and 50% for Facility Reliability Class II or III.
4. Sludge wasting, sludge stabilization (as defined by process) and holding, and a final sludge disposal site are required.

4.5.2.4 Unit Process Reliability Exceptions

1. No duplication is required when upgrading an existing plant which contains one unit large enough to provide at least 100% of the total design load capacity to that unit operation.
2. No duplication is required when upgrading an existing unit to be operated in parallel with a larger new unit, so long as the existing unit provides at least 40% of the total design load capacity of that unit operation.
3. For enhanced nutrient control facilities where the design for nitrification meets these design standards for activated sludge biological treatment and settling, including applicable unit process reliability criteria for single stage combined carbonaceous oxidation and nitrification, no duplication is required to accommodate denitrification as a supplemental treatment process, unless it is necessary to safeguard the public health or protect of water quality.

4.5.3 Power Source Reliability

Two separate and independent sources of electric power shall be provided to facilities from either a single substation and an emergency power generator or two separate utility substations. An emergency power generator is recommended where both substations may lose power from storm damage. If available from the electric utility, at least one of the facility's power sources shall be a preferred source (i.e., a utility source which is one of the last to lose power from the utility grid due to loss of power generating capacity). In areas where it is projected that sometime during the design period of the facility, the electric utility may reduce the rated line voltage (i.e., "brown out") during peak utility system load demands, an emergency power generator shall be provided as an alternate power source. Reliability and ease of starting, especially during cold weather conditions, shall be considered in the selection of the type of fuel for internal combustion engines. Where public utility gas is selected, consideration shall be given to a generator design that may be operated with an alternate fuel supply. At a minimum, the capacity of the backup power source for each Facility Reliability Class shall be as follows:

4.5.3.1 For Facility Reliability Class I facilities, the backup power source shall be sufficient to operate all vital components, during peak wastewater flow conditions, together with critical lighting and ventilation. Vital components include those associated with flow, treatment, pumping, metering and disinfection, and those parts of sludge handling which cannot be delayed without adverse effects on plant performance. Critical lighting and ventilation is needed to maintain safety and perform duties associated with operation of the vital plant components.

4.5.3.2 For Facility Reliability Class II facilities, the backup power source shall be the same as for Reliability Class I facilities, except that vital components used to support the secondary processes (i.e., mechanical aerators or aeration basin air compressors) are not required so long as sedimentation and disinfection are provided.

4.5.3.3 For Facility Reliability Class III facilities, the backup power source shall be sufficient to operate the screening or comminution facilities, the main wastewater pumps, the primary sedimentation basins, and the disinfection facility during peak wastewater flow condition, together with critical lighting and ventilation.

4.5.3.4 Requirements concerning rated capacity of electric power sources are not intended to prohibit other forms of emergency power, such as diesel driven main wastewater pumps.

4.5.3.5 Regardless of the reliability class, for facilities where a long-term (four hours or more) power outage has occurred, backup power for providing minimum aeration of an activated sludge system is required.

4.6 PLANT OUTFALL

4.6.1 General

The outfall sewer shall be designed to discharge to the receiving stream in a manner acceptable to the department. Consideration should be given to the following:

4.6.1.1 Whether free fall or submerged discharge is preferable at the site selected;

4.6.1.2 Utilization of cascade aeration of effluent discharge to increase dissolved oxygen (DO); and

4.6.1.3 Limited or complete across-stream dispersion of the final effluent as needed to protect aquatic life movement and growth in the immediate reaches of the receiving stream.

4.6.2 Protection and Maintenance

The outfall sewer shall be so constructed and protected against the effects of floodwater, ice, or other hazards as to reasonably ensure its structural stability and freedom from stoppage.

4.6.3 Sampling Provisions

4.6.3.1 All outfalls shall be designed so that an effluent sample can be obtained at a point after the final treatment process and before discharge to or mixing with the receiving waters.

4.6.3.2 If disinfection is provided, a sampling point is required immediately prior to disinfection. However, where UV radiation is used, an exception to this Section may be approved by the department on a case by case basis.

4.6.4 Effluent Diffuser System

4.6.4.1 If needed to enhance dispersion as described in Subsection 4.6.1.1, an effluent diffuser system may be considered as an alternative for the plant outfall. Proposals will be reviewed on a case by case basis at the department's discretion.

4.6.4.2 In addition to meeting the applicable requirements of this Section, a diffuser design shall maximize initial dilution in the receiving stream and should be based on an EPA-approved mixing model. All designs shall be provided with the necessary flexibility to conveniently maintain and operate the diffuser system. Pumping is recommended. The conduit requirements in Section 4.4.7 shall apply to all outfall sewers. Protection for the effluent diffuser system shall be provided by installing bar screens. If flow bypasses the effluent diffuser system, additional flow measurement and recording shall be provided.

4.6.4.3 At design pumping rates, a cleansing velocity of at least three fps should be maintained throughout each manifold.

4.6.4.4 The required degree of mixing with the receiving waters shall be achieved within 100 feet of the diffuser. Dispersion of the effluent into the receiving stream shall be uniform. Generally, port spacing should be three to six feet on centers. A zone of passage for aquatic life shall be maintained outside of the acute zone of initial dilution. Where the receiving stream may deposit sand and mud to an elevation above the port openings, the orifice flow velocity at each port should be at least 10 fps at all rates of flow within the design limits.

4.6.4.5 Each diffuser port opening should be two inches in diameter or larger.

4.6.4.6 Risers shall be placed at no more than 60 degrees from the horizontal and shall discharge below the water surface at the 7Q10 flow of the receiving stream. In no case shall the jet of water from any riser break the water surface or erode the streambed. Orifice flow velocities should not exceed 15 fps. Where pipe flow velocities greater than 10 fps are attained, special provisions should be made to protect against displacement caused by impact, as necessary.

4.6.4.7 Where multiple manifolds are provided, the effluent diffuser system shall have capacity such that, with any manifold out of service, the remaining manifolds will have capacity to disperse the maximum expected flows.

4.6.4.8 The top of all outfall sewers entering or crossing streams shall be at a sufficient depth below the natural bottom of the stream bed to protect the line. For additional requirements, see IWFDS Section 2.5.11.

4.6.4.9 Bends in the receiving stream where a sand bar may be created from channel migration should be avoided.

4.6.4.10 The location of the effluent diffuser system shall be permanently posted both upstream and downstream of the diffuser to clearly identify to recreational users the nature and presence of the plant outfall. It shall be the responsibility of the treatment plant owner to eliminate hazards to navigation and other public uses of the receiving stream.

4.7 ESSENTIAL FACILITIES

4.7.1 Water Supply

4.7.1.1 General - No piping, connections, or potential cross connection situations shall exist in any part of the treatment works which, under any conditions, might cause the contamination of a potable water supply.

4.7.1.2 Direct Connections - Potable water from a municipal or separate supply may be used directly at points above grade for the following hot and cold supplies:

1. Lavatories;
2. Water closets;
3. Laboratory sinks (with vacuum breaker);
4. Showers;
5. Drinking fountains;
6. Eye wash fountains; and
7. Safety showers.

Hot water for any of the above units shall not be taken directly from a boiler used for supplying hot water to a sludge heat exchanger or digester heating unit.

4.7.1.3 Indirect Connections - Where a potable water supply is to be used for any purpose in a plant other than those listed in Subsection 4.7.1.2, either a combination of break tank, pressure pump, and pressure tank, or an approved reduced pressure backflow preventer (AWWA C506) is required.

1. Water shall be discharged to a break tank through an air gap at least six inches above the maximum flood line or the spill line of the tank, whichever is higher.
2. A sign shall be permanently posted at every hose bib, faucet, hydrant, or sill cock located on the water system beyond a break tank or backflow preventer to indicate that the water is not safe for drinking.

4.7.1.4 Separate Potable Water Supply - Where it is not possible to provide potable water from a public water supply, a separate well may be provided. Location and construction of the well must comply with department requirements for wells.

4.7.1.5 Separate Non-Potable Water Supply - Where a separate non-potable water supply is to be provided, a break tank will not be necessary, but all system outlets shall be posted with a permanent sign indicating the water is not safe for drinking.

4.7.2 Flow Measurement

Continuous flow measurement and recording shall be provided for all wastewater treatment plants serving a population equivalent (PE) greater than 100. For facilities serving less than 100 PE, a flow measurement device shall be provided, and the design of the structure shall facilitate the installation of continuous flow recording equipment and automatic samplers. At a minimum, all continuous flow recording equipment should be designed to report the volume of flow during each one-hour period and each one-minute period.

4.7.2.1 General

1. All influent flow measurement devices shall be self-flushing. Weirs shall not be acceptable for influent flow measurement except for very low flows where an "H" flume or an equivalent self-flushing flow measuring devices are not accurate. Self-cleaning in-channel floats may be allowed for influent head measurements. Use of floats in stilling wells is acceptable.
2. Nothing in these standards shall be construed to suggest flow measurement equipment should not be used.

4.7.2.2 Requirements for Specific Systems

1. For controlled discharge lagoon, flow measurement facilities shall be provided for the total influent flow and any discharge from the lagoon. Equipment to continuously measure and record flow rates and total influent flow is required. A V-notch weir without level monitoring equipment is allowed for measuring intermittent discharges from controlled discharge facilities.

2. Flow-through treatment systems shall be capable of continuously measuring and recording flow rates and total flow to the plant.
3. If flow is equalized by a wastewater treatment process (such as sequencing batch reactors), additional flow measurement and recording shall be provided.
4. If flow bypasses a portion of the plant, additional flow measurement and recording shall be provided.
5. Operation permits may require additional flow measurement and recording on a case-by-case basis.
6. Flow measuring devices for determining recycle flow, return sludge flow, and waste sludge volume shall be provided.
7. Total retention facilities shall provide an accurate means of determining the total daily flow into the facility.

4.7.2.3 Magnetic Flow Meters - Where practicable, a magnetic flow meter on a lift station force main with automatic continuous recording equipment will be an acceptable method of providing continuous flow monitoring. Changes in pipe size or abrupt changes in pipe direction near the meter should be avoided.

4.7.2.4 Volumetric Meters - Volumetric meters may be considered for small pumping stations controlled by low level and high-level contacts.

4.7.2.5 Elapsed Time Meters - Elapsed time meters (ETMs) with an event recorder on lift station pump controls may be used for continuous flow monitoring if all the following are true:

1. The lift station is a component of a controlled discharge lagoon or for flow-through treatment facilities serving 500 PE or less, and
2. The installation of a flume with automatic continuous recording equipment, or its equivalent, is an impractical alternative.

4.7.2.6 Reliability and Accuracy - Flow measurement equipment shall accurately measure flow with a maximum deviation of $\pm 10\%$ of the true discharge rates throughout the range of discharge levels of the flow measuring device plus a deviation of $\pm 3\%$ of the maximum design flow for the transmitting-recording equipment.

4.7.3 Sampling Equipment

4.7.3.1 Effluent composite sampling equipment shall be provided as necessary to meet discharge monitoring requirements. Composite sampling equipment also shall be provided as needed for influent sampling and for monitoring plant operations. Raw wastewater influent sampling for all plants shall be located such that all contributing loads are accounted for and process return or recycle streams are excluded. Where practical or required, the design shall flow proportion composite 24-hour samples.

4.7.3.2 IWFDS Section 3.4.7 shall be considered in the design and location of influent composite sampling equipment.

4.7.3.3 Provisions to report the amount and rate of septage that will be accepted by the wastewater treatment plant above collection system loadings, if any, shall be provided.

4.8 SAFETY

It is the facility owner's responsibility to ensure that the OSHA, NFPA 70, NFPA 820, and other applicable building and construction codes and requirements are met during construction and subsequent operation. During construction, this requirement may be met by including references to OSHA, NEC, and other applicable building and construction codes in the contract documents.

4.9 LABORATORY

4.9.1 Minimum Required Laboratory Analysis Capability

4.9.1.1 Careful consideration should be given to the laboratory facilities needed for the operational control of each plant. The laboratory analyses utilized shall evaluate the efficiency of the entire treatment facility and the efficiency of individual treatment units.

4.9.1.2 The department has established the minimum self-monitoring requirements and analytical procedures for wastewater treatment plants in 567—Chapter 63. Additional monitoring may be required based on a case-by-case evaluation of the impact of the discharge on the receiving stream, toxic or deleterious effects of wastewaters, industrial contribution to the system, complexity of the treatment process, history of non-

compliance or any other factor which requires strict operational control to meet the effluent limitations of the permit.

4.9.2 Laboratory Capability

All treatment works shall include a laboratory for making the necessary analytical determinations and operating control tests, except in individual situations where operational testing is minimal or not required and self-monitoring analyses are to be performed off-site. The laboratory shall have sufficient size, bench space, equipment, and supplies to perform all on-site self-monitoring analytical work required by the operation permits, and to perform the process control tests necessary for management of each treatment process included in the design. The laboratory should have the capability and supplies to perform analytical work to support industrial waste control programs. The laboratory size and arrangement shall be sufficiently flexible and adaptable to accomplish these tasks. Laboratory guidelines are detailed in Appendix 4-B.

APPENDIX 4-A: RECOMMENDED PROCESS PIPING COLOR CODING

Raw sludge line - gray
Digested sludge line - black
Sludge recirculation suction line - brown with yellow bands
Sludge draw off line - brown with orange bands
Sludge recirculation discharge line - brown
Sludge gas line - red
Natural gas line - red with black bands
Non-potable water line - purple
Potable water line - blue
Chlorine line - yellow
Sulfur Dioxide - yellow with red bands
Sewage line - gray
Compressed air line - dark green
Process air line - light green
Water line for heating digesters or buildings - blue with a six-inch red band spaced 30 inches apart
Fuel oil/diesel - red
Plumbing drains and vents - black (or gray)
Polymer - unpainted PVC

If labeling is used, the contents should be clearly indicated on the piping in a contrasting color.

APPENDIX 4-B: LABORATORY GUIDELINES

Location and Space

The laboratory should be located on ground level, easily accessible to all sampling points, with environmental control as an important consideration. It should be located away from vibrating machinery or equipment which might have adverse effects on the performance of laboratory instruments or the analyst, or otherwise be designed to prevent adverse effects from vibration. A minimum of 180 ft² of floor space should be provided for activated sludge, physical-chemical, and advanced wastewater treatment plants; a minimum of 150 ft² of floor space should be provided for other type of treatment plants; and a minimum of 400 ft² of floor space should be provided for laboratories having a full-time laboratory chemist. Bench-top working surface should occupy at least 35% of the total floor space.

Minimum ceiling height should be eight feet six inches. If possible, this height should be increased to provide for the installation of wall-mounted equipment with extended height requirements. Additional floor and bench space should be provided to facilitate analysis of industrial wastes, as required by the operation permit or the utility's industrial waste pretreatment program. The above minimum space does not provide office or administration space.

Materials

- Ceilings - Materials used for ceilings should provide proper acoustics and access to valves and equipment. In high humidity areas, water resistant materials should be used.
- Walls - Wall finishes should be light in color and nonglare.
- Floors - Floor surfaces should be non-slip, fire resistant, and highly resistant to acids, alkalies, solvents, and salts. Floor finishes should be of a single color for ease of locating dropped items.
- Doors - Two exit doors should be located to permit a straight egress from the laboratory, preferably at least one to outside the building. Panic hardware should be used. Doors should have large glass windows for easy visibility of approaching or departing personnel. Automatic door closers should be installed; swinging doors should not be used. Flush hardware should be provided on doors if cart traffic is anticipated. Kick plates are also recommended.
- Cabinets and Bench Tops -
 - Wall-hung cabinets are useful for dust-free storage of instruments and glassware. Units with sliding glass doors are preferable. They should be hung so the top shelf is easily accessible to the analyst. Thirty inches from the bench top is recommended.
 - One or more cupboard-style base cabinets should be provided for storing large items; however, drawer units are preferred for the remaining cabinets.
 - Drawers should slide out so that entire contents are easily visible. They should be provided with rubber bumpers and with stops to prevent accidental removal. Drawers should be supported on ball bearings or nylon rollers which pull easily in adjustable steel channels. All metal drawer fronts should be double-wall construction.
 - All cabinet shelving should be acid-resistant and adjustable from inside the cabinet.
 - Water, gas, air, and vacuum service fixtures; traps, strainers, overflows, plugs and tailpieces; and all electric service fixtures should be supplied with the laboratory furniture.
 - Generally, bench-top height should be 36 inches. However, areas to be used exclusively for sit-down type operations should be 30 inches high and include kneehole space.
 - One-inch overhangs and drip grooves should be provided to keep liquid spills from running along the face of the cabinet. Tops should be finished in large sections, 1-1 ¼ inches thick. They should be field joined into a continuous surface with acid, alkali, and solvent-resistant cements which are at least as strong as the material of which the top is made.
- Hoods - Fume hoods to promote safety and canopy hoods over heat-releasing equipment, if provided, should be installed near the area where most laboratory tests are made.
- Sinks -
 - The laboratory should have a minimum of two sinks (not including cup sinks). At least one of them should be double-wall with drainboards.
 - Additional sinks should be provided in separate work areas as needed, and identified for the use intended.

- Sinks and traps should be made of material with all appropriate characteristics for laboratory applications. Materials should be highly resistant to acids, alkalies, solvents, and salts, and should be abrasion and heat resistant and nonabsorbent.
- Traps should be easily accessible for cleaning.
- Waste openings should be located toward the back so that standing overflow will not interfere.
- All water fixtures on which hoses may be used should be provided with vacuum relief valves to prevent contamination of water lines.
- Ventilation and Lighting -
 - Laboratories should be separately air conditioned, with external air supply for 100% make-up volume.
 - In addition, separate exhaust ventilation should be provided. Ventilation outlet locations should be remote from ventilation inlets. Air intake should be balanced against all supply air that is exhausted to maintain an overall positive pressure in the laboratory relative to atmospheric and other pressurized areas of the building which could be the source of airborne contaminants.
 - Good lighting, free from shadows, is important for reading instruments in the laboratory.
- Gas and Vacuum - Natural or liquified petroleum (LP) gas should be supplied to the laboratory. Digester gas should not be used. An adequately-sized line source of vacuum should be provided with outlets available throughout the laboratory.
- Equipment, Supplies and Reagents - The laboratory should be provided with all of the equipment, supplies, and reagents needed to carry out all of the facility's analytical testing requirements. Operation permit, process control, and industrial waste monitoring requirements should be considered when specifying equipment needs. References such as Standard Methods should be consulted prior to specifying equipment items.
- Microscope - A binocular or trinocular microscope with light source; phase contrast condenser; mechanical stage; 10x, 40x and 100x phase contrast objectives; wastewater reticle eyepiece; and centering telescope is recommended for process control at activated sludge plants.
- Balance and Table - An analytical balance, single pan 0.1 milligram sensitivity type, should be provided for plants performing laboratory tests including BOD₅ and suspended solids analysis. A heavy balance table which will minimize vibration of the balance is recommended. It should be located as far as possible from windows, doors or other sources of drafts or air movements.
- Power Supply Regulation - Consideration should be given to providing line voltage regulation for power supplied to laboratories using delicate instruments.
- Laboratory Water - Reagent water of a purity suitable for analytical requirements should be supplied to the laboratory.

CHAPTER 5: SCREENING AND GRIT REMOVAL**5.1 APPLICABILITY AND SCOPE**

This chapter is applicable to the construction, installation, or modification of any disposal system required to obtain a construction permit from the department under Iowa Code section 455B.183 and rule 567—60.2(455B).

5.2 SCREENING DEVICES**5.2.1 Location**

5.2.1.1 Indoors - Screening or other wet process devices installed in a building where other equipment or offices are located shall be separated from the rest of the building and provided with separate outside entrances.

5.2.1.2 Outdoors - Screening devices installed outside shall be protected from freezing. Fine screens shall not be installed outside.

5.2.1.3 Access - Screening areas shall be provided with stairway access (not ladders), adequate lighting, and a convenient and adequate means for removing the screenings.

5.2.1.4 Ventilation - For indoor installations, uncontaminated air shall be introduced continuously at a rate of 12 air changes per hour, or intermittently at a rate of 30 air changes per hour. Intermittently operated ventilating equipment shall be interconnected with the lighting system.

5.2.2 Electrical

Electrical equipment, fixtures and controls (including ventilator and heaters) in screening areas where hazardous gasses may accumulate shall meet the requirements of the NFPA 820 for Class 1, Division 1, Group D locations. Explosion proof gas detectors shall be provided for such areas.

5.2.3 Servicing

Hosing equipment shall be provided to facilitate cleaning. Provision shall be made for isolating or removing units from their location for servicing.

5.2.4 Bar Racks and Screens

5.2.4.1 When Required - All wastewater treatment plants shall be provided with protection for pumps or other equipment by installing coarse bar racks, bar screens, or trash baskets. Protection for comminutors or other grinding devices shall be provided by coarse bar racks.

5.2.4.2 Design and Installation

1. **Bar Spacing** - Clear openings between bars shall be no less than one inch for manually cleaned screens. Clear openings for mechanically cleaned screens may be as small as ¼ of an inch. Maximum clear openings shall be 1 ¾ inches.
2. **Slope** - Manually cleaned screens, except those for emergency use, shall be placed on a slope of 30 to 60 degrees from the horizontal.
3. **Velocities** - At AWW flow conditions, approach velocities should be no less than 1.25 fps to prevent settling; and no greater than 3.0 fps at MWW flow to prevent forcing material through the openings.
4. **Channels**
 - a. Channels preceding and following screens shall be shaped to minimize settling of solids. Fillets shall be installed as necessary.
 - b. Bypass channels shall be provided and equipped with the necessary gates to isolate flow from any single mechanical screening unit. Provisions shall be made to facilitate dewatering each mechanical unit. Channels shall be designed for ease of access for cleaning.
 - c. Single channels with manually cleaned screens which are removable without dewatering are acceptable for small installations.
5. **Invert** - The screen channel invert shall be three to six inches below the invert of the incoming sewer unless impractical due to hydraulic limitations.
6. **Flow Distribution** - Entrance channels shall be designed to provide equal and uniform distribution of flow to the screens.
7. **Flow Measurement** - Screening devices shall not be located such that changes in backwater elevations will interfere with the accuracy of upstream flow measuring equipment.

5.2.4.3 Accessibility**1. Railings and Gratings**

- a. Manually cleaned screen channels shall be protected by guard railings and/or deck gratings, with adequate provisions for removal of gratings to facilitate raking.
- b. Mechanically cleaned screen channels shall be protected by guard railings and/or deck gratings. Consideration should be given to temporary access arrangements to facilitate maintenance and repair.

2. **Enclosures** - Mechanical screening equipment shall have adequate removable enclosures to protect personnel against accidental contact with moving parts.

3. **Raking** - Manually cleaned screening facilities shall include an accessible platform from which personnel may rake screenings easily and safely. Suitable drainage facilities shall be provided for both the platform and the storage areas.

5.2.4.4 Control Systems

1. **Timing Devices** - All mechanical units that are operated by timing devices shall be provided with auxiliary controls which will set the cleaning mechanism in operation at a preset high-water elevation.

2. **Manual Switch** - Automatic controls should be supplemented by a manual start, stop, and/or reverse switch located in view of the equipment.

5.2.4.5 Disposal of Screenings - Facilities shall be provided for removal, handling, storage, and disposal of screenings in a sanitary manner. Separate grinding of screenings and return to the sewage flow is unacceptable, except for the material which passes the coarse bar racks required ahead of comminutors or other grinding devices.

5.2.4.6 Auxiliary Screens - Where a single mechanically cleaned screen is used, an auxiliary manually cleaned screen shall be provided. Where two or more mechanically cleaned screens are used, the design shall provide for taking any unit out of service without sacrificing the capability to handle the PHWW flow.

5.2.5 Fine Screens

5.2.5.1 General - Moving or rotating fine screens with maximum openings of 0.06 inches may be used in lieu of primary sedimentation (except preceding RBC units), providing subsequent treatment units are designed on the basis of anticipated screen performance. Fine screens should not be considered equivalent to primary sedimentation. Static fine screens shall not be permitted for continuous duty in lieu of primary sedimentation.

5.2.5.2 Design

1. **Capacity** - A minimum of two fine screens shall be provided, each unit being capable of independent operation. Capacity shall be provided to treat PHWW flow with one unit out of service.
2. **Cleaning** - A continuous cleaning device such as jets or wiper blades shall be incorporated in the design of moving or rotating fine screens, with provisions for automatic conveyance of the material removed from the screen to the sludge treatment processes.
3. **Preceding Units** - Continuously operated fine screens shall be preceded by a bar screen, by grit removal facilities, and by facilities for the removal of floatable oils and greases. Comminuting devices are not necessary ahead of fine screens.

5.3 COMMINUTORS/GRINDERS**5.3.1 Location**

Provisions for location shall be in accordance with those for screening devices in Section 5.2.1.

5.3.2 Design Considerations

5.3.2.1 Location - Comminutors or grinders should be located downstream of any grit removal equipment.

5.3.2.2 Size - Comminutor or grinder capacity shall be adequate to handle PHWW flow.

5.3.2.3 Installation

1. A screened by pass channel shall be provided with capacity to handle the PHWW flow. The use of the bypass channel should be automatic at depths of flow exceeding the design capacity of the comminutor or grinder.
2. Bypass channels will not be required where two comminutors or grinders are installed. Each comminutor or grinder shall be capable of handling the PHWW flow.

3. Channels shall be provided with the necessary gates to isolate flow from any unit, and provisions shall be made to facilitate dewatering each unit.

5.3.2.4 Downstream Clogging - Provisions shall be made to minimize the problem of downstream clogging caused by formation of rag ropes if comminutors or grinders are proposed for plants with digesters or jet type aerators for activated sludge.

5.3.2.5 Servicing - Provisions shall be made to facilitate servicing units in place or removing units from their location for servicing.

5.3.2.6 Electrical - Electrical equipment, fixtures, and controls (including ventilators and heaters) in comminutor or grinder chambers where hazardous gasses may accumulate shall meet the requirements of the NFPA 820 for Class 1, Division 1, Group D locations. Explosion proof gas detectors shall be provided for such areas. Motors in areas not governed by this requirement may need protection against accidental submergence. Control switches or a disconnecting device shall be located in view of the comminutor or grinder.

5.4 GRIT REMOVAL FACILITIES

5.4.1 When Required

Grit removal facilities shall be provided for all wastewater treatment facilities serving systems with combined sewers or systems receiving substantial quantities of grit. Grit removal facilities shall also be provided ahead of continuously operated fine screens.

5.4.2 Location

5.4.2.1 General - Grit removal facilities should be located ahead of pumps and comminuting devices. Coarse bar racks should be placed ahead of grit removal facilities.

5.4.2.2 Housed Facilities

1. **Ventilation** - Uncontaminated air shall be introduced continuously at a rate of 12 air changes per hour, or intermittently at a rate of 30 air changes per hour. Intermittently operated ventilating equipment shall be interconnected with the lighting system. Odor control facilities may also be warranted.
2. **Access** - Adequate stairway access to above- or below--grade facilities shall be provided.
3. **Electrical** - All electrical equipment, fixtures and controls (including ventilators and heaters) in enclosed grit removal areas where hazardous gasses may accumulate shall meet the requirements of the NFPA 820 for Class 1, Division 1, Group D locations. Explosion proof gas detectors shall be provided for such areas.

5.4.2.3 Outside Facilities - Grit removal facilities located outside shall be protected from freezing.

5.4.3 Type and Number of Units

Plants treating wastes from combined sewers and plants utilizing fine screens shall have at least two mechanically cleaned grit removal units, with provisions for bypassing. Adequate capacity for the MWW flow shall be provided with the largest unit out of service. A single manually cleaned or mechanically cleaned grit chamber with bypass is acceptable for small sewage treatment plants serving separate sanitary sewer systems. Minimum facilities for larger plants serving separate sanitary sewers should be at least one mechanically cleaned unit with a bypass. Facilities other than channel-type are acceptable if provided with adequate and flexible controls for agitation and/or air supply devices and with grit collection and removal equipment.

5.4.4 Design Factors

5.4.4.1 General - Design of grit chambers shall be based on the size and specific gravity of the grit particle to be removed. If this information is not obtained from actual field measurements, the design shall assume removal of all particles retained on a 65 mesh sieve (0.21 mm opening) and having a minimum specific gravity of 2.65.

5.4.4.2 Channel-type Chambers

1. Positive hydraulic control shall be provided through either the use of a parabolic cross-section controlled by a downstream Parshall flume or a rectangular cross-section controlled by a downstream proportional weir to maintain a channel velocity of one fps through the expected flow range.
2. The length of the channel shall be sufficient for the grit to reach the bottom, plus a safety factor of two times the maximum depth for entrance and exit disturbances.

5.4.4.3 Aerated Grit Chambers

1. Air rates should be adjustable in the range of three to eight ft³/minute/foot of tank length.
2. The detention time at the MWW flow rate should be in the range of three to five minutes.
3. Inlets and outlets shall be designed to prevent short circuiting. The inlet to the chamber should introduce the wastewater directly into the circulation pattern caused by the air diffusion. The outlet should be at a right angle to the inlet, and consideration should be given to installing a baffle near the outlet.
4. The grit chamber shall be designed to avoid producing dead spaces.

5.4.4.4 Detritus Style Grit Chambers

1. Hydraulics shall be controlled by adjustable deflectors that insure a relatively uniform velocity across the entire tank.
2. Consideration shall be given to the size particle to be removed by settling and to the MWW flow rate. The depth of flow shall be such that the flow is non-turbulent, with an additional allowance of depth to allow for the raking mechanisms.

5.4.4.5 Grit Washing - The need for grit washing shall be determined by the method of final grit disposal.

5.4.4.6 Drains - Provision shall be made for isolating and dewatering each unit. Drainage from grit washing facilities carrying organic solids washed from the grit shall be added to the plant flow downstream of the grit removal facilities.

5.4.4.7 Water - An adequate supply of water under pressure shall be provided for cleanup.

5.4.4.8 Grit Handling - Grit removal facilities located in deep pits shall be provided with mechanical equipment for hoisting or transporting grit to ground level. Impervious, nonslip, working surfaces with adequate drainage shall be provided for grit handling areas. Grit transporting facilities shall be provided with protection against freezing and loss of material.

CHAPTER 6: SETTLING**6.1 APPLICABILITY AND SCOPE**

This chapter is applicable to the construction, installation, or modification of any disposal system required to obtain a construction permit from the department under Iowa Code section 455B.183 and rule 567—60.2(455B). Specifically, this chapter details the design criteria for settling tanks (also known as sedimentation tanks or clarifiers) used to remove settleable solids, grease and scum from wastewater following pretreatment or to separate biomass and scum from the biological process effluent. Design criteria for different types of settling tanks are included in this chapter including primary, intermediate and secondary units following both attached growth and activated sludge processes.

6.2 GENERAL CONSIDERATIONS**6.2.1 Number of Units**

Multiple units capable of independent operation are desirable and shall be provided in all plants except those specified in IWFDS Section 4.5.

6.2.2 Flow Distribution

Flow splitting devices and control appurtenances (i.e., valves, gates, splitter boxes) shall be provided to permit proper proportioning of flow to each unit in accordance with IWFDS Subsection 4.4.9.3.

6.3 DESIGN CONSIDERATIONS**6.3.1 ~~Dimensions~~Side Water Depth**

~~The side water depth for primary settling tanks shall not be less than seven feet as follows:—Settling tanks following the activated sludge process shall have side water depths of at least 12 feet to provide an adequate separation zone between the sludge blanket and the overflow weirs. Settling tanks following the activated sludge process may have 10-foot side water depths provided that less than 340 lbs/day of BOD₅ is treated and provided the clarifier is followed by a five-day pond. Intermediate settling tanks following first stage fixed film reactors shall have side water depths of at least seven feet. Final settling tanks following fixed film reactors shall have side water depth of at least 10 feet.~~

Table 1. Settling Tank Side Water Depths

<u>Type of Settling Tank</u>	<u>Minimum Side Water Depth (ft)</u>
<u>Primary</u>	<u>10</u>
<u>Secondary - Activated Sludge^{a,b}</u>	<u>12</u>
<u>Secondary - Attached Growth^b</u>	<u>10</u>

^a Greater side water depths are recommended for secondary settling tanks in excess of 4,000 square feet of surface area.
^b Side water depths less than 12 feet may be permitted for plants with an AWW design flow of 40,000 gallons per day or less. Settling tanks following integrated fixed-film activated sludge processes incorporating both attached growth and activated sludge in a single reactor are considered activated sludge for the purposes of the table.

6.3.2 Surface Overflow and Solids Loading Rates**6.3.2.1 General**

- Settling Surface overflow and solids loading rates in this section are based on typical clarifier designs for domestic wastewaters without additions of chemical settling aids. If chemical coagulants are added to aid settling, overflow rates may be increased based on pilot studies or similar facilities already in operation.
- The flows used in the following sections are designated by the abbreviations used in IWFDS Subsection 4.4.5.2 for municipal treatment plants. The corresponding flow designations for AWW and PHWW flows for industrial wastewater treatment facilities would be the average rated flows and the peak hour flows.

6.3.2.2 Primary Settling Tanks

- Surface overflow rates for primary settling tanks should not exceed the following: 1,000 gpd/ft² at AWW flows or 1,500 gpd/ft² for PHWW flows. Clarifier sizing shall be calculated for both flow conditions, and the larger surface area determined should be used. At these rates, primary settling of normal domestic sewage can be expected to remove 30-35% of the influent BOD₅. The overflow rates may be increased, but lower removal rates shall be assumed unless adequate chemical addition is provided.

Table 2. Primary Settling Tank Surface Overflow Rates^{a,b}

Type of Primary Settling Tank	Surface Overflow Rate at AWW Flow, gpd/ft ²	Surface Overflow Rate at PHWW Flow, gpd/ft ²
Tanks not receiving waste activated sludge	1,000	1,500
Tanks receiving waste activated sludge	700	1,200

^a Clarifier sizing shall be calculated for both flow conditions, and the larger surface area determined should be used. Primary settling of typical domestic wastewater in settling tanks not receiving waste activated sludge can be expected to remove approximately one-third (1/3) of the influent BOD₅ when operating at an overflow rate of 1,000 gpd/ft².

^b Greater BOD₅ removal for typical domestic wastewater at the recommended overflow rates or anticipated BOD₅ removal for higher overflow rates, chemically enhanced primary settling, or sewage containing appreciable quantities of industrial wastes should be verified by laboratory tests, actual settling data, and consideration of the quantity and character of the wastes.

~~1.~~

~~2. Anticipated BOD₅ removal for sewage containing appreciable quantities of industrial wastes should be determined by laboratory tests, actual settling data, and consideration of the quantity and character of the wastes.~~

6.3.2.3 Intermediate Settling Tanks

~~1. Surface settling overflow rates for intermediate settling tanks shall not exceed the following: the carbonaceous stage of a separate stage nitrification activated sludge process shall not exceed 900 gpd/ft² at AWW flows or 1,200 gpd/ft² for PHWW flows. Higher surface settling rates may be permitted if such rates are shown to have no adverse effects on subsequent treatment units.~~

~~1.~~

Surface settling rates for intermediate settling tanks following other treatment units shall not exceed 1,500 gpd/ft² based on PHWW flows.

Table 3. Intermediate Settling Tank Surface Overflow Rates

Type of Intermediate Settling Tank	Surface Overflow Rate at AWW Flow, gpd/ft ²	Surface Overflow Rate at PHWW Flow, gpd/ft ²
Settling Tank Following the Carbonaceous Stage of Separate-Stage Nitrification Activated Sludge ^a	900	1,200
All Others	-	1,500

^a Higher surface overflow rates may be permitted if such rates are shown to have no adverse effects on subsequent treatment units.

~~2.~~

6.3.2.4 Final Settling Tanks

~~1. Final Settling Tanks -- Fixed Film Biological Reactors~~ **General**

~~1. To perform properly settling tanks shall be designed to meet thickening and solids separation requirements. Surface overflow and solids loading rates shall be low enough to minimize problems with excessive solids loadings, density currents, inlet hydraulic turbulence, and occasional poor sludge settleability.~~

~~a. Surface overflow rates for settling tanks following trickling filters or RBCs treating domestic wastewater shall not exceed 1,200 gpd/ft² for PHWW flows.~~

~~b. The allowable surface overflow rates may be increased if chemical addition is provided. This determination shall be based on data from pilot studies, similar systems already in operation, or the literature.~~

~~2. Final Settling Tanks -- Activated Sludge~~ **Domestic Wastewater**

~~2. The surface overflow and solids loading rates for facilities treating domestic wastewater shall not exceed the following:~~

~~a. To perform properly while producing a concentrated return flow, activated sludge settling tanks shall be designed to meet thickening and solid separation requirements. Since the rate of recirculation of return sludge from the final settling tanks to the aeration or reaeration tanks is quite high in activated sludge processes, surface overflow rates shall below enough to minimize problems with high solids loadings, density currents, inlet hydraulic turbulence, and occasional poor sludge settleability. The surface settling rates of final settling tanks following the activated sludge processes shall be based on PHWW flow. The hydraulic loadings for facilities treating domestic wastewater shall not exceed the following:~~

Process Type	Hydraulic Loading at PHWW Flow, gpd/ft²
All (except as listed below)	1,200
Contact Stabilization	1,200
Extended Aeration	1,000
Separate Nitrification	800
High Purity Oxygen with Primary Settling	1,200

Table 4. Final Settling Tank Surface Overflow and Solids Loading Rates^a

Treatment Process	Surface Overflow Rate at PHWW Flow, gpd/ft²	Solids Loading Rate at AWW Flow, lbs/day/ft²	Solids Loading Rate at PHWW Flow, lbs/day/ft²
Activated Sludge (except as listed below)	1,200	30 ^b	50 ^b
Extended Aeration	1,000		
Nitrification Stage of Separate-Stage Nitrification	800		
Attached Growth ^c	1,200	-	-

^a The allowable surface overflow and solids loading rates may be increased if chemical addition, baffling or other measures to allow increased rates while maintaining adequate settling performance are provided. This determination shall be based on data from pilot studies or similar systems already in operation.

^b The solids loading rate shall be calculated using the design maximum return sludge rate and the design MLSS concentration. Settling tank sizing shall be calculated for the surface overflow rate and both solids loading conditions and shall use the largest surface area determined.

^c Settling tanks following integrated fixed-film activated sludge processes incorporating both attached growth and activated sludge in a single reactor are considered activated sludge for the purposes of the table.

b. The final settling tank solids loading for all activated sludge processes shall not exceed 30 lbs/day/ft² of solids at AWW flow or 50 lbs/day/ft² of solids at PHWW flow. Settling tank sizing shall be calculated for both flows and both solids loading conditions and shall use the largest surface area determined.

c. The allowable surface overflow rates may be increased if chemical addition is provided. This determination shall be based on data from pilot studies, similar systems already in operation, or literature data.

3. Final Settling Tanks - Industrial Waste

3.

a. For industrial waste treatment facilities and domestic waste treatment facilities with significant industrial contributions, surface overflow rates shall ~~may~~ be based on pilot studies, representative water analyses and jar test studies, data from similar systems already in operation, or literature data. The surface overflow rates shall not exceed those allowed in Subsections ~~6.3.2.4.1 and~~ 6.3.2.4.2.

b. When the department has actual operating experience with two similar facilities, it may require lower settling rates or additional solids removal capability.

6.3.3 Inlet Structures

~~6.3.3.16.3.3 When the department has actual operating experience with two similar facilities, it may require lower settling rates or additional solids removal capability.~~

~~6.3.3.2~~ Inlet structures shall be designed to dissipate the inlet velocity, to distribute the flow equally both horizontally and vertically, and to prevent short circuiting. Channels shall be designed to maintain a velocity of at least one fps at one-half the AWW flow. Corner pockets and dead ends shall not be allowed and corner fillets or channeling shall be used where necessary. Provisions shall be made for elimination or removal of floating materials in the inlet structures.

6.3.4 Weirs

6.3.4.1 General - Overflow weirs shall be readily adjustable for leveling. The range of adjustment shall consider uneven settling over the life of the structure. Overflow weirs shall be serrated with V-Notches or

similar notches.

6.3.4.2 Location - Overflow weirs shall be located to optimize actual hydraulic detention time and minimize short circuiting. Peripheral weirs should be placed at least one foot away from the clarifier wall or baffles should be provided to minimize wall effects. Interior weirs are permissible if accompanied by effective means of scum removal.

6.3.4.3 Design Rates - Weir loadings shall not exceed 10,000 gpd/lineal ft for plants designed for AWW flows of 1.0 mgd or less. Higher weir loadings may be used for plants designed for larger AWW flows, but should not exceed 15,000 gpd/lineal ft. If pumping to the settling tanks is required, weir loading should be related to pump delivery rates to avoid short circuiting. Pumping ~~should not be intermittent, but as nearly continuous as possible, and pumping~~ into a final clarifier should be avoided, but if necessary should be as continuous as possible.

6.3.4.4 Weir Troughs - Weir troughs shall be designed to prevent submergence at PHWW flow with the largest tank out of service, and to maintain a velocity of at least one fps at ½ the AWW flow.

6.3.4.5 Unit Dewatering and Bypassing - Unit dewatering features shall conform to IWFDS Subsection 4.4.8.2. Unit bypass design shall also provide for proportional redistribution of the plant flow to the remaining units.

6.3.4.6 Freeboard - Walls of settling tanks shall extend at least six inches above the surrounding ground surface and shall provide not less than 12 inches freeboard. Additional freeboard or the use of wind screens is recommended where large settling tanks are subject to high winds that would cause tank surface waves and inhibit effective scum removal.

6.4 SLUDGE AND SCUM REMOVAL

6.4.1 Scum Removal

Scum collection and removal facilities, including baffling, shall be provided for all primary and final settling tanks. Characteristics of certain treatment process scum (i.e., nitrification, industrial wastewater) which may adversely affect pumping, piping, sludge handling, or disposal, shall be recognized in the design.

6.4.2 Sludge Removal

Sludge collection and withdrawal facilities shall be designed to assure rapid removal of ~~the~~ sludge and facilitate accurate measurement and control of the sludge withdrawal rate from each individual clarifier. Suction withdrawal should be ~~provided-considered~~ for activated sludge settling tanks.

6.4.2.1 Sludge Hopper - The minimum slope of the side walls shall be 1.7 vertical to 1 horizontal. Hopper wall surfaces shall be made smooth with rounded corners to aid in sludge removal. Hopper bottoms shall have a maximum plan dimension of two feet. Extra depth sludge hoppers for sludge thickening are not acceptable.

6.4.2.2 Cross-Collectors - Cross-collectors serving one or more settling tanks may be useful in place of multiple sludge hoppers.

6.4.2.3 Sludge Removal Piping - Each hopper shall have an individual sludge withdrawal line at least six inches in diameter with a valve. The static head available for sludge withdrawal shall be 30 inches or greater, as necessary to maintain a three fps velocity in the withdrawal pipe. Clearance between the end of the withdrawal line and the hopper walls should be sufficient to prevent “bridging” of the sludge. Provisions shall be made for rodding or back flushing individual pipe runs. Piping may also be provided to return waste sludge to primary clarifiers.

6.4.2.4 Sludge Removal Control - Sludge wells equipped with telescoping valves or other appropriate equipment should be provided for viewing, sampling, and controlling the rate of sludge withdrawal. The use of easily maintained sight glass, sampling valves, and sludge density meters may be appropriate. A means of measuring the sludge removal rate shall be provided. Air lift type of sludge removal will not be approved for removal of primary sludges. Sludge pump ~~motor~~ control systems should include variable frequency drives or time clocks and valve ~~activators-actuators~~ for regulating the duration and sequencing of sludge removal.

6.5 PROTECTIVE AND SERVICE FACILITIES

6.5.1 Operation Protection

All settling tanks should be equipped to enhance safety for operators. Such features should appropriately include machinery covers, life lines, stairways, walkways, handrails, and slip resistant surfaces.

6.5.2 Mechanical Maintenance Access

The design should provide for convenient and safe access to routine maintenance items such as gear boxes, scum removal mechanisms, baffles, weirs, inlet stilling baffle area, and effluent channels.

6.5.3 Electrical Fixtures and Controls

The fixtures and controls should be located so as to provide convenient and safe access for operation and maintenance. Adequate area lighting should be provided (see IWFDS Section 4.8). Appropriate pump controls should be located near sludge and scum viewing points.

6.5.4 Cold Weather Protection

The design should provide measures for cold weather protection such as the use of wind screens, protective walls, or other means, as appropriate, to alleviate the problems of freezing.

CHAPTER 7: SLUDGE HANDLING AND DISPOSAL

7.1 APPLICABILITY AND SCOPE

This chapter is applicable to the construction, installation, or modification of sludge handling and disposal systems required to obtain a construction permit from the department under Iowa Code section 455B.183 and rule 567—60.2(455B), including sewage sludge stabilization, storage, handling, and disposal.

7.2 DESIGN CONSIDERATIONS

Facilities for processing sludge shall be provided at all mechanical wastewater treatment plants. Complete calculations including design basis, unit sizing and process reliability shall be presented in the facility plan. The selection of sludge treatment, handling, and disposal methods shall address all of the following:

- Volume of sludge to be treated. Whenever possible, the design information should be obtained from chemical analysis and measurement;
- Energy requirements;
- Efficacy of sludge thickening and dewatering;
- Complexity of equipment;
- Staffing requirements;
- Toxic effects of heavy metals and other substances on sludge stabilization and disposal;
- Sludge digestion or stabilization requirements, including appropriate pathogen and vector attraction reduction;
- Prior treatment process; e.g., poor quality supernatant results from anaerobic digestion of activated sludge;
- Treatment of side-stream or return flows, such as digester, sludge storage, dewatering, or thickener supernatant;
- Biological phosphorus removal in the activated sludge process and its impact to the digester;
- A back-up method of sludge handling and disposal; and
- Ultimate methods of sludge disposal.

7.3 SLUDGE THICKENING AND CONDITIONING

7.3.1 Sludge Thickening

As the first step of sludge handling, the need for sludge thickeners to reduce the sludge volume shall be addressed in the preliminary report or facilities plan. If it is determined that sludge thickening is needed, the thickener design shall consider the type and concentration of sludge, the sludge stabilization processes, the ultimate sludge disposal method, chemical needs, and operation costs. Particular attention shall be given to the pumping and piping of the concentrated sludge and possible onset of anaerobic conditions. Sludge should be thickened to at least 5% solids prior to transmission to digesters.

7.3.2 Sludge Conditioning

Conditioning is the treatment of sludge to facilitate water removal by a thickening or dewatering process. Conditioning normally has a significant effect on both the efficiency of the thickening and/or dewatering process and the liquid treatment portion of the treatment plant. The facility plan shall include a thorough discussion addressing the effects of conditioning on all processes.

7.4 SLUDGE STABILIZATION AND HOLDING

7.4.1 Anaerobic Sludge Digestion

7.4.1.1 General

1. Multiple Units - Multiple tanks are recommended. Where a single tank is used, an alternate method of sludge processing or emergency storage to maintain continuity of service shall be provided.
2. Depth - For those units proposed to serve as supernatant separation tanks, the depth shall be sufficient to allow for the formation of a reasonable depth of supernatant liquor. A minimum side water depth of 20 feet is recommended.
3. Maintenance Provisions - To facilitate draining, cleaning, and maintenance, the following features shall be provided:
 - a. Slope - The tank bottom shall slope to drain toward the withdrawal pipe. For tanks equipped with a suction mechanism for withdrawal of sludge, a bottom slope not less than 1:12 is required. Where

the sludge is to be removed by gravity alone, a slope not less than 1:4 is required.

- b. Access Manholes - At least two access manholes, not less than 24-inches in diameter, shall be provided in the top of the tank. A gas dome, if provided, shall not be considered an access manhole. Stairways or attached ladders shall be provided to reach the access manholes. A separate sidewall manhole shall be provided, with openings large enough to allow the use of mechanical equipment to remove grit and sand. All access manholes shall be provided with gas tight and watertight covers.
- c. Safety - Non-sparking tools, safety lights, rubber-soled shoes, safety harness, gas detectors for inflammable and toxic gasses, and at least two self-contained breathing units shall be provided for emergency use.

7.4.1.2 Sludge Inlets and Outlets

1. Multiple recirculation withdrawal and return points shall be provided in order to enhance flexible operation and effective mixing, unless mixing facilities are incorporated within the digester. In order to assist in scum breakup, the returns shall discharge above the liquid level and be located near the center of the tank.
2. Raw sludge discharge to the digester shall be through the sludge heater and recirculation return piping, or directly to the tank if internal mixing facilities are provided.
3. Sludge withdrawal to disposal shall be from the bottom of the tank. The pipe shall be interconnected with the recirculation piping to increase versatility in mixing the tank contents, if such piping is provided.

7.4.1.3 Tank Capacity

1. The total digestion tank capacity should be determined using calculations which consider the sludge volume to be treated, total and volatile solids concentrations, percent solids and character, temperature to be maintained in the digesters, degree or extent of mixing to be obtained, degree of volatile solids reduction required, and further treatment and/or disposal of digested sludge and supernatant liquors. Sufficient sludge storage capacity shall be provided for periods of inclement weather and equipment failure. If possible, adequate detention should be provided to avoid sludge application on frozen or snow-covered ground. Calculations shall be submitted to justify the basis of design.
2. If calculations are not based on the above factors, the minimum combined digestion tank capacity outlined below will be required. The requirements assume that raw sludge is derived from ordinary domestic wastewater, that a digestion temperature will be maintained in the range of 90-100°F (32°C to 38°C), that 40-50% volatile matter will be maintained in the digested sludge, and that the digested sludge will be removed frequently from the system.
3. Mixing is required as part of the digestion process, and each tank requiring mixing shall have sufficient mixing equipment or design flexibility to ensure that the total mixing capability is not lost with the failure of any one piece of mixing equipment. It is permissible for the backup equipment to be uninstalled.
 - a. Completely-Mixed Systems - Completely-mixed systems shall provide for intimate and effective mixing to prevent stratification and to assure homogeneity of digester content. The system may be loaded at a rate up to 80 lbs/1,000 ft³ of volume/day of volatile solids in the active digestion units. The minimum sludge retention time shall be 15 days.
 - b. Moderately-Mixed Systems - For digestion systems where mixing is accomplished only by circulating sludge through an external heat exchanger, it is recommended that the system be loaded at a rate of no more than 40 lbs/1,000 ft³ of volume/day of volatile solids in the active digestion units. Subject to departmental concurrence, this loading may be modified upward or downward depending upon the degree of mixing provided. Minimum sludge retention time shall be 30 days.

7.4.1.4 Gas Collection, Piping and Appurtenances

1. General - All portions of the gas system, including the space above the tank liquor, the storage facilities, and the piping, shall be designed so that under all normal operating conditions, including sludge withdrawal, the gas will be maintained under positive pressure. All enclosed areas where gas leakage might occur shall be adequately ventilated.
2. Safety Equipment - Safety facilities shall be included where gas is produced. Pressure and vacuum relief valves and flame traps, together with automatic safety shutoff valves, shall be provided. Water seal equipment shall not be installed. Gas safety equipment and gas compressors shall be housed in a

separate room with an exterior entrance.

3. Gas Piping and Condensate - Gas piping shall be of adequate diameter and shall slope to condensate traps at low points. Float-controlled condensate traps shall not be used.
4. Gas Utilization Equipment - Gas-fired boilers for heating digesters shall be located in a separate room not connected to the digester gallery. Such a separated room would not ordinarily be classified as a hazardous location. Gas lines to these units shall be provided with suitable flame traps.
5. Electrical Fixtures - In places enclosing anaerobic digestion appurtenances where hazardous gasses are normally contained in the tanks and piping, the electrical fixtures and controls shall comply with the location specified in the NEC for Class I, Division 1, Group D. Digester galleries should be isolated from normal operating areas, in accordance with paragraph 7. of this section, to avoid an extension of the hazardous location.
6. Waste Gas - Waste gas burners shall be readily accessible. Burners should be located at least 25 feet away from any plant structure if placed at ground level, or may be located on the roof of the control building if sufficiently removed from the tank. All waste gas burners shall be equipped with automatic ignition, such as pilot light or a device using a photoelectric cell sensor. Consideration should be given to the use of natural or propane gas to ensure reliability of the pilot light.
7. Ventilation - Any underground enclosures connecting with digestion tanks or containing sludge or gas piping or equipment shall be provided with forced ventilation for dry wells in accordance with paragraphs 42.71 through 42.74 and 42.76 of the Ten States Standards. The piping gallery for digesters should not be connected to other passages. Where used, tightly fitting, self-closing doors shall be provided at connecting passages and tunnels to minimize the spread of gas.
8. Meter - A gas meter with bypass shall be provided to meter total gas production.

7.4.1.5 Digester Heating

1. Insulation - Digestion tanks should be constructed above groundwater level and shall be suitably insulated to minimize heat loss.
2. Heating Facilities - Sludge may be heated by circulating the sludge through external heaters or by heating units located inside the digestion tank.
 - a. External Heating - Piping should be designed to provide for the preheating of feed sludge before introduction to the digesters. Provisions shall be made in the layout of the piping and valving to facilitate cleaning of these lines. Heat exchanger sludge piping shall be sized for heat transfer requirements.
 - b. Other Heating Methods - Other types of heating facilities will be considered on their own merits.
3. Heating Capacity - Heating capacity sufficient to consistently maintain the design sludge temperature shall be provided. Where digester tank gas is used for sludge heating, an auxiliary fuel supply is required.
4. Hot Water Internal Heating Controls
 - a. Mixing Valves - A suitable automatic valve shall be provided to temper the boiler water with return water so that the inlet-water to the heat jacket can be held below a temperature at which caking will be accentuated. Manual control shall be provided by suitable bypass valves.
 - b. Boiler Controls - The boiler shall be provided with suitable automatic controls to maintain the boiler temperature at approximately 180°F (82°C) to minimize corrosion and to shut off the main gas supply in the event of pilot burner or electrical failure, low boiler water level, or excessive temperature.
 - c. Thermometers - Thermometers shall be provided to show temperatures of the sludge, hot water feed, hot water return, and boiler water.

7.4.1.6 Supernatant Withdrawal

1. Piping Size - Supernatant piping shall not be less than six inches in diameter.
2. Withdrawal Arrangements
 - a. Withdrawal Levels - Piping shall be arranged so that withdrawal can be made from three or more levels in the digester. A positive unvalved vented overflow shall be provided.
 - b. Supernatant Selector - If a supernatant selector is provided, provisions shall be made for at least one other drawoff level located in the supernatant zone of the tank in addition to the unvalved emergency supernatant drawoff pipe. High pressure backwash facilities shall be provided.

3. Sampling - Provisions shall be made for sampling each supernatant drawoff level. Sampling pipes shall be at least 1 ½ inches in diameter, and shall terminate at a suitably-sized sampling sink or basin.
4. Supernatant Disposal - The supernatant shall be returned to the treatment process at an appropriate point. Consideration should be given to the effect of supernatant on plant performance and effluent quality and whether supernatant conditioning is appropriate.

7.4.2 Aerobic Sludge Digestion

7.4.2.1 Tank Duplication - Multiple tanks are recommended. A single sludge digestion tank may be used in the case of small treatment plants or where adequate provision is made for sludge handling and where a single unit will not adversely affect normal plant operations.

7.4.2.2 Mixing and Air Requirements - Aerobic sludge digestion tanks shall be designed for effective mixing. Sufficient aeration shall be provided to maintain DO of at least one mg/L.

1. Diffused Air Systems - To meet minimum mixing and oxygen requirements, an aeration rate of 30 cfm/1,000 ft³ of tank volume shall be provided with the largest blower out of service.
 - a. Bottom Diffusers - Nonclog diffusers are required. All plants employing less than four independent tanks shall be designed to incorporate removable diffusers that can be serviced and/or replaced without dewatering the tank. The air diffusion system for the total aerobic digestion system shall be designed such that the diffusers can be isolated without losing more than 25% of the oxygen transfer capability of the total system.
 - b. Jet Aeration - If jet aerators are utilized, a complete spare aeration system (pumps and aerator) shall be provided on site and shall be capable of being installed without dewatering the tank, unless at least 75% of the oxygen transfer capability of the system can be maintained with the largest aeration unit inoperable.
2. Mechanical Aeration Systems - Mechanical aerators shall not be used unless adequate performance data is submitted for existing comparable installation(s) to satisfactorily demonstrate that the proposed aerators are capable of continuous operation during periods of severe climatic conditions. If mechanical aerators are used, a minimum of 1.0 horsepower/1,000 ft³ shall be provided. At least two aerators shall be installed. A complete spare mechanical aerator shall be provided on site unless at least 75% of the oxygen transfer capability of the system can be maintained with the largest aeration unit inoperable. Replacement of mechanical aerators shall be provided for such that replacement can be accomplished without dewatering the tank. Where mechanical aerators are used, if the solids concentration is greater than 8,000 mg/L, bottom mixers shall be provided.

7.4.2.3 Tank Capacity - Tank capacities shall be determined using calculations which consider the quantity of sludge produced, sludge characteristics, time of aeration, and sludge temperature. Sufficient sludge storage capacity shall be provided for periods of inclement weather and equipment failure. If possible, adequate detention should be provided to avoid sludge application on frozen or snow covered ground. Calculations shall be submitted to justify the basis of design. Additional volume or supplemental heat may be required if the land application disposal method is used in order to meet applicable EPA requirements.

1. Volatile Solids Loading - The volatile suspended solids loading should not exceed 100 lbs/1,000 ft³ of volume/day in the digestion units. Lower loading rates may be necessary depending on temperature, type of sludge, and other factors.
2. Solids Retention Time - Required minimum solids retention time for stabilization of biological sludges vary depending on type of sludge. A minimum of 15 days retention shall be provided for waste activated sludge and 20 days for combination of primary and waste activated sludge, or primary sludge alone. Where sludge temperature is lower than 59°F (15°C), additional detention time shall be provided so that digestion will occur at the lower biological reaction rates.

7.4.2.4 Supernatant Separation - Provisions shall be made for effective supernatant separation and withdrawal. The supernatant shall be returned to the treatment process at an appropriate point. The supernatant drawoff unit should be designed to prevent the recycling of scum and grease back to plant process units.

7.4.3 Other Methods of Sludge Stabilization

If other sludge stabilization methods, such as heat treatment, lime stabilization, or composting are considered, a detailed description of the process and design data shall accompany the engineering report or facility plan.

Additional design information may be required if the land application disposal method is used in order to meet applicable EPA requirements.

7.4.4 Sludge Storage Tanks

Sludge storage facilities shall be provided at all mechanical treatment plants. Sludge storage may be provided as additional storage volume to sludge digestion in the sludge digestion units or provided as separate storage tanks or facilities, such as drying beds.

7.4.4.1 Tank Reliability - A single sludge storage tank may be used when adequate provisions are made for sludge handling and when a single unit will not adversely affect normal plant operation.

7.4.4.2 Tank Capacity - The determination of capacity shall be based on rational calculations, including such factors as quantity of sludge, sludge characteristics, and climatic conditions. Sufficient sludge storage capacity shall be provided for periods of inclement weather and equipment failure. If possible, adequate detention should be provided to avoid sludge application on frozen or snow covered ground, area seasonal rainfall patterns, and crop growth on land application sites. Calculations shall be submitted to justify the basis of design.

7.4.4.3 Mixing and Air Requirements - The design shall provide for odor control in sludge storage tanks including, mixing, aeration, covering, or other appropriate means. When mixing and aeration are needed, the following design is recommended.

1. Diffused Air Systems - An aeration rate of 20 cfm/1,000 ft³ of tank volume should be provided with the largest blower out of service. If diffusers are used, the nonclog type is required and they should be designed to permit continuity of service.
2. Mechanical Aeration Systems - If mechanical aerators are used, a minimum of 1.0 horsepower/1000 ft³ should be provided. Use of mechanical equipment is discouraged when freezing temperatures are normally expected.

7.4.4.4 Supernatant Separation - Same requirements as Subsection 7.4.2.4.

7.4.5 Sludge Storage Lagoons

Sludge storage lagoons shall not be used for final disposal of sludges. Unless adequate justification is provided, sludge storage lagoons should not be used as storage where the sludge has been stabilized through the treatment process. Where sludge lagoons are allowed, adequate provisions shall be made for other acceptable sludge handling methods in the event of upset or failure of the sludge digestion process. When sludge storage lagoons are justified, they should be designed in accordance with this Section.

7.4.5.1 Lagoon Reliability - A single lagoon may be used where adequate provisions are made for sludge handling and where a single lagoon will not adversely affect normal plant operation.

7.4.5.2 Lagoon Capacity - Same requirements as Subsection 7.4.4.2.

7.4.5.3 Mixing and Air Requirements - Same requirements as Subsection 7.4.4.3.

7.4.5.4 Cleaning - The lagoon(s) shall be designed to facilitate cleaning.

7.4.5.5 Lagoon Construction Details - The lagoon shall, in general, be constructed in accordance with IWFDs Section 8C.7.

7.4.5.6 Supernatant Separation - Facilities may be provided for effective separation and withdrawal of supernatant. Supernatant shall be returned to the treatment process at an appropriate point.

7.5 SLUDGE PUMPS AND PIPING

7.5.1 Sludge Pumps

7.5.1.1 Capacity - Provisions for varying pump capacity are recommended.

7.5.1.2 Duplicate Units - Duplicate units shall be provided such that with any one pump out of service, the remaining pumps will have capacity to handle the peak flow.

7.5.1.3 Type - Plunger pumps, screw feed pumps, recessed impeller type centrifugal pumps, progressive cavity pumps, or other types of pumps with demonstrated solids handling capability shall be provided for handling raw sludge.

7.5.1.4 Minimum Head - A minimum positive head of 24 inches shall be provided at the suction side of centrifugal-type pumps and is desirable for all types of sludge pumps. Maximum suction lifts shall not exceed 10 feet for plunger pumps.

7.5.1.5 Sampling Facilities - Unless sludge sampling facilities are provided, quick-closing sampling valves shall

be installed at the sludge pumps. The size of the valve and piping shall be at least 1½ inches.

7.5.2 Sludge Piping

7.5.2.1 Size and Head - Sludge withdrawal piping should have a minimum diameter of eight inches for gravity withdrawal and six inches for pump suction and discharge lines. Where withdrawal is by gravity, the available head on the discharge pipe should be adequate to provide at least 3.0 fps velocity.

7.5.2.2 Slope - Gravity piping shall be laid on uniform grade and alignment. The hydraulic slope of gravity discharge piping shall not be less than 3%. Provisions shall be made for cleaning, draining, and flushing discharge lines.

7.5.2.3 Supports - Special consideration shall be given to the corrosion resistance and continuing stability of supporting systems located inside the digestion tank.

7.6 SLUDGE DEWATERING

7.6.1 Sludge Drying Beds

7.6.1.1 Area - In determining the area of sludge drying beds, consideration shall be given to climatic conditions, the character and volume of the sludge to be dewatered, the method and schedule of sludge removal, and other methods of sludge disposal. In general, the sizing of the drying bed may be estimated on the basis of 2.0 ft²/capita when the drying bed is the primary method of dewatering, and 1.0 ft²/capita if it is to be used as a backup dewatering unit.

7.6.1.2 Percolation Type - The lower course of gravel around the underdrains shall be properly graded and shall be 12 inches in depth, extending at least six inches above the top of the underdrains. The gravel should be placed in two or more layers. The top three inches of the gravel shall consist of gravel ⅛-¼ inch in size.

1. **Sand** - The top course shall consist of six to nine inches of clean coarse sand. The finished sand surface shall be level.
2. **Underdrains** - Underdrains shall be plastic or concrete drain tile or clay pipe at least four inches in diameter laid with open joints. Underdrains shall be spaced not more than 20 feet apart. The underdrain filtrate shall be returned to the treatment process at an appropriate point.

7.6.1.3 Partially Paved Type - The design of the partially paved drying bed shall consider the space required to operate mechanical equipment for removing the dried sludge.

7.6.1.4 Walls - Walls shall be watertight and extend 15-18 inches above and at least six inches below the bed surface. Outer walls shall be curbed to prevent soil from washing onto the beds.

7.6.1.5 Sludge Removal - Not less than two beds shall be provided and they shall be arranged to facilitate sludge removal. Concrete truck tracks shall be provided for all percolation-type sludge beds. Pairs of tracks for the percolation-type beds shall be on 20-foot centers.

7.6.1.6 Sludge Influent - The sludge pipe to the drying beds shall terminate at least 12 inches above the bed surface and be so arranged that it will drain. Splash plates for percolation-type beds shall be provided at sludge discharge points.

7.6.2 Sludge Lagoons

Sludge lagoons shall not be substituted for adequate sludge digestion and shall not be approved for use as a sludge volume reduction process, except as provided for in Subsection 7.4.5.6.

7.6.3 Mechanical Dewatering Facilities

7.6.3.1 General - Provision shall be made to maintain sufficient continuity of service so that sludge may be dewatered without accumulation beyond storage capacity. The number of vacuum filters, centrifuges, filter presses, belt filters, or other mechanical dewatering facilities should be sufficient to dewater the sludge produced. Unless other standby facilities are available, adequate storage facilities shall be provided. The storage capacity should be sufficient to handle at least a three-month sludge production.

7.6.3.2 Spare Parts for Mechanical Dewatering Facilities

1. Spare parts shall be available for all mechanical dewatering facilities to replace parts which are subject to wear and breakage.
2. A backup vacuum pump and filtrate pump shall be installed for each vacuum filter. It is permissible to have an uninstalled backup vacuum pump or filtrate pump for every three or less vacuum filters, provided that the installed unit can easily be removed and replaced.

7.6.3.3 Ventilation - Adequate facilities shall be provided for ventilation of the dewatering area in accordance with IWFDS Section 3.7.1. The exhaust air should be properly conditioned to avoid odor nuisance.

7.6.3.4 Chemical Handling Enclosures - Lime mixing facilities should be completely enclosed to prevent the escape of lime dust. Chemical handling equipment should be automated to eliminate manual lifting.

7.6.4 Drainage and Filtrate Disposal

Drainage from beds or filtrate from dewatering units shall be returned to the sewage treatment process at appropriate points.

7.6.5 Other Dewatering Facilities

If an alternative method of sludge dewatering or disposal is proposed, a detailed description of the process and design data shall accompany the preliminary report or facility plan.

7.7 FINAL DISPOSAL OF SLUDGE

7.7.1 Sludge Disposal on Land

A sludge land application program must be evaluated as an integral system, including stabilization, storage, transportation, application, soil, crop, and groundwater. The requirements for municipal sludge land application are in 567—Chapter 67.

7.7.2 Other Sludge Disposal Methods

When other sludge disposal methods, such as incineration or landfill, are considered, a detailed description of the process and design data shall accompany the preliminary report or facility plan.

CHAPTER 8A: FIXED FILM MEDIA TREATMENT

8A.1 APPLICABILITY AND SCOPE

This chapter is applicable to construction, installation, or modification of any disposal system required to obtain a construction permit from the department under Iowa Code section 455B.183 and rule 567—60.2(455B).

8A.2 PROCESS SELECTION

8A.2.1 Applicability

The fixed film media treatment processes discussed in this chapter include trickling filters and rotating biological contactors (RBCs). These processes can be used for roughing, secondary treatment, nitrification, or polishing to treat wastewater which is amenable to biological treatment.

8A.2.2 Specific Process Selection

Fixed film media treatment processes and their modifications may be employed to accomplish varied degrees of removal of suspended solids and reduction of carbonaceous and nitrogenous oxygen demand. Choice of the most applicable process will be influenced by the proposed plant size, type of waste to be treated, treatability of waste, degree and consistency of treatment required, and local factors.

8A.3 PRETREATMENT

RBCs and trickling filters shall be preceded by settling tanks or other pretreatment devices which provide for effective removal of grit, debris, and excessive oil or grease. Bar screening or comminution are not suitable as the sole means of pretreatment.

8A.4 INDUSTRIAL WASTES

Consideration shall be given to the type and effects of industrial wastes on the treatment process. It may be necessary to pretreat industrial wastes prior to discharge to the sanitary sewer system.

8A.5 DESIGN INFORMATION

Fixed film media treatment processes shall be designed to provide for reduction in carbonaceous and/or nitrogenous oxygen demand in accordance with water quality standards and objectives for the receiving waters as established by the department, or to properly condition the wastewater for subsequent treatment processes. When proposing the use of fixed film media treatment processes, the design engineer shall provide all of the following information:

- influent BOD₅, TSS, TKN, and NH₃-N concentrations;
- influent temperature;
- wastewater heat loss through the various units;
- calculations of expected BOD₅ removal and TKN/NH₃-N removal (where appropriate);
- basis for sizing of units; and
- recirculation rates (if appropriate).

8A.6 TRICKLING FILTERS

8A.6.1 General

8A.6.1.1 Where existing trickling filters are being utilized to upgrade wastewater treatment facilities, or where unusual conditions may exist, the department may vary from these design criteria provided that adequate engineering justification is submitted.

8A.6.1.2 Process Types - Trickling filters shall be classified according to the applied hydraulic and organic loadings at AWW flow.

1. The hydraulic loading is the total volume of liquid, including recirculation, per unit time per square unit of filter plan surface area.
2. The organic loading is the BOD₅, including recirculation, per unit time per cubic unit of filter volume.
3. Typical loadings for the various classifications of filters are summarized in Table 1.

Table 1. Typical Design Criteria

Operating Characteristics	Filter Classification				
	Low or Standard Rate	Intermediate Rate	High Rate	Super Rate	Roughing
Type of Media	Rock	Rock	Rock or Manufactured	Manufactured	Rock or Manufactured
Hydraulic loading: gpd/ft ²	25-90	90-230	230-900	350-2,100	700-4,200
Hydraulic loading: gpd/ft ²	0.017-0.063	0.063-0.160	0.160-0.625	0.243-1.458	0.486-2.917
Organic loading: 1lb BOD ₅ /1,000 cu. ft./day	5-25	15-30	25-300	Up to 300	100-500
Depth (ft)	6-8	6-8	3-8	10-40	3-20
Typical BOD ₅ removal (%)	80-85	50-70	65-80	65-85	40-65

Note: The BOD₅ removal credits allowed will be based upon the calculations submitted.

8A.6.2 Hydraulics

8A.6.2.1 Distribution

1. Wastewater shall be distributed over filters by rotary distributors or other suitable devices which will ensure uniform distribution to the surface area under all design flow conditions.
2. For rotary type distributors, a minimum head of 24 inches between low water level in the siphon chamber and the center of the arms is required, or a similar allowance shall be added to pumping head requirements.
3. For rotary type distributors, a minimum clearance of six inches between media and distributor arms shall be provided.

8A.6.2.2 Piping System - The piping, pumps and distribution system must be capable of handling either the PHWW flow or other flows plus recirculation, if the total of such flows is greater than PHWW flow.

8A.6.3 Media

8A.6.3.1 Manufactured Media

1. Description - Manufactured media is the term used to describe media made from plastic or other material (such as wood), as distinguished from rock media.
2. Quality - Manufactured media shall be resistant to UV degradation, disintegration, erosion, aging, all common acids, alkalis and solvents, organic compounds, and fungus or other biological attack. Manufactured media shall be durable and insoluble in sewage.
3. Depth - Manufactured filter media depth shall not exceed 40 ft.

8A.6.3.2 Rock/Slag Media

1. Quality - Rock/slag media shall be durable, resistant to spalling or flaking, and relatively insoluble in sewage. The top 18 inches shall have a loss by the 20-cycle, sodium sulfate soundness test of not more than 10%, as prescribed by the ASCE Manual of Engineering Practice, No. 13. The balance is passing a 10-cycle test using the same criteria. Slag media shall be free from iron.
2. Depth - Rock and/or slag filter media depths shall not exceed 10 ft.
3. Size and Grading - Rock, slag, and similar media should not contain more than 5% by weight of pieces whose longest dimension is three times the least dimension.
4. Composition - Rock/slag media shall be free from thin, elongated and flat pieces, dust, clay, sand, or fine material and shall conform to the following size and grading when mechanically graded over vibrating screens with square openings.
 - Passing 4½ inch screen - 100% by weight
 - Retained on 3 inch screen - 95-100% by weight
 - Passing 2 inch screen - 0.2% by weight
 - Passing 1 inch screen - 0.1% by weight

8A.6.4 Underdrainage System

8A.6.4.1 Arrangement - The underdrainage system shall cover the entire floor of the filter. Inlet openings into the underdrains shall have a total area equal to at least 15% of the surface area of the filter.

8A.6.4.2 Hydraulic Capacity and Ventilation

1. Underdrains shall have a minimum slope of 1%. Effluent channels shall be designed to produce a minimum velocity of 2 fps at AWW flow.
2. The underdrainage system, effluent channels, and effluent pipe shall be designed to permit free passage of air. The sizes of drains, channels, and pipes shall be such that not more than 50% of their cross-sectional area will be submerged under the MWW flow, including proposed or possible future recirculated flows.
3. Consideration should be given to the use of forced ventilation for deep manufactured media filters or filters with high organic loadings.

8A.6.4.3 Flushing - Provision shall be made for flushing the underdrains. In small filters, use of a peripheral head channel with vertical vents is acceptable for flushing purposes.

8A.6.5 Special Features**8A.6.5.1 Covers**

1. Covers shall be provided for all new filter installations. Covers shall be removable, or shall be designed to provide adequate clear space for maintenance and for removal and replacement of equipment and media.
2. Covers shall be constructed of suitable corrosion resistant materials. Windows or simple louvered mechanisms which can be opened in the summer and closed in the winter shall be installed to provide adequate ventilation.
3. Nonmetallic covers shall be firmly reinforced with corrosion resistant metal at points of attachment, movement and wear, including windows, ventilation ports, doors, and/or base flanges where attached to walls or foundations. All hardware for windows, ports, doors, and base flanges shall be of corrosion resistant metal; plastic is not acceptable.

8A.6.5.2 Recirculation - The piping system shall be designed for recirculation as required to achieve the design removal efficiency and maintain adequate surface wetting rates. The recirculation rate shall be variable and subject to plant operator control.

8A.6.5.3 Recirculation Measurement - Facilities shall be provided to allow measurement of the recirculation rate.

8A.6.6 Rotary Distributor Seals

Mercury seals are not permitted.

8A.6.7 Unit Sizing

Required volumes of filter media should be no less than those given in Subsection 8A.6.1.1, Table 1. The unit sizing shall be verified by utilizing an applicable equation from the literature (such as ASCE Manual of Practice No. 36, standard engineering texts, or research literature).

8A.6.8 Activated Filters

Typical values for organic loadings to the filter should range from 100-350 lbs BOD₅/1,000 ft³ of filter media (4,300-15,000 lbs BOD₅/acre ft/day). The hydraulic wetting rate should range from 1.0-5.5 gpm/ft². Criteria for media should be in accordance with Subsection 8A.6.1.1, Table 1, and Subsection 8A.6.3.1. The aeration basin size and oxygen requirements should be estimated in accordance with IWFDS Chapter 8B. Calculations of mixed liquor suspended solids (MLSS) should consider the influent suspended solids and the solids sloughing from the filter in addition to the growth of activated sludge due to BOD₅ removal.

8A.7 ROTATING BIOLOGICAL CONTRACTORS**8A.7.1 Surface Area**

8A.7.1.1 Standard Density - Standard density media is defined as media with a surface area of 100,000-128,250 ft² for a typical modular unit. A typical modular RBC unit has a maximum shaft length of approximately 27 feet, with 25 feet occupied by media. Maximum media diameter is 12 feet.

8A.7.1.2 High Density - High density media is defined as media with a surface area of 138,000-180,000 ft² for a typical modular unit. If typical modular units with surface areas between 128,250 and 138,000 ft² become available, a determination will be made on a case-by-case basis on whether they are to be classified as standard density or high-density media.

8A.7.2 Accessibility

Access shall be provided for the repair or replacement of the media or shafts or entire RBC units. If the use of portable hoisting equipment for unit removal or replacement is proposed, the arrangement shall be such that the portable hoisting equipment can be located directly adjacent to any unit to be removed.

8A.7.3 Enclosures

8A.7.3.1 RBCs shall be covered to protect the biological growth from cold temperatures and to prevent excessive loss of heat from the wastewater.

8A.7.3.2 If individual enclosures are used, they shall be constructed of a suitable corrosion resistant material. Windows or simple louvered mechanisms which can be opened in the summer and closed in the winter shall be installed to provide adequate ventilation. Enclosures shall be adequately insulated to minimize heat loss.

8A.7.3.3 Nonmetallic enclosures shall be firmly reinforced with corrosion resistant metal at points of attachment, movement and wear, including windows, ventilation ports, doors, access hatches, and/or base flanges where attached to foundations. All hardware for windows, ports, doors, access hatches, and base flanges shall be of corrosion resistant metal; plastic is not acceptable.

8A.7.3.4 All enclosures shall provide for media inspection and shaft removal capabilities. If drive mechanisms and bearings are within the enclosures, properly sized and located access openings shall be provided for maintenance and repair.

8A.7.3.5 If multiple RBCs are to be housed in a permanent structure or building, provision shall be made for complete removal of the roof over each unit to allow for unit replacement, or other suitable means shall be provided for replacement of entire units without dismantling permanent portions of the building. The provisions of Section 8A.7.2 shall apply.

8A.7.3.6 Consideration should be given to the requirements for heating and ventilation to control excess condensation and provide sufficient oxygen under both summer and winter conditions. Motors, control centers, lighting, electrical gear, and ventilation equipment should be adequately designed to withstand possible temperatures.

8A.7.4 Design Considerations

8A.7.4.1 Dewatering - Separate dewatering capabilities shall be provided for each tank, with the flow being returned to the plant for adequate treatment.

8A.7.4.2 Rotation - Variable speed capability should be considered for all mechanical drive units to improve overall plant performance. Provisions shall be made on mechanical drive units for sustained periods of reverse rotation (three to four days) in order to shear excess biomass without damaging the RBC units or associated equipment. This shall include the provision of anchored radial support arms for the drives for reverse rotation.

8A.7.4.3 Staging

1. Each RBC facility shall include at least two parallel trains with a minimum of two stages per train.
2. For smaller facilities, staging may be provided by installing baffles in the tank. The baffles shall be removable and shall be constructed to prevent solids deposition within the tank.
3. Standard density media shall be used in the first two stages of an RBC train.

8A.7.4.4 Weight Measurement - All units shall be equipped with suitable means for measuring the total weight of the shaft, media, and biofilm at any time.

8A.7.4.5 Flow Control - RBC design shall incorporate adequate flow control devices to ensure that:

1. Flow is evenly divided among all trains in the system and flow to each train can be measured individually;
2. Flow is evenly distributed to prevent short-circuiting in each tank; and
3. Solids are kept in suspension in flow splitter boxes.

8A.7.4.6 Other Design Requirements

1. Wastewater temperatures shall be accounted for during design, as available data indicate that organic removal and nitrification rates diminish at wastewater temperatures below 55°F.
2. RBCs shall be designed to maintain a positive DO level in all stages.
3. Means for removing excess biofilm growth shall be provided, such as air stripping or chemical additives (in addition to reverse rotation on mechanical drive units).

8A.7.4.7 Other Design Recommendations

1. Periodic high organic loadings may require supplemental aeration in the first stage.
2. An evaluation of flow equalization vs. additional RBC media surface area is recommended when consistently low ammonia nitrogen levels are required in the effluent.
3. Consideration should be given to providing:
 - a. Power factor correction for all RBC mechanical and air drive systems;
 - b. High efficiency motors and drive equipment; and
 - c. Sampling points at the influent and effluent end of each RBC unit.

8A.7.5 Flexibility

The following operational and control strategies should be considered to provide adequate flexibility in process control:

- Variable rotational speeds;
- Positively controlled alternate flow distribution systems, such as step feed;
- Positive air flow metering and control to each shaft when air drive units are used; and
- Recirculation of secondary clarifier effluent.

8A.7.6 Organic Load

The maximum loading on any stage having standard density media shall not exceed 3 lbs/day/1,000 ft² of soluble BOD₅. Loading shall not exceed 2.0 lbs/day/1,000 ft² of soluble BOD₅ for any high-density media unit.

8A.7.7 Design for Nitrification

Effluent concentrations of ammonia nitrogen from an RBC process designed for nitrification are affected by diurnal load variations. Therefore, it may be necessary to increase the design surface area proportional to the ammonia nitrogen diurnal peaking rates to meet effluent limitations. Alternatively, flow equalization sufficient to ensure process performance may be provided to meet effluent limitations.

CHAPTER 8B: ACTIVATED SLUDGE BIOLOGICAL TREATMENT

8B.1 APPLICABILITY AND SCOPE

This chapter is applicable to the construction, installation, or modification of any disposal system required to obtain a construction permit from the department under Iowa Code section 455B.183 and rule 567—60.2(455B). Specifically, this chapter applies to the activated sludge process, which uses aeration tanks containing suspended biomass and a means of sludge retention to reduce oxygen demand and/or oxidize ammonia to nitrate following pretreatment or primary settling. Variations of the activated sludge process employing anoxic and/or anaerobic basins, zones or cycles may also be used for biological nutrient removal.

8B.2 PROCESS SELECTION

8B.2.1 Applicability

The activated sludge process and its various modifications may be used to treat wastewater amenable to biological treatment.

8B.2.2 Operational Requirements

The activated sludge process requires close attention and competent operating supervision. Facilities and appurtenances for routine control and testing, including suitable laboratory apparatus, shall be provided at all activated sludge plants.

8B.2.3 Specific Process Selection

The activated sludge process and its modifications may be employed to accomplish varied degrees of removal of suspended solids and reduction of carbonaceous and nitrogenous oxygen demand. Choice of the most applicable process will be influenced by the proposed plant size, type of waste to be treated, treatability of waste, degree and consistency of treatment required, and local factors. All designs shall provide for flexibility in operation. All plants with a design over 1 MGD at AWW flow over 1 mgd should be designed to be operable in more than one mode. Seasonal organic loadings and significant wet weather flow increases are factors that affect mode of operation.

8B.3 PRETREATMENT

When primary settling tanks are not used, effective removal or exclusion of grit, debris, and excessive oil or grease, and comminution/grinding or screening of solids shall be accomplished prior to the activated sludge process. Where primary settling is used, it may be desirable to include provisions for discharge of raw wastewater directly to the aeration tanks to facilitate plant startup and initial operation.

8B.4 AERATION

8B.4.1 Design Basis

In addition to the requirements of IWFDS Chapter 1, the design basis for an activated sludge process shall be prepared by the owner's representative ~~an~~ engineer (as indicated in Schedule A) and included in the engineering report or facilities plan or submitted under separate cover for review and approval. The design basis shall include a discussion of all of the following:

- All design parameters used in sizing the activated sludge treatment facilities;
- Mode of operation, including discussion of process flexibility;
- Influent wastewater characteristics and flows, including the ADW, AWW, MWW, and PHWW flows;
- Wastewater temperature range, including estimates of temperature losses through the treatment plant and subsequent effect on removal efficiencies;
- Pretreatment of the waste;
- Effects of variable hydraulic and organic loadings applied to the aeration basins and secondary clarifiers, particularly variations resulting from infiltration/inflow to the system;
- Anticipated MLSS concentration to be maintained in the aeration basin;
- Aeration time;
- Oxygen transfer and mixing requirements at the ADW, AWW, and MWW flows;
- Where nitrification is required, evaluation of process alkalinity requirements;

- Sludge recirculation and wasting (ranges and average values), including proposed method of control and anticipated typical operating mode; and
- Design calculations for oxygen requirements, blower or aerator capacity, aeration basin and clarifier sizing, clarifier solids loading, and treatment efficiency.

8B.4.2 Capacities and Permissible Loadings

8B.4.2.1 Aeration tank size shall be determined by full scale experience, pilot plant studies, and/or rational calculations based on food to microorganism ratio, solids retention time, and MLSS levels. Other factors, such as treatment plant size, diurnal load variations, and degree of treatment required shall also be considered.

~~8B.4.2.2~~ Table 1 represents typical design parameters for domestic wastewater. Design parameters differing substantially from those in Table 1 may be allowed if applicable references are submitted demonstrating their use and long-term effectiveness. These may include but are not limited to shall referencedata from actual operating plants, ~~or~~ pilot plant studies, standard textbooks or current technical literature. Table 1 applies to plants receiving peak to average diurnal organic load ratios ranging from approximately 2:1 to 4:1. The department may approve organic loading rates that exceed those specified in Table 1 if flow equalization is provided to reduce the diurnal peak organic load.

~~8B.4.2.3~~ The single stage of a two-stage activated sludge system designed to remove ammonia shall maintain adequate alkalinity concentrations and a pH level between 7.2 and 8.4. Chemical feed equipment shall be provided if necessary. Flow equalization shall be considered where necessary to limit TKN peaks resulting from industrial wastes. For two stage systems, CBOD₅ concentration to the second stage should be limited to 20–50 mg/L. A bypass around the first stage shall be provided to allow discharge of raw or primary settled wastewater to the second stage aeration tank as needed for process control.

~~8B.4.2.4~~ Due to the dilute nature of some design load concentrations, a minimum hydraulic detention time may be required to ensure that the colloidal, finely suspended, and dissolved organics are adsorbed by the activated sludge. The minimum hydraulic detention time shall be based on the AWW flow plus the return sludge flow and shall not be less than 60 minutes.

~~8B.4.3~~ **Aeration Tanks**

~~8B.4.3.1~~ Multiple Units ~~Multiple units shall be provided in accordance with IWFDS Chapter 4. Tanks shall be designed so that each tank may be dewatered and operated independently.~~

Table 1. Typical Aeration Tank Loadings and Design Parameters

Process	<u>Aerobic Solids Retention* Time-Days</u>	<u>Maximum Aeration Tank Organic Loading^a lbs BOD₅/1,000 ft³/day</u>	<u>F/M Ratio^a lbs BOD₅/lbs MLVSS/day</u>	<u>MLSS^b mg/L</u>
Conventional, Step Aeration, and Complete Mix and Conventional (Without Nitrification)	63-1510	4050	0.2-0.5	1,000-3,000
Contract Stabilization (Without Nitrification)	65-1510****c	5065^{c***}	0.2-0.6 ^{c***}	1,000-3,000
Extended Aeration (Provides Nitrification)	>1520-30	1520	0.05-0.1	3,000-5,000
Single-Stage Nitrification (Combined Carbon Oxidation- and Nitrification)	15-25>10	1525	0.081-0.162	2,000-5,000
Carbonaceous Stage of Separate-Stage Nitrification	3-10	70	0.3-0.8	1,000-2,500
Nitrification Stage of Separate-Stage Nitrification	15-25	10 ^{d*}	0.05-0.20 ^{e**}	1,000-3,000

^a Based on the influent organic load to the aeration tank(s) at the maximum 30-d BOD₅ design load. The influent organic load to the aeration tank(s) may consider BOD₅ reductions from preceding treatment units or zones that meet the reliability criteria of IWFDS Section 4.5. Excludes BOD₅ attributable to supplemental carbon sources used to sustain biological nutrient removal processes.

^b For systems incorporating biological nutrient removal meeting the reliability criteria of IWFDS Section 4.5, MLVSS and MLSS concentrations may be determined using anaerobic and anoxic as well as aerobic mixed volumes. The MLVSS mass in the F/M Ratio is the mass in the aeration tank(s) only.

^c Total aeration capacity includes both contact and reaeration capacities.

^d lbs NH₃-N/1,000 ft³/d

^e lbs NH₃-N/lbs MLVSS/d

Process	Aerobic Solids Retention* Time-Days	Maximum Aeration Tank Organic Loading* ^a lbs BOD ₅ /1,000 ft ³ /day	F/M Ratio* ^a lbs BOD ₅ /lbs MLVSS/day	MLSS ^b mg/L
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*Maximum—30 day BOD₅ loading

**lbs NH₃-N/1,000 ft³/day

***lbs NH₃-N/lbs MLVSS/day

****Total aeration capacity includes both contact and reaeration capacities.

8B.4.3 Aeration Tanks

8B.4.3.1 Multiple Units - Multiple units shall be provided in accordance with IWFDS Chapter 4. Tanks shall be designed so that each tank may be dewatered and operated independently.

8B.4.3.2 Tank Geometry - Tank dimensions shall not inhibit effective mixing or utilization of air. Liquid depths should not be less than 10 ft or more than 30 ft. The shape of the tank and the installation of aeration equipment shall provide for positive control of short-circuiting through the tank.

8B.4.3.3 Freeboard and Froth Control - All aeration tanks shall have a minimum freeboard of 18 inches. Suitable water spray systems or other approved means of froth and foam control shall be provided if excessive foaming is anticipated. Otherwise, provisions for future installation of froth or foam control should be considered.

8B.4.3.4 Inlet and Outlet Control - Inlets and outlets for each aeration tank unit shall be suitably equipped with valves, gates, stop plates, weirs, or other devices to permit balancing, proportioning, and splitting of the flow to and from any unit, and to maintain reasonably constant liquid level. The hydraulic elements of the system shall permit the peak hydraulic load to be carried with any single aeration tank out of service. This shall be done in accordance with IWFDS Subsection 4.4.9.3.

8B.4.3.5 Conduits - Channels and pipes carrying liquids with solids in suspension shall be designed to maintain self-cleansing velocities or shall be agitated to keep such solids in suspension at all design rates of flow. Provisions should be made to drain segments of channels when not in use.

8B.4.3.6 Winter Protection - Protection against freezing shall be considered to ensure continuity of operation and performance in cold weather. Maximum utilization of earthen bank insulation should be considered to minimize heat losses.

8B.4.4 Aeration Equipment

8B.4.4.1 General

- Aeration requirements depend upon mixing energy, BOD₅ and nitrogen loading, degree of treatment, oxygen uptake rate, MLSS concentration, and sludge age. Required oxygen delivery shall be determined using a minimum dissolved oxygen concentration of 2 mg/L in aerobic basins or zones. Aeration equipment shall be capable of maintaining a DO concentration of 2.0 mg/L in the aeration tanks at all times. Energy transfer shall be sufficient to maintain the mixed liquor solids in suspension.
- In the absence of experimentally determined values, the design oxygen requirements for all activated sludge processes (with the exception of the extended aeration process) shall be 1.1 lbs oxygen/lb BOD₅/day at the MWW flow, plus 50% of the difference between the MWW flow and four-hour peak above that rate based on the maximum 30-day BOD₅ loading applied to the aeration tanks. For the extended aeration process, the design oxygen requirements shall be 1.85 lbs oxygen/lb peak 12-hour maximum 30-d BOD₅.
- For nitrification, the oxygen requirement for oxidizing ammonia must be added to the above requirement for CBOD₅ removal. The nitrogenous oxygen demand (NOD) shall be 4.6 times the daily TKN content of the influent at MWW flow maximum day TKN loading.
- An allowance for oxygen recovery through denitrification may be considered where denitrification unit processes and equipment meet the reliability criteria of IWFDS Section 4.5.
- Additional oxygen shall be supplied to meet the oxygen demands due to recycle flows, including, but not limited to, anaerobic digester, thickener or sludge storage facilities supernatant and sludge dewatering, belt press centrate/filtrate, and elutriates.
- Careful consideration should be given to maximizing oxygen utilization per unit power input. Unless flow equalization is provided, consideration should be given to designing the aeration system to match the diurnal organic load variations while economizing power input.

8B.4.4.2 Diffused Air System

1. Design calculations for diffused air systems shall consider:
 - a. Tank depth;
 - ~~b.~~ b. Alpha factor of wastes (considering aeration device characteristics and tank geometry);
 - ~~b-c.~~ c. Fouling factor;
 - ~~c-d.~~ d. Beta factor of waste;
 - ~~d-e.~~ e. Certified aeration device transfer efficiency;
 - ~~e-f.~~ f. Minimum aeration tank DO concentrations;
 - ~~f-g.~~ g. Critical wastewater temperature; and
 - ~~g-h.~~ h. Altitude of the plant.

In the absence of experimentally determined alpha, fouling and beta factors, wastewater field oxygen transfer efficiency shall be assumed to be not greater than 50 percent of clean water oxygen transfer efficiency for plants treating primarily (90 percent or greater) domestic wastewater. Treatment plants where the wastewater contains higher percentages of industrial wastes shall consider lower field transfer efficiencies due to the presence of wastes that may result in diminished oxygen transfer capability. 10% or more of the waste is industrial waste shall experimentally determine the alpha and beta factors and shall submit test result calculations to justify the factors. The design basis shall include detailed computations for all diffused air systems and account for the factors listed above.

2. Blowers or air compressor capacity design should consider that the air intake temperature may reach 104°F (40°C) or higher and that the barometric pressure may be less than normal.
3. Motor drive capacity design should consider that the intake air temperature may reach -22°F (-30°C) or lower, which may require motor oversizing as a means of reducing the rate of air delivery to prevent overheating or damage.
4. Multiple blowers shall be provided. Blowers shall be arranged ~~and~~ in such capacities as to meet the maximum total air demand with the single largest unit out of service. Blower design shall provide for the ability to adjust air flow in proportion to the load demand of the plant. Aeration equipment shall be easily adjustable in increments and maintain solids suspension within the limits.
5. Air piping systems should be designed such that total head loss from blower outlet (or silencer outlet where used) to the diffuser inlet does not exceed 0.5 pounds per square inch at average operating conditions. The air diffusion piping and diffuser system shall be capable of delivering air without excessive head loss with all available blowers on. Air diffusion piping includes all of the piping from the blower to the aeration basin. Diffusers shall should be spaced to meet in accordance with the mixing and oxygenation requirements throughout the length of the channel or tank and should be designed to facilitate spacing adjustments without major revision to air header piping. Diffusers in any single assembly shall have substantially uniform pressure loss.
6. Individual diffuser assembly units shall be equipped with control valves, preferably with indicator markings for throttling and for complete shut off. For aeration basin configurations that do not meet Unit Process Reliability Criteria B or C (IWFDS Section 4.5.2) the diffuser arrangement shall permit unit removal for inspection, maintenance, and replacement without dewatering the tank and without shutting off the air supply in the tank, unless the dewatering basins are 50% or less of the total aeration basin capacity.
7. Air filters shall be provided in such numbers, arrangement, and capacities as to furnish at all times an air supply sufficiently free from dust to prevent clogging of the diffuser system. Air filters will not be required where coarse bubble diffusers are used.

8B.4.4.3 Mechanical Aeration Systems

1. Oxygen Transfer Performance - The mechanisms and drive unit shall be designed for the expected conditions in the aeration tank in terms of the power performance. Certified testing ~~shall~~ should be provided to verify mechanical aerator performance. Refer to applicable provisions of Section 8B.4.4.2. In the absence of specific design information, the oxygen transfer capability shall be calculated using a clean water transfer rate not to exceed 2 pounds of oxygen per horsepower per hour under standard test conditions. Design transfer efficiencies shall be included in the specifications.
2. Design Requirements - The mechanical aeration system shall:

- a. ~~Determine oxygen delivery using a minimum dissolved oxygen concentration of 2 mg/L in aerobic basins or zones. Maintain a minimum of 2.0 mg/L of DO in the mixed liquor at all times throughout the tank or basin;~~
 - b. Provide a liquid waste turnover time such that a minimum velocity of 1.0 fps is maintained at all points in the basin to provide adequate mixing and to prevent solids deposition;
 - c. Be protected from excessive ice coating in inclement weather; and
 - d. Include multiple unit installation designed to meet the maximum oxygen demand with the largest unit out of service and provide for rapid replacement.
3. The design should also provide for varying the amount of oxygen transferred in proportion to the load demand on the plant. If depth of submersion is an important criterion, the aeration system shall be adjustable or the basin levels shall be readily controllable with regard to depth. Spray protection in the form of mist shields or high walls around tanks should be considered.

8B.5 RETURN SLUDGE EQUIPMENT

8B.5.1 Return Sludge Rate

The minimum permissible return sludge rate of withdrawal from a settling tank is a function of the concentration of suspended solids in the mixed liquor entering the tank, the sludge volume index of the solids, and the length of time the solids in the final settling tanks may be deleterious to the aeration and sedimentation phases of the activated sludge process. The rate of sludge return expressed as a percentage of the AWW design flow shall be variable between ~~limits of 25 – 100%. This requirement shall apply to all activated sludge processes except extended aeration, single stage nitrification, and the nitrification stage of separate stage nitrification, for which the return sludge rate shall be variable from 50 – 150%~~the values set forth as follows:-

Table 2. Return Sludge Rates

<u>Type of Process</u>	<u>% of Design AWW Flow Lower^a</u>	<u>% of Design AWW Flow Upper^a</u>
<u>Conventional, Step Aeration, Complete Mix, or Carbon Oxidation Stage of Separate-Stage Nitrification</u>	<u>10</u>	<u>67</u>
<u>Contact Stabilization, Single-Stage Nitrification (Combined Carbon Oxidation and Nitrification) or Extended Aeration</u>	<u>33</u>	<u>100</u>
<u>Nitrification Stage of Separate-Stage Nitrification</u>	<u>33</u>	<u>133</u>

^a Minimum rates below the lower values or maximum rates above the upper values, i.e. wider ranges, are acceptable.

8B.5.2 Return Sludge Pumps

8B.5.2.1 If motor driven return sludge pumps are used, the maximum return sludge capacity shall be obtained with the largest pump out of service. The rate of sludge return shall be varied by means of variable speed motors or drives or other suitable means. A positive head should be provided on pump suctions. Pumps shall have at least three-inch suction and discharge openings.

8B.5.2.2 If air lift pumps are used for returning sludge from each settling tank, no standby unit shall be required provided that the air lifts are designed to facilitate rapid and easy cleaning. Air lifts should be at least three inches in diameter.

8B.5.3 Return Sludge Piping

8B.5.3.1 Suction and discharging piping should be at least four inches in diameter and should be designed to maintain a velocity of not less than 1.0 fps when return sludge facilities are operating at ~~normal~~-return sludge rates within the ranges of IWFDS Section 8B.5.1. (25%–150%).

8B.5.3.2 ~~Independent~~ Devices for observing, measuring, sampling and controlling return activated sludge flow from each settling tank shall be provided, as outlined in IWFDS Section 6.4.2.4.

8B.5.4 Waste Sludge Control

8B.5.4.1 Waste sludge control facilities should be sized based on the expected maximum sludge production rates and minimum sludge concentrations. Although continuous wasting is preferred, for non-continuous wasting the capacity of pumps and pipelines should be designed to handle the wasting rates expected. have a maximum capacity of not less than 25% of the AWW flow and function satisfactorily at rates of 0.5% of ADW flow or a minimum of 10 gallons/minute, whichever is larger.

8B.5.4.2 Means for observing, measuring, sampling and controlling waste activated sludge flow shall be provided. It is desirable to have separate waste sludge equipment so that sludge return is not interrupted.

8B.6 SEQUENCING BATCH REACTORS

Batch fill-and-draw or continuous inflow batch draw variants of the activated sludge process may be approved on a case-by-case basis. The design shall meet applicable requirements of Chapters 4, 6 and 8B, except as modified in this Section. Reliability of treatment equal to that of the continuous flow-through modes of the activated sludge process shall be provided.

8B.6.1 Design Requirements

8B.6.1.1 Design F/M ratios in the range of 0.05 to 0.1 pounds of BOD₅ per day per pound of MLVSS are permissible. The aeration tank organic loading should not exceed 15 pounds BOD₅ per 1,000 cubic feet per day. The reactor MLSS and MLVSS concentrations and aeration tank organic loading should be calculated at the low-water level.

8B.6.1.2 More than two (2) tanks should be provided. Two tanks may be acceptable where in-line flow equalization is provided in addition to the decantable volume.

8B.6.1.3 Designs employing fewer than 4 basins shall provide a decantable volume of at least four (4) hours with the largest tank out of service based on 100 percent of the design MWW. In-line flow equalization capacity may be considered in determining the decantable volume.

8B.6.1.4 System reliability with any single aeration tank unit out of service and the instantaneous delivery of flow shall be evaluated in the design of decanter weirs and approach velocities.

8B.6.1.5 Solids-excluding decanters are required.

8B.6.1.6 The treated effluent from each reactor should be free of scum and should have a design suspended solids concentration no greater than 30 mg/L at any time. Scum removal shall be provided. An adequate zone of separation between the sludge blanket and the decanter(s) shall be maintained throughout the decant phase.

8B.6.1.7 Decanters that draw the treated effluent from near the water surface throughout the decant phase are recommended.

8B.6.1.8 Solids management to accommodate tank dewatering shall be considered. See IWFDS Section 4.4.8.2.

8B.6.1.9 The blowers shall be provided in multiple units, so arranged and in such capacities as to meet the maximum air demand in the oxic portions of the fill and react phases of the cycle with the single largest unit out of service. See IWFDS Section 8B.4.4.

8B.6.1.10 Mechanical mixing independent of aeration should be considered for all systems where biological nitrogen and/or enhanced biological phosphorus removal is required. Mixing equipment should be sized to thoroughly mix the entire tank from a settled condition within five (5) minutes without aeration.

8B.6.1.11 All 24-hour effluent quality composite samples for monitoring process operations should be flow-paced and should include samples collected at the beginning and end of each decant phase. Continuous turbidity monitoring to separately monitor the effluent quality from each tank is recommended.

8B.6.1.12 A programmable logic controller (PLC) shall be provided. Multiple PLCs should be provided as necessary to ensure rapid process recovery and minimize the deterioration of effluent quality from the failure of a single controller. An uninterruptible power supply with electrical surge protection shall be provided for each PLC to retain program memory through a power loss. A hard-wired back-up for manual

override shall be provided in addition to automatic process control. Both automatic and manual controls shall allow independent operation of each tank.

8B.6.2 Additional Considerations

As necessary, consideration shall be given to pretreatment, positive flow division control, measures for creating uniform waste loadings to each tank, diffusers suitable for cyclic aeration, type of decanter, emergency overflow, effect of peak discharge flow rates on downstream process units, sludge transfer and sludge wasting.

8B.7 BIOLOGICAL NUTRIENT REMOVAL

Biological Nutrient Removal (BNR) processes may be approved on a case-by-case basis with consideration of applicable design information derived from data from actual operating plants, pilot plant studies, standard textbooks or current technical literature. For BNR processes that are not well established see IWFDS Section 4.4.3. The design shall meet applicable requirements under IWFDS Chapters 4, 6 and 8B except as modified in this Section.

Consideration shall be given to wastewater composition, type of BNR treatment process, peak wastewater flow rates, actual nutrient loading relative to the plant design capacity (with all recycle flows excluded), effluent requirements, presence of biological inhibitors or toxic constituents, initial low flow conditions, anticipated treatment efficiency, side stream recycle flows (e.g., digester, thickener, or sludge storage facilities supernatant, sludge dewatering centrate/filtrate, wet oxidation return stream, etc.), internal recycle flows (e.g., mixed liquor, RAS), chemical usage, process control and maintenance requirements, and optimum operation for water quality protection.

All designs shall provide for flexibility in operation and should provide for operation in various BNR modes, if feasible. Unit process reliability for BNR facilities (e.g., anaerobic or anoxic basins) in accordance with IWFDS Section 4.5 is required where BNR is proposed to meet effluent limits established by Iowa Water Quality Standards or an EPA-approved Water Quality Improvement Plan (Total Maximum Daily Load) and recommended for other BNR applications. Provisions for chemical phosphorus removal may be considered in lieu of unit process reliability for EBPR processes. Sufficient numbers of installed vital components for mixed liquor recycle or mechanical mixing to maintain design capacity with the largest unit(s) offline are recommended.

8B.7.1 Biological Nitrogen Reduction

Biological nitrogen removal is typically accomplished by biological oxidation of ammonia to nitrate (nitrification) followed by biological denitrification of nitrate to nitrogen gas.

8B.7.1.1 Nitrification - Biological nitrification is used to convert ammonia to nitrate to meet effluent requirements or as the first step in nitrogen removal. Ammonia is oxidized to nitrite and then to nitrate by nitrifying bacteria in an aerobic environment. Nitrification consumes alkalinity.

Nitrification can be achieved with either a single-stage nitrification process (combined carbon oxidation and nitrification) or with a separate-stage nitrification process. In each case, suspended growth, attached growth or hybrid systems can be used. See Sections 8B.4 and 8B.5.

For plants subject to high wet weather flows, often also associated with low temperatures, flexibility in design and operation to periodically aerate additional zones (i.e., swing zones) should be provided as necessary to ensure that nitrification is consistently achieved and maintained as part of the BNR process. Swing zones are zones in a biological reactor that can be operated in multiple modes such as anaerobic, anoxic, or aerobic conditions, depending on the operational strategy.

8B.7.1.2 Denitrification - Denitrification is the biological process where facultative bacteria (i.e., most heterotrophs and some autotrophs) convert nitrate to nitrogen gas under anoxic conditions. The process generates alkalinity and therefore restores up to half the alkalinity consumed during nitrification.

A soluble, biodegradable organic carbon source is required to drive the denitrification process. The carbon requirements for denitrification may be provided by influent wastewater, sludge fermentation, or by an external source such as methanol, ethanol, acetate or glycerin. For BNR processes that have both a pre-

anoxic zone before the nitrification zone and a post-anoxic zone, denitrification in the post-anoxic zone is driven by either carbon from endogenous activity or an external carbon source that may be added to accelerate the denitrification rate in that zone. An aerobic zone typically follows the post-anoxic zone.

The anoxic zone(s) of a BNR process may be divided into two (2) or more cells, one of which can be equipped with both mixers and aerators designed to operate independently, to allow for operation in either anoxic or oxic mode (i.e., sing zone), as necessary. Flexibility in operation should be provided to adequately address potential fouling of aeration devices during extended periods of anoxic operation. Consider baffling to maintain zone integrity and prevent any short-circuiting or back-mixing.

8B.7.2 Enhanced Biological Phosphorus Removal

A number of process configurations for enhanced biological phosphorus removal (EBPR) have been developed as alternatives to phosphorus removal by chemical treatment (see IWFDs Section 9.2). Phosphorus accumulating organisms (PAOs) in EBPR process biological solids incorporate phosphorus into their cell mass in excess of their metabolic requirements, allowing them to achieve enhanced removal of phosphorus from wastewater. Exposure of activated sludge microorganisms to alternating anaerobic and aerobic conditions allows PAOs to proliferate in numbers sufficient to remove phosphorus.

The design shall ensure that readily biodegradable organic matter in sufficient quantities is available in an anaerobic environment to promote the proliferation of PAOs, which is reflected by the release of ortho-phosphate in the anaerobic zone of the EBPR process. The amount of readily biodegradable organic matter can be increased by fermentation of wastewater sludge, or a fermentable supplemental carbon source, or by the addition of supplemental volatile fatty acids such as acetic acid.

The volume of the anaerobic zone should be large enough to accommodate EBPR without switching off mechanical mixers. In no case should the design anaerobic mass fraction be less than 12 percent, with 20 to 25 percent being desirable. The anaerobic mass fraction is the amount of sludge subjected to anaerobic conditions relative to the total mass of sludge in all of the BNR reactor zones. Timers and/or VFDs for mechanical mixers should be provided for all plants to allow for process optimization. Consider baffling to maintain zone integrity and prevent any short-circuiting or back-mixing.

To create truly anaerobic conditions, both dissolved oxygen and combined oxygen (e.g., nitrate) shall be excluded. Many EBPR process configurations include the denitrification process to limit the nitrate concentration in the anaerobic zone.

Intermittent mixing in the mainstream anaerobic zone for settling and fermentation of MLSS or the alternative of a side stream anaerobic fermentation tank(s) for RAS may be desirable in cases where the readily biodegradable organic content in the influent wastewater is low (i.e. low readily biodegradable chemical oxygen demand relative to total phosphorus, or rbCOD to TP ratio).

EBPR process sludge containing the excess accumulated phosphorus can be wasted, or the excess phosphorus can be removed and recovered from the waste sludge by a side stream sludge treatment process. The EBPR process may require chemical treatment as a back-up system or for polishing to achieve very low effluent phosphorus levels. The EBPR process is often combined with nitrification and denitrification processes.

8B.7.3 Combined Biological Nitrogen and Phosphorus Removal

A number of BNR processes have been developed for the combined biological removal of nitrogen and phosphorus. Combinations of anaerobic, anoxic and aerobic zones or compartments are designed to accomplish biological nitrogen and phosphorus removal.

8B.7.4 BNR Monitoring

8B.5.4.2 Monitoring equipment to routinely measure ortho-phosphate, nitrate, nitrite, dissolved oxygen and ammonia in all zones (i.e., anaerobic, anoxic and aerobic) is recommended at appropriate locations. Oxidation-reduction potential (ORP) monitoring may also be beneficial for process control.

CHAPTER 8C: WASTEWATER TREATMENT LAGOONS (PONDS)

8C.1 APPLICABILITY AND SCOPE

This chapter is applicable to the construction, installation, or modification of any lagoon-type disposal system required to obtain a construction permit from the department under Iowa Code section 455B.183 and rule 567—60.2(455B).

The term “lagoon” is used in this chapter to include the total earthen treatment facility. The term “cell” is used to designate the individual units of the total facility. The terms “seal” or “sealing” are used in this chapter to mean the methods and materials as detailed in Section 8C.7.3.

These design criteria deal specifically with the design of earthen wastewater treatment lagoon (pond) systems. The emphasis is on wastewater treatment lagoon systems which will serve as the sole wastewater treatment system for domestic wastewater. The use of wastewater treatment lagoons as supplementary treatment in combination with other treatment systems shall require evaluation on a case-by-case basis.

Wastewater treatment lagoon systems under this chapter are systems designed to achieve secondary treatment effluent limitations by reducing the BOD₅ without maintaining all biological solids in suspension. Systems considered shall be the 180-day controlled discharge lagoon system and the flow-through aerated facultative lagoon system. Flow-through photosynthetic lagoon systems shall not be considered as a viable treatment alternative for achieving secondary effluent limitations.

8C.2 SUPPLEMENT TO ENGINEERING REPORT

The engineering report shall contain pertinent information on location, geology, soil conditions, area for expansion, and any other factors that will affect the feasibility and acceptability of the proposed project. The following information must be included in the engineering report, in addition to that required in IWFDS Chapter 1.

8C.2.1 Area Development

Provide the location of all residences, commercial developments, parks, recreational areas, and water supplies, including a log of each well (if available) within one-quarter mile of the proposed lagoon. If a well log is not available, or is incomplete, all available construction details shall be provided, including, but not limited to, well and casing depths, casing material, pumping rate, or static and pumping water levels.

8C.2.2 Area Planning

Discuss any applicable land use zoning adjacent to the proposed lagoon site. The project shall conform with local and regional planning. Clearance from the appropriate planning agencies shall be included when required.

8C.2.3 Site Description

Provide a site description, including maps showing elevations and contours of the site and adjacent area. Due consideration shall be given to additional treatment units and increased waste loadings in determining land requirements. Current U.S. Geological Survey and Soil Conservation Service maps may be considered adequate for preliminary evaluation of the proposed site.

8C.2.4 Field Tile

Provide the location, depth and discharge point(s) of any field tile in the immediate area of the proposed site.

8C.2.5 Soils Testing

Data from soil borings conducted by a qualified engineering organization normally engaged in soil testing activities and a discussion of their effect on construction and operation of the lagoon shall be submitted, in order to determine the subsurface soil characteristics and groundwater characteristics (including elevation and flow) of the proposed site. The number and location of the soil borings will vary on a case-by-case basis as determined by the design engineer. Soil boring data shall be submitted to the department for verification and acceptance prior to the construction of a lagoon system. The following are minimum requirements for soil borings:

8C.2.5.1 A minimum of three borings will be required for lagoons 0.5 acres or less, and four or more for lagoons larger than 0.5 acres. One additional boring per acre is recommended for lagoons larger than four acres where borings show inconsistent soils.

- 8C.2.5.2** Location emphasis shall be placed at points of deepest excavation; however, a true cross-sectional indication of substrata characteristics for the entire site shall be provided.
- 8C.2.5.3** All borings should be taken to a minimum depth of 10 feet below the bottom elevation of the lagoon.
- 8C.2.5.4** At least one boring shall be taken to a depth of 25 feet below the bottom elevation of the lagoon or into bedrock, whichever is shallower. If the boring of 25 feet encounters a water bearing strata, each of the required borings shall also extend to the water bearing strata, with a maximum depth of 25 feet.
- 8C.2.5.5** For sites where bedrock is encountered, samples at five-foot intervals from one appropriate boring shall be submitted along with boring logs, boring locations, and the soils report on the site.
- 8C.2.5.6** All borings shall be backfilled with excavated material, except for borings encountering sand, gravel or a water bearing strata, which shall be backfilled with a mixture of natural soil and bentonite.
- 8C.2.5.7** Sufficient soil borings shall be taken at borrow pit areas to establish the consistency and nature of the material as it relates to the use of borrow material within the lagoon construction. The boring depths are optional, but they should be at least one foot below the lowest borrow layer.
- 8C.2.5.8** The type of soil sealant and the amount required to meet percolation standards shall be determined prior to construction by laboratory permeameter testing. Such testing shall be done by the consulting engineering firm or by an independent soil testing laboratory. Results provided by a sealant supplier laboratory are not acceptable.
- 8C.2.5.9** A procedure should be used similar to that submitted by C.L. Sawyer of the Bureau of Public Roads, on pages 141-145 of ASTM's Fifth Edition of *Special Procedures for Testing Soil and Rock for Engineering Purposes* (ASTM STP479). Also acceptable are similar methods which deal with the evaluation of relatively tight systems using falling-head permeameters.
- 8C.2.5.10** Seal testing subsequent to construction shall be done in accordance with Subsection 8C.7.3.2.

8C.3 LOCATION

8C.3.1 Site Inspection

Proposed wastewater treatment lagoon sites shall be inspected as required by 567—paragraph 60.2(2)"a" and meet the separation distances under 567—paragraph 60.2(2)"c." The requirements of 567—paragraph 60.2(3)"c" must be met before a site survey can be conducted.

8C.3.2 Future Expansion

Lagoon site selection should consider the possibility of expansion or addition of future treatment units as may be necessary to meet applicable discharge standards.

8C.3.3 Prevailing Winds

If practical, the lagoon should be located so that prevailing winds will be in the direction of uninhabited areas.

8C.3.4 Surface Runoff

8C.3.4.1 Provisions shall be made to divert all stormwater runoff from entering the lagoon, thus protecting the lagoon from excessive hydraulic loadings, inner-embankment erosion, and siltation.

8C.3.4.2 Storm sewers or other conveyances for stormwater shall not be located under lagoon cells. Storm sewers may be placed within the dike itself if all of the following conditions are met:

1. The flow line (invert) of the storm sewer is not more than three feet below the high-water level in the adjacent lagoon cells;
2. The horizontal distance from the centerline of the storm sewer to the adjacent lagoon cell water surface is at least eight feet; and
3. The storm sewer is centered in the dike in such a manner that excavation of the storm sewer could be accomplished without disturbing the inner sloped embankments of the dike.

8C.3.4.3 Erosion protection shall be provided for all external stormwater ditches as needed to prevent erosion of the outer lagoon embankments.

8C.3.5 Hydrology

8C.3.5.1 Horizontal Separation - Construction of the lagoon in close proximity to water supplies and other facilities vulnerable to contamination should be avoided, but in no case shall the separation distances be less than the minimum requirements of 567—paragraph 60.2(2)"c" and IWFDS Section 4.2.3.

8C.3.5.2 Vertical Separation

1. A minimum separation of four feet between the top of the seal and the maximum groundwater table is recommended; however, in no case shall the top of the lagoon seal be below the maximum groundwater table. If the maximum anticipated groundwater table is less than two feet below the top of the seal, the lagoon shall be provided with a synthetic liner as described in Subsection 8C.7.3.2.a.
2. Provisions for lowering of groundwater layers on a site may be considered. Minimum requirements shall include the permanent lowering of the groundwater table to an elevation one foot below the top of the seal. Detailed justification shall be provided to confirm the adequacy of the proposed permanent groundwater lowering method.
3. At the nearest point, drainage tile shall be installed a horizontal distance of at least two feet outside any lagoon embankment.

8C.3.6 Geology**8C.3.6.1 Karst Features**

1. All proposed lagoon facilities in Karst areas will be subject to a special hydrogeologic site review before facility plan approval. If the facility is or will be located in an area of known or suspected Karst topography, all cells shall be lined with a synthetic liner.
2. Lagoons shall not be located on sites that exhibit Karst features, such as sinkholes or solution channeling in areas underlain by limestone or dolomite. If it is determined that a potential for sinkhole development exists at the site, a lagoon system will not be permitted.

8C.3.6.2 Bedrock Separation - A separation of ten feet between the top of seal and any bedrock formations is recommended. A minimum separation of four feet is required. A synthetic liner shall be required if the top of the seal is to be located less than ten feet above a carbonate or sandstone formation.

8C.3.7 Flooding Protection

The top of the lagoon embankments shall be constructed at least one foot above the elevation of the Q100 (100-year flood). Other flood protection requirements shall be in accordance with IWFDS Section 4.2.6.

8C.4 DESIGN LOADINGS**8C.4.1 Hydraulic**

8C.4.1.1 Controlled Discharge Lagoons - The hydraulic design of controlled discharge lagoons shall be based upon the average flow for the wettest 180 consecutive days of record (AWW-180 flow). The design flow may be adjusted to account for infiltration and inflow eliminated by sewer system rehabilitation.

8C.4.1.2 Aerated Lagoons

1. For municipal wastes, the hydraulic flows used to determine aerated lagoon cell sizes shall be based upon the ADW flow plus 30% of the 30-day AWW flow in excess of the ADW flow, or 100 gpcd, whichever is greater, in accordance with Section 8C.6.1. The design flow may be adjusted to account for infiltration and inflow eliminated by sewer system rehabilitation.
2. For industrial and commercial wastes, the hydraulic flows used to determine cell sizes shall be based upon the average daily flow for the maximum 15-day period, in accordance with Section 8C.6.1. This value may be reduced up to 10% if the average daily flow for the maximum 30-day period is less than 70% of the 15-day value.

8C.4.1.3 Other Waste Sources - The hydraulic flows used to determine cell sizes for low volume waste sources such as parks, camps, schools, campgrounds, or similar facilities can be based on published values for liquid waste generation from that type of facility, in accordance with Sections 8C.5.3 and 8C.6.1. The design flows for new municipal systems shall comply with IWFDS Subsection 4.4.5.4.

8C.4.2 Organic

The organic design loads for lagoons shall comply with IWFDS Section 4.4.6.

8C.4.3 Industrial Waste

The industrial waste design flows and loads for lagoons shall comply with IWFDS Subsections 4.4.5.5 and 4.4.6.2 and Section 8A.4.

8C.5 CONTROLLED DISCHARGE LAGOON DESIGN**8C.5.1 Number of Cells**

8C.5.1.1 Two Cells - A minimum of two cells are required for small installations in which less than one acre of total surface area is required. Two-cell systems shall consist of one primary cell and one secondary cell. The primary cell should contain approximately two-thirds of the total water surface area.

8C.5.1.2 Three Cells - A minimum of three cells are required for all facilities with greater than one acre of total surface area. Systems consisting of three or more cells shall have a minimum of two secondary cells and one or more primary cells.

8C.5.2 Organic Loading

8C.5.2.1 Two Cells - The maximum organic loading on the primary cell of a two-cell controlled discharge lagoon system shall be based upon the water surface area of the primary cell at the maximum lagoon water depth and shall not exceed 20 pounds of BOD₅/acre/day.

8C.5.2.2 Three or More Cells - The maximum organic loading on the primary cell(s) of a three-or-more cell controlled discharge lagoon system shall be based upon the total water surface area of the primary cell(s) at the maximum lagoon water depth and shall not exceed 25 pounds of BOD₅/acre/day.

8C.5.3 Hydraulic Storage**8C.5.3.1 Entire System**

1. Controlled discharge lagoon systems shall provide a minimum hydraulic storage time of 180 days based upon the wettest 180 consecutive days of record, except where hydraulic storage times of greater than 180 days are required to maintain the quality of the receiving stream.
2. Storage shall be computed as the total volume provided in the entire system between the two-foot depth level and the maximum water surface level. The volume below the two-foot level shall not be considered when computing storage time.

$$\text{Storage} = \frac{V}{Q} \geq 180 \text{ days}$$

V = volume above the two-foot depth level of the entire system and below the maximum water surface level, in gallons.

Q = average daily design flow based on the wettest 180 consecutive days of record, in gpd. The design flow may be adjusted to account for infiltration and inflow eliminated by sewer system rehabilitation.

8C.5.3.2 Secondary Cells - The secondary cells of a controlled discharge lagoon having three or more cells shall provide a minimum storage of 30 days each. The secondary cell of a two-cell system shall provide a minimum storage of 60 days.

8C.5.4 Liquid Depths

8C.5.4.1 Primary Cells - The liquid depth of the primary cell(s) shall not exceed a total of six feet.

8C.5.4.2 Secondary Cells - The liquid depth of the secondary cell(s) shall not exceed a total of eight feet.

8C.5.5 Piping Arrangement

8C.5.5.1 Reliability - Lagoon cells and piping shall be designed to provide reliability and flexibility of operation.

8C.5.5.2 Cell Isolation - Controlled discharge lagoon systems shall contain piping and control structures to ensure the system will remain in operation with any cell out of service.

1. Individual influent lines shall be provided in accordance with Section 8C.7.4 to allow for primary cell isolation.
2. Multi-level cell drawdown lines shall be provided in accordance with Subsection 8C.7.6.4 to allow for secondary cell isolation, controlled discharge, and selective drawdown. The piping for secondary cells of a three-cell system shall be arranged so that transfer of wastewater from the primary cell to one of the secondary cells can occur simultaneously with discharge to the receiving stream from the other secondary cell.

8C.5.5.3 Influent - In a three-cell system, the piping shall be arranged so that raw influent can be diverted to only one of the secondary cells.

8C.5.5.4 Effluent - The piping shall be arranged so that effluent from any primary cell cannot be discharged directly to the receiving stream.

8C.5.6 Control Structures

A minimum of three control structures shall be provided to allow for system operation and operator accessibility, as follows:

8C.5.6.1 Influent Structure - The influent control structure shall be located prior to the system to allow for diversion of the raw influent into a minimum of two cells, thus allowing for primary cell isolation.

8C.5.6.2 Inter-Cell Structure - An inter-cell control structure shall allow multi-level drawoff from the primary cell(s) and flow diversion to any secondary cell.

8C.5.6.3 Effluent Structure - The effluent control structure shall provide for multi-level drawdown of any secondary cell and discharge to the receiving stream.

8C.6 AERATED FACULTATIVE LAGOON DESIGN**8C.6.1 Sizing of Aerated Facultative Lagoons**

8C.6.1.1 Detention Time for Typical Waste - As a minimum, aerated facultative lagoon systems designed to treat typical domestic waste ($BOD_5 \leq 200$ mg/L) shall consist of two or more aerated cells and one quiescent cell or zone which provide the following minimum hydraulic detention times:

Minimum Detention Times for Aerated Lagoon Cells for Typical Domestic Waste ($BOD_5 \leq 200$ mg/L)

*No. Of Aerated Cells	**Days for Treatment	Quiescent Cell, Days	Total Detention Time, Days
2	29	2	31
3	24	2	26
4	23	2	25

*The first two cells shall be of equal size and no one cell shall provide more than 50% of the total required volume.

**Includes five days detention time for ice cover and sludge accumulation. Ice cover represents 10% of the original treatment volume in the above table and shall be calculated on the basis of an average ice thickness of 12 inches. Sludge volume is based upon 1.54 days of detention time per 100 mg/L of suspended solids in the influent for a 20-year accumulation of sludge.

8C.6.1.2 Detention Time for Greater Strength Waste

1. The design minimum detention times of aerated cells treating domestic waste of greater strength than 200 mg/L BOD_5 should be determined using the following equation on a per cell basis.

$$t = \frac{E}{2.3K_1 \times (100 - E)}$$

t = detention time in each aerated cell, in days

E = percent of BOD_5 to be removed in the aerated cell, as a whole number

K_1 = reaction coefficient, per day, base 10. For normal domestic sewage the K_1 value may be 0.12/day for $T = 20^\circ\text{C}$ and 0.06/day for $T = 1^\circ\text{C}$. Any other K values for domestic type wastes shall be determined in accordance with Section 8C.6.1.5.

See Appendix 8C-A for formula derivation.

2. Aerated facultative lagoon systems designed to treat greater strength waste with a BOD_5 of 400 mg/L or more shall consist of three or more aerated cells in series and one quiescent cell or zone. The first two cells shall be of equal size and no one cell shall provide more than 50% of the total required volume.
3. The following minimum detention times are presented for illustration and result from use of the above formula with the provision of additional volume for sludge accumulation and ice cover.

Minimum Detention Times for Aerated Lagoon Cells for Greater Strength Waste (BOD₅ > 200 mg/L)

Influent BOD ₅ mg/L	No. of Aerated Cells	*Days for Treatment	Quiescent Cell, Days	Total Detention Days
400	3	40	2	42
400	4	35	2	37
400	5	34	2	36
1000	3	70	2	72
1000	4	61	2	63
1000	5	56	2	58
1000	6	54	2	56

*Includes nine days detention for ice cover and sludge accumulation at 400 mg/L and 19-20 days detention for ice cover and sludge accumulation at 1000 mg/L. Suspended solids assumed at 400 and 1000 mg/L.

- Ice cover represents 10% of the original treatment volume in the above table and shall be calculated on the basis of an average ice thickness of 12 inches.
- The days for sludge accumulation should be adjusted for actual conditions if the suspended solids concentrations differ appreciably from the assumed values given.
- Required volume for sludge accumulation for 20 years may be computed on the basis of 1.54 days of volume required per 100 mg/L of suspended solids in the influent flow.

8C.6.1.3 Temperatures - The minimum detention time required in the aerated cells shall be determined using a maximum design temperature of 1°C for domestic wastes. A temperature of 20°C shall be used in determining the oxygen requirements of the system unless the wastes will be at a higher temperature.

8C.6.1.4 Reaction Rate Conversion - The reaction rate coefficient to temperatures other than 20°C shall be converted using the following formula:

$$K_1 = K_{20}\theta^{(T-20)}$$

K₁ = reaction rate coefficient at 1°C

K₂₀ = reaction rate coefficient at 20°C

T = Reactor temperature in °C

θ = Temperature correction factor

8C.6.1.5 K-Factor Determination - The values for K and θ shall be determined experimentally for aerated lagoon systems which will be subjected to septic waste, partially treated waste, other nondomestic waste, or industrial waste that will have a substantial impact upon the treatment system. Conversion of the reaction rate coefficient to the appropriate temperature shall be based upon experimental data using one of the following methods.

- BOD₅ Bottle Simulation Experimental Technique** - BOD₅ bottle simulation may be used to simulate the BOD₅ removal rate K. When this technique is used, at least four composite samples must be obtained on days representative of the design condition. To verify results, each of these four samples should be split and a BOD₅ bottle simulation test conducted for each. Samples should be incubated at critical operating temperatures, and a series of tests run over a 10 to 20 day period. The K rate at critical low temperature sets the detention time in a lagoon. The K rate at critical high temperature sets the maximum required oxygen supply rate. The data can be used to determine the K rate using the Thomas method or the least squares method.
- Bench Scale K-Factor Determination** - At least four reactors with detention times from 2 to 20 days should be used. Reactors should be set up and flow rates established to achieve the desired detention time. Continuous aeration should be provided.
 - COD tests should be made daily. When effluent values have stabilized, the influent and effluent BOD₅ and COD will indicate the applicable K rate. The source of feed to each reactor should be the same and should be at a continuous rate. The DO and mixing power level in the reactor should approximate that of the aerated lagoon.

- b. The temperature correction factor may be established by lowering the reactor temperature or by using the BOD₅ bottle simulation technique.
3. Other Experimental Techniques - Another experimental technique may be used for K and θ factor determination. A description of the experimental technique and program should be submitted to the department for approval prior to initiating the testing program.

8C.6.2 System Reliability and Piping

8C.6.2.1 Lagoon cells and piping shall be designed to provide reliability and flexibility of operation. All systems shall be designed with piping flexibilities to permit isolation of any cell without affecting the transfer and discharge capabilities of the total system.

8C.6.2.2 The ability to discharge the influent waste load to a minimum of two cells and to all primary cells in the system shall be provided.

8C.6.2.3 Raw influent shall not be diverted to the quiescent cell or zone.

8C.6.2.4 When disinfection is required, cell isolation shall not result in bypassing of the disinfection facilities.

8C.6.3 Cell Depths

The cell depths should be in the range of 10 - 15 feet and shall be at least five feet.

8C.6.4 Aeration Equipment

8C.6.4.1 General - The following provisions apply to all aeration equipment. Manufacturer's data may be submitted to verify the mixing zone and oxygen dispersion capabilities of the aerators.

1. Adequate mixing to provide oxygen dispersion shall be provided.
2. Oxygen requirements will generally depend upon the BOD₅ loading, degree of treatment required, temperature, and if applicable, the concentration of suspended solids to be maintained. Aeration equipment shall be capable of supplying a minimum of two lbs. O₂/lb. of BOD₅ applied, and maintaining an average DO level of two mg/L or greater in the aeration cells at all times.
3. Suitable protection from the elements shall be provided for electrical controls, aerators, and piping.
4. Reliability in diffused air systems, including bottom diffusers and jet aeration, shall be provided in accordance with the following:
 - a. The blowers shall be provided in multiple units, so arranged and in such capacities as to meet the maximum air demand with the single largest unit out of service; and
 - b. The air diffusion system for each aeration cell shall be designed such that the largest section of diffusers can be isolated without losing more than 50% of the oxygen transfer capability within each cell.
5. There shall be a sufficient number of aerators to enable the design oxygen transfer of a cell to be maintained with the largest capacity aerator in that cell out of service. It is permissible for a backup aerator to be a complete uninstalled unit or a motor and prop assembly (drive train), provided that the installed aerator or parts can be easily removed and replaced. At least two aerators shall be installed in each primary cell.
6. Aeration Reliability Exceptions - When upgrading an existing plant which contains one unit large enough to provide at least 100% of the total design loading capacity to that unit operation, a case-by-case determination of duplication requirements shall be made by the department.

8C.6.4.2 Diffused Aeration - The following provisions apply to systems that use any aeration diffusers.

1. Blowers or air compressor capacity design should consider that the air intake temperature may reach 104°F (40°C) or higher and that the barometric pressure may be less than normal.
2. Motor drive capacity design should consider that the intake air temperature may reach -22°F (-30°C) or lower, which may require motor oversizing as a means of reducing the rate of air delivery to prevent overheating or damage.
3. Blowers shall be provided in multiple units, arranged and in such capacity as to meet the maximum air demand with the single largest unit out of service. Consideration should be given to varying the volume of air delivered in proportion to the demand resulting from differing loads on the lagoons. Blower design shall consider the potential for future loads which may require a greater oxygen supply.
4. The spacing of the aeration diffusers should be in accordance with the oxygenation requirements throughout the length of each lagoon. Ice cover affecting air distribution during winter operation should be considered in the design of the air diffuser system and selection of the blowers.

5. Individual control valves shall be provided at each junction in the aeration matrix, preferably with indicator markings for throttling or for complete shut off. Aeration diffusers and piping in any single assembly shall be designed to have substantially uniform pressure loss.
6. Air filters shall be provided in numbers, arrangements, and capacities to furnish at all times an air supply sufficiently free from dust to prevent clogging of the aeration diffuser system. The location of air filters shall be easily accessible for maintenance purposes.
7. Blower unit locations shall be carefully chosen to reduce noise levels in adjacent working areas.

8C.6.4.3 Tube Diffuser Systems - The following provisions apply to systems that use tube aeration diffusers.

1. The aeration diffuser lines (tubes) shall extend across a lagoon with sufficient slack allowed for raising and cleaning. The air headers shall be protected from freezing.
2. To prevent clogging of the air lines, provisions shall be made to accommodate frequent cleaning. Hydrogen chloride gas ports and adequate hydrogen chloride gas cleaning equipment may be provided for this purpose.

8C.6.4.4 Other Diffused Air Systems - The following provisions apply to systems that use aeration diffusers other than tube aeration diffusers.

1. The air supply lines shall be properly anchored with corrosion resistant anchors capable of withstanding two times the buoyant force of the lines and be protected against temperature expansion and contraction.
2. Aeration diffusers or equipment subject to clogging should be designed to be easily removed or cleaned without completely draining a lagoon.
3. The top of the aeration diffusers shall terminate below the elevation of maximum anticipated ice thickness to avoid winter freezing problems. The air headers shall be protected from freezing.

8C.6.4.5 Platform Mounted Surface Aerators - The following provisions apply to systems that use platform mounted aerators.

1. Mechanisms shall be protected from freezing. Consideration should be given to the installation of splash plates for controlling misting.
2. Platform legs shall be spaced at a sufficient distance from the aerator to minimize the effect of ice buildup caused by splashing.
3. Consideration should be given to varying the amount of oxygen transferred in proportion to the demand represented by the load on a lagoon.
4. Sufficient standby power shall be provided to prevent the aerators from freezing solid in an ice cover, or special provisions shall be made for aerator start-up under icing conditions.
5. Aerator accessibility shall be provided for periodic and major maintenance repairs. Access bridges shall be designed to provide structural support for necessary maintenance and removal equipment. Safety railings shall be corrosion resistant. Adequate provisions shall be made for easy aerator/motor removals.
6. A positive means of controlling the minimum liquid depth or other means shall be provided to prevent scouring of the lagoon bottom and destruction of the bottom seal.

8C.6.4.6 Floating Surface Aerators - The following provisions apply to systems that use floating surface aerators.

1. Floating surface aerators shall be of the submerged motor type or the subsurface horizontally mixing aspirator type. As a minimum, one surface aerator shall be installed for each acre of aerated lagoon surface area and at least two aerators shall be installed in each primary cell.
2. Floating surface aerators shall be anchored in at least three directions or attached to secure structural framing or bridging.
3. The floating aerator shall be designed to prevent icing conditions or tipping problems caused by an ice buildup on one side or on top of the unit.
4. A positive means of controlling the minimum liquid depth or other means shall be provided to prevent scouring of the lagoon bottom and destruction of the seal.
5. Adequate means shall be provided to prevent failure of operation of aspirator type aerators due to freezing or icing conditions.
6. Provisions shall be made for removal of floating aerators.

8C.6.5 Modifications to Existing Lagoons

Any cell that is modified (i.e. dike construction for cell expansion, lagoon bottom reconstruction) shall be upgraded to meet the design standards for seepage loss through the seal in accordance with Section 8C.7.3.2.

8C.7 LAGOON CONSTRUCTION DETAILS**8C.7.1 Lagoon Shape**

8C.7.1.1 General - The shape of all cells should be such that there are no narrow or elongated portions. No islands, peninsulas, or coves shall be allowed. Dikes should be rounded at corners to minimize accumulations of floating materials. Common dike construction, wherever possible, is strongly encouraged. Individual cells shall be separated by earthen dikes, except that a quiescent cell or zone may be formed by baffling off an area in the final aerated cell. Additional baffling in any cell can be provided to prevent short circuiting.

8C.7.1.2 Controlled Discharge Lagoons - Round, square, or rectangular cells with a length not exceeding three times the width are considered most desirable.

8C.7.1.3 Aerated Facultative Lagoons - Aerated lagoons shall have a minimum length to width ratio of 2:1 and a maximum length to width ratio of 5:1 for each of the first two cells. A similar ratio is recommended for any additional aerated cells but is not mandatory. The inlet-outlet structures should be located in a manner that assures thorough mixing of all wastes.

8C.7.2 Embankments and Dikes

8C.7.2.1 Material - Dikes shall be constructed of relatively impervious material and compacted to at least 95% Standard Proctor Density to form a stable structure. Vegetation and other unsuitable materials should be removed from the area upon which an embankment is to be placed.

8C.7.2.2 Top Width - The minimum dike top width shall be eight feet to permit access of maintenance vehicles, except for systems whose total surface area does not exceed one acre, a minimum top width of six feet will be acceptable. A vehicle turnaround point or complete loop shall be included for vehicle access.

8C.7.2.3 Maximum Slopes - Inner and outer dike slopes shall not be steeper than a 3:1 ratio of horizontal to vertical length.

8C.7.2.4 Minimum Slopes - Inner slopes should not be flatter than a 4:1 ratio of horizontal to vertical length. Flatter slopes can be specified for larger installations because of wave action, but such slopes have the disadvantage of added shallow areas being conducive to emergent vegetation. Outer dikes shall be designed and constructed to preclude surface runoff from entering the lagoons. A minimum channel depth of one foot on the outer slope of the dike is recommended.

8C.7.2.5 Freeboard - Minimum freeboard shall be two feet, measured vertically between the maximum water level and the top of the dike. Additional freeboard may be required for large and/or elongated cells where severe wave action could occur.

8C.7.2.6 Design Depth - The minimum operating depth should be sufficient to prevent damage to dikes, bottom, control structures, aeration equipment, and other appurtenances. Lagoon design operating depths shall not be less than two feet.

8C.7.2.7 Erosion Control

1. Erosion protection for all lagoons, regardless of size, shall be provided. Protection may be provided via the use of concrete or asphaltic aprons, stone riprap or artificial membranes. The minimum thickness of stone riprap shall be six inches. Placement of riprap or other erosion protection devices should be such that quiescent areas, conducive to mosquito breeding, are not formed.
2. The erosion protection for all lagoon cells shall be provided completely around the inner embankments and shall be placed from two feet below the minimum operating depth to at least one foot above the maximum operating depth (measured on the vertical). Additional height of erosion protection devices may be required for large and/or elongated cells where severe wave action could occur, and should be determined as a function of reach and wind velocity.

8C.7.2.8 Additional Erosion Protection - Riprap or an equivalent method of erosion control is required around all piping entrances and exits. Additional erosion control may be required on the exterior dike slope(s) to protect the embankment(s) from erosion due to severe flooding of an adjacent water course.

8C.7.2.9 Seeding - Wherever riprap is not utilized, dikes shall have a minimum cover layer of four inches of fertile topsoil to promote establishment of an adequate vegetative cover. Perennial, low-growing, spreading grasses that withstand erosion and can be mowed are recommended for dike seeding. Alfalfa and other long-rooted crops shall not be used for seeding since roots of this type are apt to impair dike water holding efficiency.

8C.7.3 Lagoon Bottom

8C.7.3.1 Soil - The soil used in constructing the lagoon bottom (not including seal) and dike cores shall be relatively incompressible and tight and compacted at or up to 4% above the optimum water content to at least 95% Standard Proctor Density.

8C.7.3.2 Seal and Seal Testing

1. Lagoon Seal Requirements

- a. Lagoons shall be sealed such that seepage loss through the seal is as low as practically possible. The percolation rate shall not exceed 500 gallons/acre/day at a water depth of six ft.
- b. Soil seals shall include bentonite or equivalent clay material in addition to optimum compaction. The minimum seal thickness should be 12 inches. In lieu of bentonite, alternate sealing materials such as membranes, soil cement, or asphalt may be used.
- c. Synthetic liners shall have a minimum thickness of 0.75 mm (30 mils), except for high density polyethylene liners, which shall have a minimum thickness of at least 1.50 mm (60 mils). Where industrial wastewater is treated or groundwater protection is critical, greater liner thickness and/or double liners may be required.
- d. Liners shall be installed under the supervision of a qualified manufacturer's representative. Synthetic liners shall be anchored at the dike berm and shall be sloped in the range of 0.5% to 2.5% from the center of the lagoon to the dikes to avoid gas buildup below the liner. Consideration should be given to providing a method of gas venting if the groundwater table is highly variable or large areas of organic materials are present beneath the liner. All vent outlets shall be at least two feet above the high-water elevation of the lagoon with the vent flap facing down slope to prevent surface water runoff from entering the vent.
- e. There may be special conditions when reinforced membranes should be considered where extra tensile strength is required. The membrane liner material should be compatible with the contents of the lagoons such that no damage results to the liner.
- f. The plans and specifications shall include the subgrade requirements for the synthetic liner. The subgrade should be graded and compacted so that there are no holes, exposed angular rocks, pieces of wood, or debris. If the subgrade is very gravelly and contains angular rocks that could damage the liner, a minimum bedding of three inches of sand should be provided directly beneath the liner.

2. Lagoon Seal Testing After Construction

- a. Following construction of the lagoon and prior to startup of lagoon operation, the results of a testing program indicating the adequacy of the seal shall be provided to the department.
- b. Where water is available, the seal should be tested by prefilling the lagoon to a minimum depth of six feet. Not less than seven days after filling is completed, testing shall be performed to determine the water loss through the lagoon bottom and embankments. The water loss calculations shall consider the influences of precipitation and evaporation during the test. A leakage rate confidence interval of up to 1,000 gpd/acre is acceptable for the water balance test.
- c. Lagoon seal testing may be performed by a soil testing laboratory. Tests shall be performed on undisturbed soil samples collected in accordance with ASTM D-1587 and analyzed to determine the coefficient of permeability. Soil samples shall have a minimum depth of 12 inches. The testing shall be done at a head equivalent to a six-foot lagoon operating depth.
- d. At least one soil sample per acre shall be tested, with a minimum requirement of two samples per cell. Selective testing shall be performed to sample both the lagoon bottom and inner embankment slopes below the maximum operating depth. Using the coefficient of permeability, the rate of water loss through the seal shall be determined.

- e. If unsatisfactory test results are obtained by either of the above test procedures, the lagoon shall be drained, if necessary, and reworked. Additional testing shall be performed until an adequate seal is obtained.

8C.7.3.3 Over-Excavation - For earthen lagoons, a minimum over-excavation of two feet is required where the bottom materials contain sand seams or gravel, or are generally unfit for lagoon bottom construction. The two-foot excavation shall be replaced by suitable homogeneous bottom material prior to compaction and sealing.

8C.7.3.4 Uniformity - Prior to seal placement, the lagoon bottom shall be as level as possible at all points. Finished elevations shall not be more than three inches from the average elevation of the bottom.

8C.7.4 Influent Lines

8C.7.4.1 Material - Generally accepted material for underground sewer construction shall be considered for the influent line to the lagoon. For other materials, consideration shall be given to the quality of the wastes, exceptionally heavy external loadings, corrosion, abrasion, soft foundations, and similar problems.

8C.7.4.2 Influent Structure - An influent structure shall be installed prior to the entrance of the influent line into the lagoon and shall be located within or as close to the lagoon dike as topography permits. The influent sewer invert shall be at least six inches above the maximum operating level of the lagoon and provide sufficient hydraulic head without surcharging the manhole. The six-inch requirement may be reduced on gravity systems if sufficient head is not available, but the influent sewer invert elevation shall be no less than the maximum operating level of the lagoon and shall provide sufficient hydraulic head without surcharging the interceptor sewer.

8C.7.4.3 Flow Distribution - Flow distribution structures for lagoons having multiple primary cells shall be designed to effectively split hydraulic and organic loads equally to the primary cells.

8C.7.4.4 Location - Influent lines may be located along the bottom of the lagoon with the top of the pipe just below the average elevation of the lagoon seal. However, the full seal depth shall be maintained below the bottom of the pipe and throughout the transition area from the bottom of the pipe to the lagoon bottom. The department will review designs where an influent line(s) is placed above the average upper elevation of the lagoon seal. Where pipes penetrate the lagoon seal, provisions to prevent seepage (such as anti-seep collars) shall be made.

8C.7.4.5 Flotation - Influent line flotation shall be prevented with appropriate construction or anchoring. Where the influent line must be anchored, concrete pads placed at intervals not less than one pipe length are recommended.

8C.7.4.6 Construction - The construction method shall ensure that the pipe and liner are not damaged during installation. All designs shall accommodate sludge removal.

8C.7.4.7 Point of Discharge

1. All primary cells for controlled discharge lagoons shall have individual influent line(s) terminating at approximately the center of the cell for proper solids dispersion. Consideration should be given to multiple influent discharge points for large primary cells to enhance distribution of the load on the cell.
2. All primary cells for aerated lagoons shall have influent lines which distribute the load within the mixing zone of the aeration equipment to assure complete mixing of the incoming waste. For surface aerators, the inlet should be beneath or in immediate proximity to one aerator. Consideration of multiple inlets should be closely evaluated for any diffused aeration systems. Discharge into each cell should be at the opposite end from the draw off out of the cell to enhance plug flow and minimize short circuiting.

8C.7.4.8 Influent Discharge Apron

1. Influent lines can be placed above or below the average elevation of the lagoon seal. Where an influent line(s) is placed below the average elevation of lagoon seal, it shall discharge horizontally into a shallow saucer-shaped depression which has a radius of at least 50 ft for the primary cell(s) of a controlled discharge lagoons. Smaller depressions for lagoons having a total area less than one acre and for secondary cells will be approved on a case-by-case basis. The depression shall have a minimum depth of one foot and a maximum depth of one foot plus the influent pipe diameter. Proper sealing of the depression shall be provided.

2. The end of the discharge line(s) shall rest on a suitable concrete apron which is large enough that the terminal influent velocity at the end of the apron does not cause soil erosion. The minimum apron size shall be two ft by two ft.

8C.7.5 Control Structures

8C.7.5.1 Multipurpose control structures shall be considered, where possible, to minimize the number of construction sites within the dikes and to facilitate normal operational functions such as drawdown, flow distribution, flow and depth measurement, sampling, recirculation pumping, or chemical addition and mixing.

8C.7.5.2 As a minimum, control structures shall be:

1. Accessible for maintenance and adjustment of controls.
2. Not obstructive for lagoon dike maintenance and dike travel (centered and flush with top dike grade or to the side of and adjacent to top of dike).
3. Adequately ventilated for safety and to minimize corrosion.
4. Locked to discourage vandalism.
5. Equipped with controls to allow variable water level and flow rate control, complete shut-off, and draining to the two-foot level.
6. Constructed of non-corrosive materials (metal on metal contact in controls should be of like alloys to discourage electro-metallic reactions).
7. Located to minimize short circuiting within the cell.
8. Protected against freezing and ice damage.

8C.7.5.3 Individual unit isolation, dewatering, and transferring capabilities shall be designed to provide flexibility in operation and maintenance. Either elevation differential or pumping capabilities may be used to provide this flexibility.

8C.7.6 Lagoon Piping

8C.7.6.1 Material - All lagoon withdrawal and transfer piping shall be of ductile iron, PVC, or generally accepted material that is compatible with wastewater characteristics, suitable for underground sewer construction, and poses no corrosion problems. All pipes shall be anchored to prevent pipe movement.

8C.7.6.2 Hydraulic Capacity

1. The hydraulic capacity for intermittent discharge structures and the piping for controlled discharge lagoons shall permit transfer of water at a minimum rate of six inches of lagoon water depth per day at the maximum design head.
2. The hydraulic capacity for continuous discharge structures and the piping for aerated lagoon systems shall allow for a minimum of the MWW flow or 200% of the MSDWW flow, whichever is greater. The MSDWW flow is defined in IWFDS Subsection 4.4.5.2.

8C.7.6.3 Interconnecting Piping - Interconnecting piping for series operation of aerated lagoon cells and interconnection between divided primary cells and between secondary cells of controlled discharge lagoons shall be valved or provided with other arrangements to regulate flow between the cells. Interconnecting pipes should discharge horizontally onto splash blocks and be terminated as near the dividing dike as construction permits. The piping shall be located at the two-ft minimum depth (from the bottom of the cell) for controlled discharge lagoons and between the two-ft and three-ft depth (from the bottom of the cell) for aerated lagoons.

8C.7.6.4 Controlled Discharge Drawdown Structure Piping

1. **Multi-Level Drawoffs** - A minimum of two drawoff levels shall be provided from each primary cell to the secondary cells, and a minimum of three drawoff levels from each secondary cell to the receiving stream. The bottom drawoff pipe shall be at the two-ft depth, and the remaining pipes shall be evenly spaced to permit adequate drawoff of optimum quality cell effluent.
2. **Scum Control** - Provisions shall be included to ensure that scum and floating materials shall not be drawn off with the cell effluent. Minimum requirements shall be either 90-degree elbows on each drawdown pipe, or the adequate sloping of each drawdown pipe. Where the bottom takeoff is sloped, the piping shall be located two feet above the lagoon seal at its lowest point and the hydraulic storage time shall be calculated based on the invert elevation at the control structure.

8C.7.6.5 Aerated Facultative Lagoon Discharge Structure Piping

1. **Multi-Level Drawoffs (Quiescent Cell)** - For lagoons that are designed deep enough to permit stratification of lagoon content, multiple drawoffs are required, and there shall be a minimum of two withdrawal pipes at different elevations. A near surface overflow type withdrawal is recommended for use under constant discharge and warm weather conditions, in order to withdraw the best effluent. Submerged withdrawal is recommended under cold weather conditions to avoid freezing problems.
2. **Scum Control** - Provisions shall be included to ensure that scum and floating materials shall not be drawn off with the cell effluent.

8C.7.7 Prefilling

Where water is available, the lagoon shall be prefilled to the two ft level (or to the level at which the aeration equipment can effectively operate) to protect the liner, prevent weed growth, encourage rapid startup of the biological process, discourage odor, reduce freezing problems for late fall startups, confirm the seal integrity, and to maintain the water content of the soil liner at or above optimum. The dikes and lagoon bottom shall be completely prepared and sealed as described in Sections 8C.7.2 and 8C.7.3 before the introduction of water. Water for prefilling may be taken from a municipal water supply system or a nearby lake or stream. The use of more than 25,000 gpd of water must be registered with the department as required by 567—subrule 51.6(5). The raw sewage influent alone should not be used for prefilling purposes. Final effluent from an existing wastewater treatment plant may be used for prefilling.

8C.7.8 Cell Dewatering

The piping/pumping configuration of controlled discharge lagoons shall be designed so that no discharge to the receiving stream will occur below the level of two ft for the secondary cells or directly from any level in the primary cell(s). Access to control and valve structures for cell drain lines shall be provided for maintenance and to insure the complete closure of lines when not in operation.

8C.8 FLOW MEASUREMENT

Flow measurement provisions for controlled discharge and aerated facultative lagoon systems shall be included as follows:

8C.8.1 Influent

Equipment and structures required to measure and record continuous flow rates and to obtain 24-hour composite samples shall be included. Weirs shall not be used for influent flow measurement, except for very low flows where self-flushing flow measuring devices are not accurate. Elapsed time meters (ETMs) with an event recorder on lift station pump controls will generally be an acceptable method of continuous influent flow monitoring, except when screw pumps or variable speed pumps are used.

8C.8.2 Effluent

Effluent flow measurement facilities shall be provided for all wastewater treatment lagoons; however, continuous recording capabilities are not required. The capacity of effluent measurement facilities shall be adequate to measure maximum discharge rates. A V-notch weir without level monitoring equipment is permitted.

8C.8.3 Small Facilities

Continuous flow measurement and recording requirements may be waived for small wastewater treatment lagoon systems less than 100 PE. However, flow measurement devices should still be provided, and the design of the structure shall facilitate the installation of continuous flow recording equipment and automatic samplers.

8C.8.4 Equipment Protection

Effective weather and vandalism protection shall be provided for the flow measurement and recording equipment.

8C.8.5 Structures

Flow measurement structures shall have a diameter of at least five feet. The sidewalls shall be extended vertically to the top of the structure. The access opening shall be sufficiently large to provide easy access and adequate lighting and ventilating of the structure whenever entrance is necessary.

8C.9 DISINFECTION

Lagoon disinfection design shall meet all applicable requirements of IWFDS Chapters 4 and 10.

8C.10 MISCELLANEOUS**8C.10.1 Fencing**

The lagoon area shall be enclosed with an adequate fence to prevent livestock from entering and discourage trespassing. Fencing should not obstruct vehicle traffic on top of the dike. A vehicle access gate of sufficient width to accommodate mowing equipment shall be provided. All access gates shall be provided with locks.

8C.10.2 Access

An all-weather access road shall be provided to the lagoon site to allow year-round facility maintenance.

8C.10.3 Warning Signs

Appropriate permanent signs shall be provided along the fence around the lagoon to designate the nature of the facility and advise against trespassing. At least one sign shall be provided on each side of the site and one for every 500 ft of its perimeter.

8C.10.4 Groundwater Monitoring

An approved system of groundwater monitoring wells or lysimeters may be required around the perimeter of the lagoon site to facilitate groundwater monitoring. The need for such monitoring will be determined on a case-by-case basis.

8C.10.5 Laboratory Equipment

Laboratory equipment shall meet the requirements of IWFDS Chapter 4.

8C.10.6 Lagoons Level Gauges

Lagoon level gauges shall be provided for all cells. Gauge devices shall be permanently installed to allow easy observation of lagoon operational depths. A calibrated mast, pipe, or inclined concrete section of the dike may be used. If a calibrated mast or pipe is used, the mast or pipe shall be adequately anchored. Wooden staff gauges will not be approved. The outlet control structures may also be utilized for depth measurement if properly and permanently calibrated.

8C.10.7 Service Building

Consideration should be given to the design of a service building for laboratory and maintenance equipment.

8C.11 SLUDGE REMOVAL AND DISPOSAL

Sludge removal may be needed when upgrading an existing lagoon system to increase lagoon volume or to ensure the best effluent quality. The final sludge disposal site shall be verified with and accepted by the department. 567—Chapter 67 contains standards for land application of sewage sludge, and 567—Chapter 121 contains standards for land application of industrial sludge. Following sludge removal, the lagoon system shall remain sealed and shall meet applicable seepage loss requirements. Under no circumstances shall sludge be transferred from an existing lagoon into a new lagoon cell for disposal.

APPENDIX 8C-A: DERIVATION OF REACTION FORMULA (AERATED FACULTATIVE LAGOON)

$$t = \frac{E}{2.3K_1 \times (100 - E)}$$

t = detention time, days

E = percent BOD₅ to be removed

K₁ = reaction coefficient

Above formula was developed from the following equations and assumptions:

Equation 1 (1st order kinetics)

$$-\frac{dC}{dt} = K_1 C$$

Equation 2 (complete mix reactor)

$$-\frac{dC}{dt} V = Q(C_0 - C)$$

C₀ = concentration, influent (mg/L)

C = concentration, within reactor and effluent (mg/L)

Q = flow rate (MGD)

K₁ = reaction of coefficient (time-1), base 10

V = volume of reactor (MG)

Combining equations 1 and 2 with:

$$E = \frac{C_0 - C}{C_0} \times 100$$

E = efficiency

Gives:

$$t = \frac{E}{2.3K_1 \times (100 - E)}$$

i.e.: By coming equations 1 and 2:

$$K_\theta C = \frac{Q}{V} (C_0 - C)$$

Also since

$$\frac{Q}{V} = \frac{1}{t}$$

Then

$$K_\theta C = \frac{C_0 - C}{t}$$

Or

$$t = \frac{C_0 - C}{K_\theta C}$$

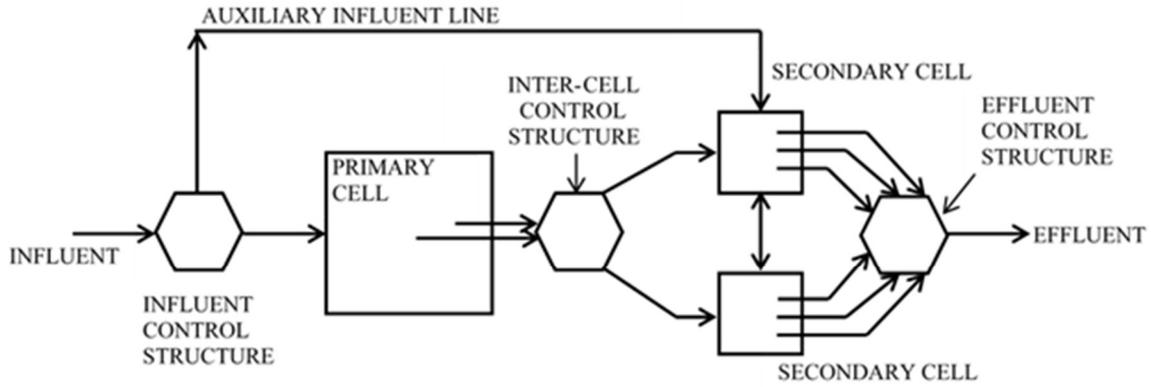
Combining

$$t = \frac{C_0 - C}{K_\theta C}, \frac{C_0 - C}{t} 100 = E, \text{ and } K_\theta = 2.3K_1 (\ln = 2.3 \log 10)$$

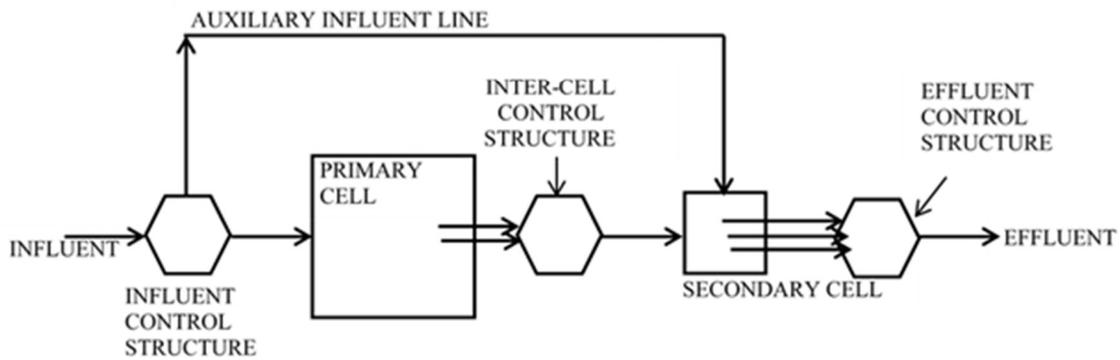
Produces

$$t = \frac{E}{2.3K_1 \times (100 - E)}$$

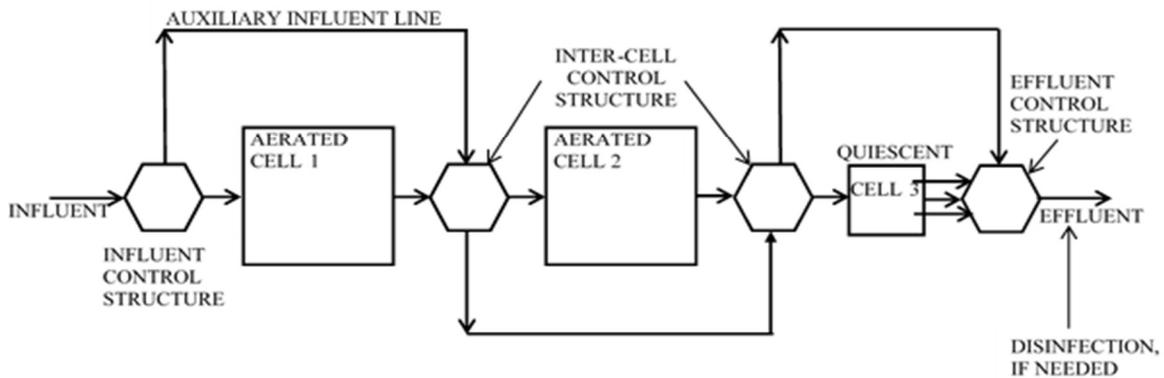
APPENDIX 8C-B: WASTEWATER TREATMENT LAGOON FLOW SCHEMATICS FOR PIPING & RELIABILITY



3-CELL CONTROLLED DISCHARGE POND SYSTEM



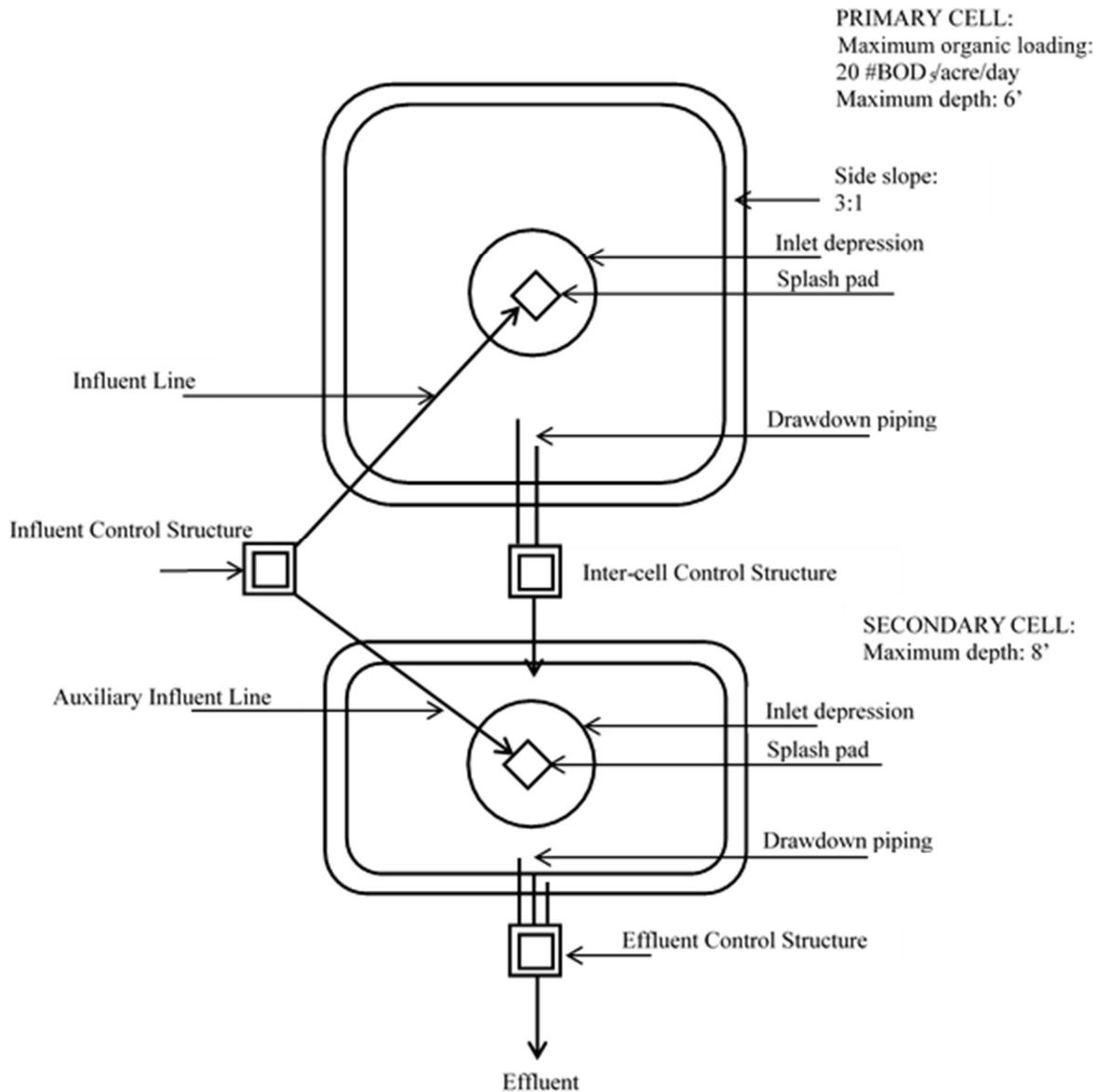
2-CELL CONTROLLED DISCHARGE POND SYSTEM



AERATED FACULTATIVE POND SYSTEMS

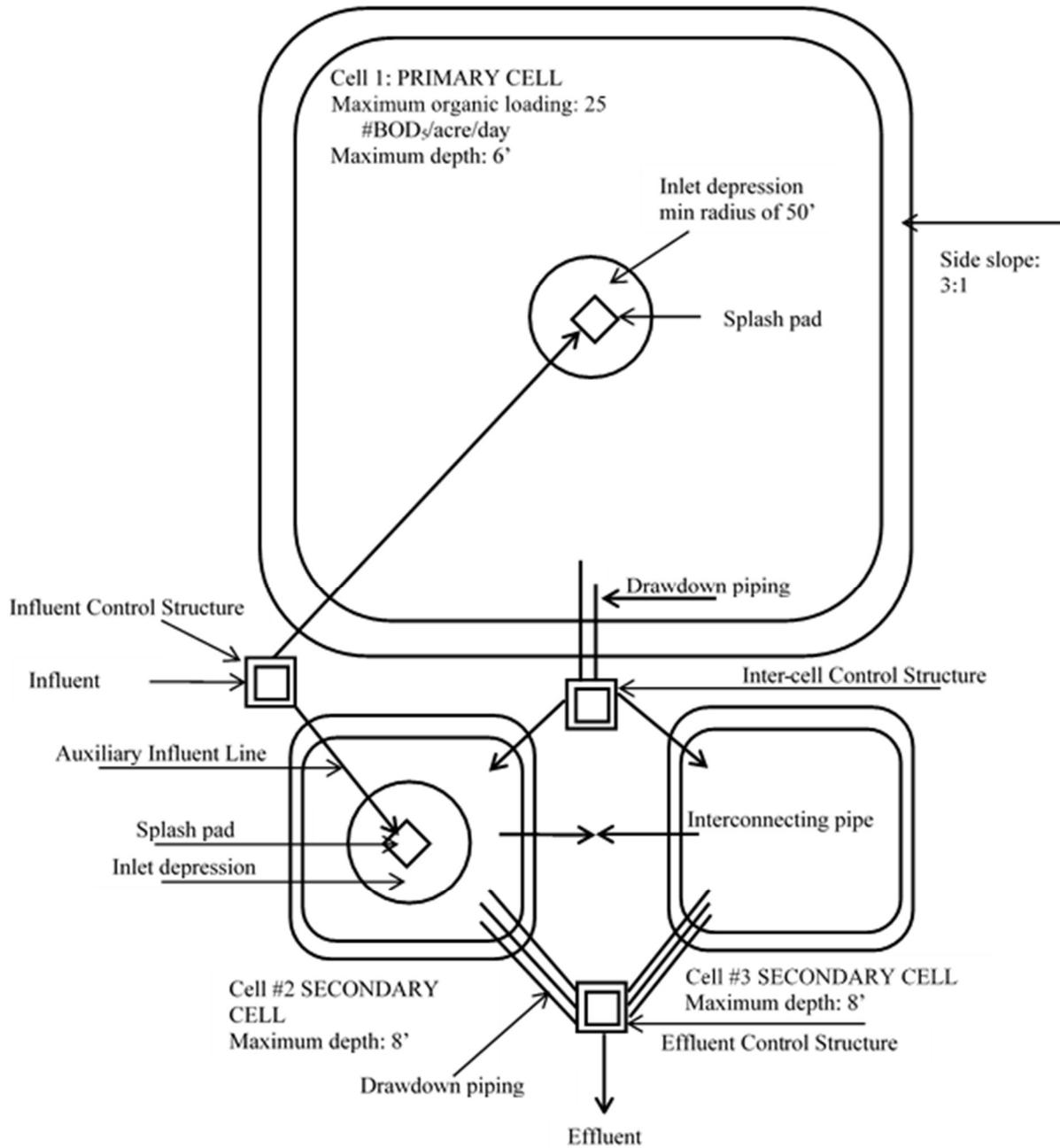
APPENDIX 8C-C: TYPICAL 2-CELL CONTROLLED DISCHARGE LAGOON

- 180 days total storage above the 2' depth level provided (storage based upon wettest consecutive 180-day flow period)
- Maximum total surface area for 2-cell systems of 1 acre
- Primary cell area approximately 2/3 of total surface area
- Secondary cell minimum storage of 60 days



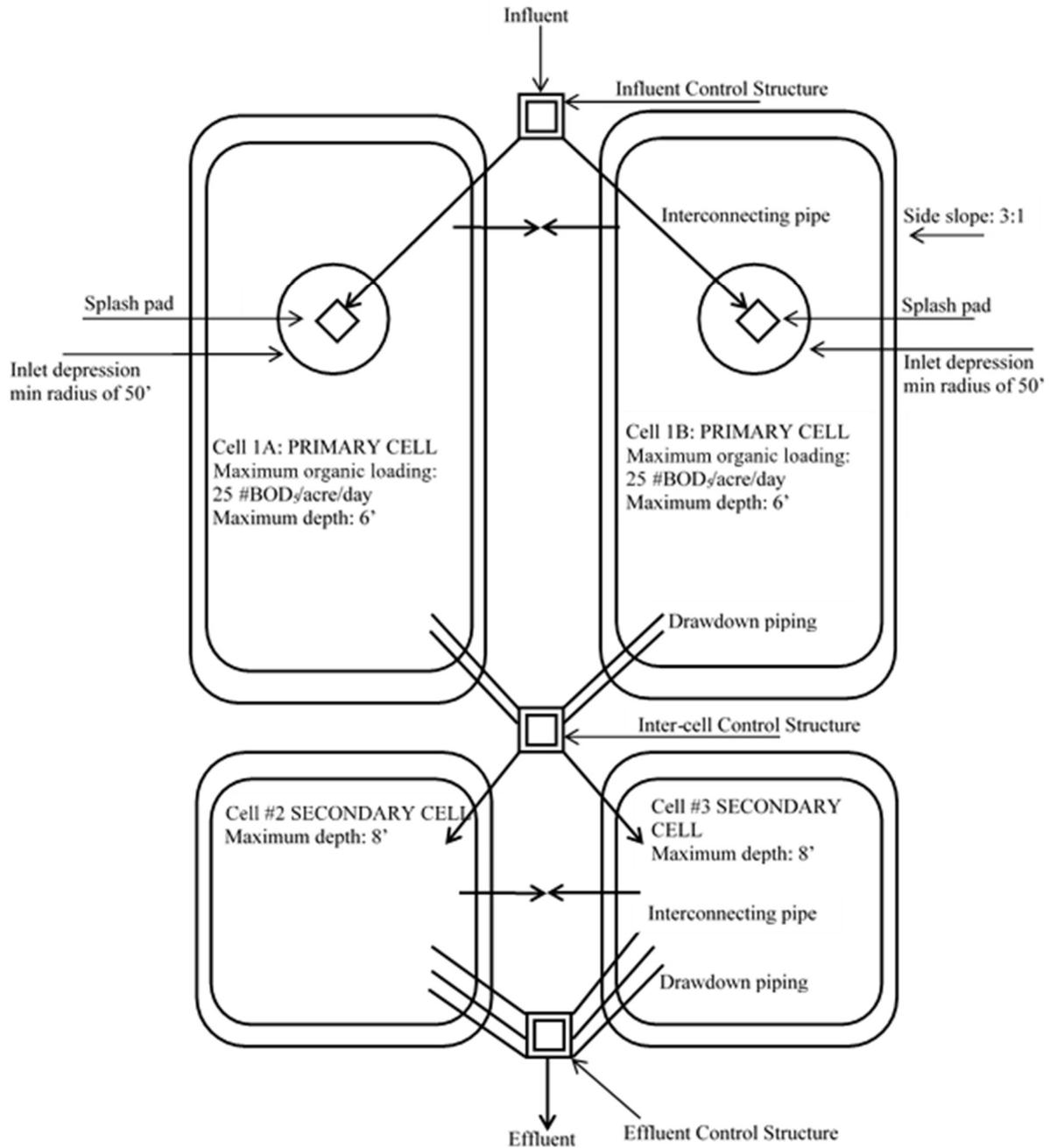
APPENDIX 8C-D: TYPICAL 3-CELL CONTROLLED DISCHARGE LAGOON

- 180 days total storage above the 2' depth level provided (storage based upon wettest consecutive 180-day flow period)
- Secondary cell minimum storage of 30 days



APPENDIX 8C-E: TYPICAL 4-CELL CONTROLLED DISCHARGE LAGOON

- 180 days total storage above the 2' depth level provided (storage based upon wettest consecutive 180-day flow period)
- Secondary cell minimum storage of 30 days



CHAPTER 9: SUPPLEMENTAL TREATMENT PROCESSES

9.1 APPLICABILITY AND SCOPE

This chapter is applicable to the construction, installation, or modification of any disposal system required to obtain a construction permit from the department under Iowa Code section 455B.183 and rule 567—60.2(455B).

9.2 PHOSPHORUS REMOVAL BY CHEMICAL TREATMENT

9.2.1 General

9.2.1.1 Method - Addition of lime or the salts of aluminum or iron may be used for the chemical removal of soluble phosphorus. Phosphorus reacts with calcium, aluminum, or iron ions to form insoluble compounds. These insoluble compounds may be flocculated with or without the addition of a coagulant aid, such as a polyelectrolyte to facilitate separation by sedimentation.

9.2.1.2 Design Basis

1. Preliminary Testing - Laboratory, pilot, or full scale trials of various chemical feed systems and treatment processes are recommended to determine the achievable performance level, cost-effective design criteria, and ranges of required chemical dosages.
2. System Flexibility - Systems shall be designed with sufficient flexibility to allow for several operational adjustments in chemical feed location, chemical feed rates, and for feeding alternate chemical compounds.

9.2.2 Process Requirements

9.2.2.1 Dosage - The required chemical dosage shall include the amount needed to drive the chemical reaction to the desired state of completion plus the amount required due to inefficiencies in mixing or dispersion. Excessive chemical dosage should be avoided.

9.2.2.2 Chemical Selection

1. The choice of lime or the salts of aluminum or iron should be based on the wastewater characteristics and the economics of the total system.
2. When lime is used, it may be necessary to neutralize the high pH prior to subsequent treatment in secondary biological systems or prior to discharge in those flow schemes where lime treatment is the final step in the treatment process.

9.2.2.3 Chemical Feed Points - Selection of chemical feed points shall include consideration of the chemicals used in the process, necessary reaction times between chemical and polyelectrolyte additions, and the wastewater treatment processes and components utilized.

9.2.2.4 Flash Mixing - Each chemical shall be mixed rapidly and uniformly with the flow stream. Separate mixing basins equipped with mechanical mixing devices should be provided with a detention period of at least 30 seconds.

9.2.2.5 Flocculation - The particle size of the precipitate formed by chemical treatment may be very small. Consideration should be given in the process design to the addition of synthetic polyelectrolytes to aid settling. The flocculation equipment should be adjustable in order to obtain optimum floc growth, control deposition of solids, and prevent floc destruction.

9.2.2.6 Liquid - Solids Separation

1. The velocity through pipes or conduits from flocculation basins to settling basins should not exceed 1.5 fps in order to minimize floc destruction. Entrance works to settling basins should also be designed to minimize floc shear.
2. Settling basin design shall comply with the criteria in IWFDS Chapter 6. When designing the sludge handling system, special consideration should be given to the type and volume of sludge generated in the phosphorus removal process.

9.2.2.7 Filtration - Effluent filtration shall be considered where effluent total phosphorus concentrations of less than one mg/L must be achieved.

9.2.3 Feed Systems

9.2.3.1 Location - All liquid chemical mixing and feed installations shall be installed on corrosion resistant pedestals elevated above the floor level for ease of cleaning. Lime feed equipment shall be located so as to minimize the length of slurry conduits. All slurry conduits shall be accessible for cleaning.

9.2.3.2 Liquid Chemical Feed System

1. Liquid chemical feed pumps shall 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.
2. Screens and valves shall be provided on the chemical feed pump suction lines.
3. 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.
4. Consideration shall be given to providing pacing equipment to optimize chemical feed rates.

9.2.3.3 Dry Chemical Feed System

1. Each dry chemical feeder shall be equipped with a dissolver which is capable of providing a minimum 5-minute retention at the maximum feed rate.
2. Polyelectrolyte feed installations shall be equipped with two solution vessels and transfer piping for solution makeup and daily operation.
3. Makeup 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.

9.2.4 Storage Facilities

9.2.4.1 Size - Storage facilities shall be sufficient to ensure that an adequate supply of the chemical is available at all times. Exact size required will depend on size of shipment, length of delivery time, and process requirements. Storage for a minimum of 10-day supply shall be provided.

9.2.4.2 Location - The liquid chemical storage tanks and tank fill connections shall be located within a containment structure having a capacity exceeding the total volume of all storage vessels. Valves on discharge lines shall be located adjacent to the storage tank and within the containment structure. Containment areas shall be sloped to a sump area and shall not contain floor drains. Bag storage shall be located near the solution makeup point to avoid unnecessary transportation and housekeeping problems.

9.2.4.3 Accessories - Platforms, ladders, 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.

9.2.5 Other Requirements

9.2.5.1 Materials - All chemical feed equipment and storage facilities shall be constructed of materials resistant to chemical attack by all chemicals normally used for phosphorus treatment.

9.2.5.2 Temperature, Humidity and Dust Control - Precautions shall be taken to prevent chemical storage tanks and feed lines from reaching temperatures likely to result in freezing or chemical crystallization at the concentrations employed. A heated enclosure or insulation may be required. Provisions shall be made for temperature, humidity and dust control in all chemical feed room areas.

9.2.5.3 Cleaning - Consideration shall be given to the accessibility of piping. Piping shall be installed with plugged wyes, tees or crosses at changes in direction to facilitate cleaning.

9.2.5.4 Drains and Drawoff - Above-bottom drawoff from chemical storage or feed tanks shall be provided to avoid withdrawal of settled solids into the feed system. A bottom drain shall be installed for periodic removal of accumulated settled solids.

9.2.6 Sludge Handling

9.2.6.1 General - Provisions shall be made for the type and additional capacity of the sludge handling facilities needed when chemicals are added.

9.2.6.2 Dewatering - Design of dewatering systems shall be based, where possible, on an analysis of the characteristics of the sludge to be handled. Consideration shall be given to the ease of operation, effect of recycle streams generated, production rate, moisture content, dewatering, final disposal, and operating cost.

9.3 HIGH RATE EFFLUENT FILTRATION**9.3.1 General**

9.3.1.1 Applicability - Granular media filters may be used as a tertiary treatment device for the removal of residual suspended solids from secondary effluents. Where effluent suspended solids requirements are less

than 10 mg/l, where secondary effluent quality can be expected to fluctuate significantly, or where filters follow a treatment process where significant amounts of algae will be present, a pretreatment process such as chemical coagulation and sedimentation or other acceptable process should precede the filter units.

9.3.1.2 Design Considerations - Care should be given in the selection of pumping equipment ahead of filter units to minimize shearing of floc particles. Consideration should be given in the plant design to providing flow-equalization facilities to moderate filter influent quality and quantity.

9.3.1.3 Filter Types - Filters may be of the gravity type or pressure type. Pressure filters shall be provided with ready and convenient access to the media for treatment or cleaning. Where greases or similar solids which result in filter plugging are expected, filters should be of the gravity type.

9.3.2 Filtration Rates

9.3.2.1 Allowable Rates - Filtration rates shall not exceed five gpm/ft² based on the maximum hydraulic flow rate applied to the filter units.

9.3.2.2 Number of Units - Total filter area shall be provided in two or more units, and the filtration rate shall be calculated based on the total available filter area with one unit out of service.

9.3.3 Backwash

9.3.3.1 Backwash Rate - The backwash rate and procedure shall be appropriate for the filter media used, with fluidization capability or other means provided for dual or triple media filters to permit restratification of the layers in their desired positions at the end of the backwash. The backwash system shall be capable of providing a variable backwash rate having a maximum of at least 20 gpm/ft² and a minimum backwash period of 10 minutes.

9.3.3.2 Backwash - Pumps for backwashing filter units shall be sized and interconnected to provide the required rate to any filter with the largest pump out of service. Filtered water shall be used as the source of backwash water. Waste filter backwash shall be returned to the plant influent for further treatment.

9.3.4 Filter Media

9.3.4.1 Selection of proper media size and type will depend on the filtration rate selected, the type of treatment provided prior to filtration, filter configuration, and effluent quality objectives. In dual or multimedia filters, media size selection must consider compatibility among media.

9.3.4.2 The media size and depth shall be selected to provide an effluent meeting the specific conditions and treatment requirements relative to the project under consideration. Furthermore, the head loss provided shall be appropriate for the media to ensure that the backwash volume required does not exceed 10% of the plant production when the plant is at design capacity.

9.3.5 Filter Appurtenances

The filters shall be equipped with washwater troughs, overflow troughs or a central gullet, surface wash or air scouring equipment, means of measurement and positive control of the backwash rate, equipment for measuring filter head loss, positive means of shutting off flow to a filter being backwashed, and filter influent and effluent sampling points. If automatic controls are provided, there shall be a manual override for operating equipment, including each individual valve essential to the filter operation. The underdrain system shall be designed for uniform distribution of backwash water (and air, if provided) without danger of clogging from solids in the backwash water. Provision shall be made to allow periodic chlorination of the filter influent or backwash water to control slime growths.

9.3.6 Access and Housing

Each filter unit shall be designed and installed so that there is ready and convenient access to all components and the media surface for inspection and maintenance without taking other units out of service. Housing shall be provided for all filter units and all controls shall be enclosed. The structure housing filter controls and equipment shall be provided with adequate heating and ventilation equipment to minimize problems with excess humidity.

9.3.7 Backwash Surge Control

The rate of return of waste filter backwash water to treatment units shall be controlled such that the rate does not exceed 15% of the design average daily flow rate to the treatment units. The hydraulic and organic load from waste backwash water shall be considered in the overall design of the treatment plant. Where waste backwash water is returned for treatment by pumping, adequate pumping capacity shall be provided with the largest unit out of service.

9.3.8 Backwash Water Storage

Total backwash water storage capacity provided in an effluent clearwell or other unit shall equal or exceed the volume required for two complete backwash cycles although additional capacity shall be considered to allow for operational flexibility.

9.3.9 Proprietary Equipment

Where proprietary filtration equipment, such as shallow bed, traveling bridge, continuous backwash type filters, is proposed, data which supports the capability of the equipment to meet effluent requirements under design conditions shall be provided to the department for review on a case-by-case basis.

9.4 OTHER SUPPLEMENTAL TREATMENT PROCESSES

Other supplemental treatment processes, such as DO adjustment, pH adjustment, carbon adsorption, denitrification processes, biological phosphorus removal systems, and other advanced treatment processes are available but have not been discussed in detail in this standard. This does not preclude design engineers from submitting proposals for the application of such technologies where they may seem to offer appropriate solutions to wastewater treatment problems.

CHAPTER 10: DISINFECTION**10.1 APPLICABILITY AND SCOPE**

This chapter is applicable to the construction, installation, or modification of any disposal system required to obtain a construction permit from the department under Iowa Code section 4558.183 and rule 567—60.2(455B).

10.2 PROCESS SELECTION**10.2.1 Applicability**

The disinfectants discussed in this chapter include chlorine, calcium or sodium hypochlorite, chlorine dioxide, ozone, bromine and ultraviolet radiation. These disinfectants can be used as appropriate to treat wastewater which requires disinfection.

10.2.2 Specific Process Selection

Chlorination is the most commonly used method for wastewater disinfection. The forms most often used are liquid or gaseous chlorine and calcium or sodium hypochlorite. Other disinfectants, including chlorine dioxide, ozone, bromine, peracetic acid, or UV radiation may be accepted by the department. The chemical or method should be selected after due consideration of waste flow rates, application and demand rates, pH of the wastewater, cost of equipment, chemical availability, reliability, and maintenance problems. If chlorination is used, it may be necessary to dechlorinate to meet discharge permit limitations.

10.3 CHLORINE FEED EQUIPMENT**10.3.1 Type**

Solution-feed vacuum-type chlorinators are generally preferred for large chlorination installations. The use of hypochlorite feeders of the positive displacement type should be considered when flow discharge is intermittent. The preferred method of generation of chlorine dioxide is the injection of a sodium chlorite solution into the discharge line of a solution-feed gas-type chlorinator, with subsequent formation of the chlorine dioxide in a reaction chamber at a pH of 4.0 or less.

10.3.2 Capacity

10.3.2.1 Required disinfection capacity will vary, depending on the uses and points of application of the disinfection chemical. For disinfection, the capacity shall be adequate to produce an effluent that will meet the limits specified by the department for that installation. For domestic wastewater, the following may be used as an estimating guide in sizing chlorination facilities.

Type of Treatment	Chlorine Dosage, mg/L (based on flow)
Primary effluent	15
Trickling filter plant effluent	10
Activated sludge plant effluent	8
Tertiary filtration effluent	6
Nitrified effluent	6

10.3.2.2 When industrial wastes are present, laboratory estimation of chlorine demand may be necessary.

10.3.2.3 Equipment shall be provided to handle the entire range of expected flows and dosages throughout the design period.

10.3.3 Standby Equipment and Spare Parts

Where disinfection is required for the entire year, standby equipment of sufficient capacity shall be installed to provide disinfection with the largest unit out of service. Spare parts shall be available for all disinfection equipment to replace parts which are subject to wear and breakage.

10.3.4 Water Supply

An ample supply of water shall be available for operating the chlorinator injector. The water source can be either potable water or effluent taken from the chlorine contact chambers. When a booster pump is required, duplicate equipment or an alternate water supply shall be provided. Protection of a potable water supply shall

comply with IWFDS Section 4.7.1.

10.3.5 Automatic Switchover

Where disinfection is required for the entire year, automatic switchover of chlorine cylinders or containers shall be provided.

10.3.6 Dosage Control

10.3.6.1 For plants with less than 3,000 PE, automatic chlorine feed rate control will not be required.

10.3.6.2 Plants for more than 3,000 PE shall be provided with chlorine feed-rate control proportional to the wastewater flow.

10.3.6.3 In all cases where dechlorination is required, a compound loop control system should be considered.

10.4 CHLORINE SUPPLY

10.4.1 Tank Cars

At large chlorination installations, consideration should be given to the use of tank cars, generally accompanied by evaporators. Liquid chlorine lines from tank cars to evaporators shall be buried and installed in a conduit and shall not enter below grade spaces. Systems shall be designed for the shortest possible pipe transportation of liquid chlorine.

10.4.2 Scales

Scales or load cells for weighing cylinders or ton containers shall be provided at all plants using chlorine gas. Scales shall be provided for each cylinder or container in service; one scale is adequate for a group of cylinders or containers connected to a common manifold. At large plants, scales of the indicating and recording type are recommended. Scales shall be of corrosion-resistant material.

10.4.3 Evaporators

Where manifolding of several containers will be required to evaporate sufficient chlorine, consideration should be given to the installation of evaporators, to produce the quantity of gas required.

10.4.4 Leak Detection and Alarms

10.4.4.1 A bottle of 56% ammonium hydroxide solution shall be available for detecting chlorine leaks.

10.4.4.2 All installations utilizing 2,000 lb cylinders shall have suitable continuous chlorine leak detectors.

Continuous chlorine leak detectors should be considered at all other installations. Whenever chlorine leak detectors are installed, they shall be connected to a centrally located alarm system and should automatically start exhaust fans.

10.4.5 Handling Equipment

The following handling equipment shall be provided.

10.4.5.1 100 and 150 pound Cylinders

1. A hand-truck specifically designed for cylinders.
2. A method of securing cylinders to keep them up-right.

10.4.5.2 Ton Containers

1. Two-ton capacity hoist.
2. Container lifting bar.
3. Monorail or hoist with sufficient lifting height to pass one container over another.
4. Cylinder trunnions to allow rotating the container for proper connection.

10.5 CHLORINE PIPING AND CONNECTIONS

10.5.1 General

Piping systems shall be as simple as possible, specifically selected and manufactured to be suitable for chlorine service, with a minimum number of joints. Piping should be well supported and protected against temperature extremes. Due to the corrosiveness of moist chlorine gas, all lines designed to handle dry chlorine gas should be protected from the entrance of water or air containing water.

10.5.2 Chlorine Piping

10.5.2.1 Chlorine Supply System

1. That portion of the system between the cylinder or ton container and the chlorinator inlet should be constructed of Schedule 80 black seamless steel pipe with 2,000 lb forged steel fittings. Unions should be ammonia type with lead gaskets; never use a ground joint union. The use of bushings should be

avoided; use reducing fittings.

2. All valves shall be Chlorine institute approved.
3. Gauges shall be equipped with a silver diaphragm protector.
4. Piping can be assembled by either welded or threaded connections. All threaded pipe shall be cleaned with a solvent, preferably trichloroethylene and dried with nitrogen gas or dry air. Teflon tape should be used for thread lubrication lieu of pipe tape.

10.5.2.2 Injector Vacuum Lines - The vacuum lines between the chlorinator and the injector should be Schedule 80 PVC or fiberglass pipe approved for moist chlorine gas use.

10.5.2.3 Chlorine Solution Lines

1. Chlorine solution lines can be Schedule 80 PVC; fiberglass; PVC, Saran, or rubber-lined steel; polyethylene tubing; or rubber hose with either natural or reclaimed rubber lining, all approved for moist chlorine gas use. Valves shall be PVC, PVC-lined, or rubber-lined.
2. Gauges should be provided to show the injector operating water pressure and the chlorine solution pressure. The chlorine solution gauge shall be a compound unit reading to 30 inches mercury vacuum and to a pressure greater than the anticipated operating pressure. The gauge shall also be equipped with a silver diaphragm protector.

10.5.2.4 Nuts and Bolts - Nuts and bolts used on piping systems should be 316 stainless steel, galvanized or cadmium plated steel.

10.5.3 Diffusers

10.5.3.1 Diffusers located in open channels are of two general types: a series of nozzles suspended from a flexible hose and a perforated pipe across the channel; the latter being the preferred type. Both types must be located in a highly turbulent zone with a minimum water cover of nine inches.

10.5.3.2 The minimum recommended velocity through the diffuser holes is 10 - 12 fps. All diffusers should be removable for cleaning.

10.6 CHLORINE HOUSING

10.6.1 General

10.6.1.1 If gas chlorination equipment or chlorine cylinders will be in a building used for other purposes, a gas-tight room shall separate this equipment from any other portion of the building. There must not be any means by which chlorine gas can enter other areas of a common building. Floor drains from the chlorine room shall 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. Areas housing chlorinators and chlorine cylinders or containers in use shall be located on or above ground level.

10.6.1.2 The storage area should be separated from the feed area. Chlorine cylinder or container storage areas shall be located on or above ground level and shaded from direct sunlight.

10.6.1.3 Chlorination equipment should be situated as close to the application point as reasonably possible.

10.6.1.4 Chlorination systems should be protected from fire hazards and water should be available for cooling cylinders in case of fire.

10.6.1.5 Adequate room shall be provided for easy access to all equipment for maintenance and repair. The minimum acceptable clearance around and in back of equipment is two feet, except for units designed for wall or cylinder mounting.

10.6.2 Inspection Window

A clear glass 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. The window shall be gas-tight if installed in an interior wall.

Windows in both the door and wall are recommended.

10.6.3 Heat

Rooms containing disinfection equipment shall be provided with a means of heating so that a temperature of at least 60°F can be maintained. Cylinders or containers in a separate room shall be kept at a temperature equal to or slightly less than the chlorinator room, except when liquid chlorine is withdrawn from 2,000-pound containers.

10.6.4 Ventilation

With chlorination systems, forced mechanical ventilation shall be installed which will provide one complete air

change every four minutes when the room is occupied and one complete air change every fifteen minutes at all times. The inlet to the air exhaust duct from the room shall be near the floor and the point of discharge shall be so located as not to contaminate the air inlet to any buildings. Air inlets and exhausts shall be so located as to provide cross ventilation and at such temperature that will not adversely affect the chlorination equipment.

10.6.5 Vents

Chlorinators and some accessories require individual vents to a safe outside area. The vent should terminate not more than 25 feet above the chlorinator or accessory and have a slight downward slope from the highest point. The outside end of the vent should bend down to preclude water entering the vent and be covered with an insect screen.

10.6.6 Electrical Controls

Electrical controls for lights and fans should operate automatically when entrance doors are opened. Manually controlled override switches shall be located adjacent to and outside of all entrance doors with an indicator light indicating fan operation at each entrance. Electrical controls shall be excluded, insofar as possible, from chlorine rooms.

10.7 CHLORINE RESPIRATORY PROTECTION

Respiratory air-pac protection equipment of the pressure-demand type, meeting the NIOSH requirements, shall be available where chlorine gas is handled. The equipment shall be stored at a convenient location near the chlorine room, but not inside any room where chlorine is used or stored. Instructions for using the equipment shall be posted. The units shall use compressed air, have at least 30-minute capacity, and be compatible with the units used by the fire department responsible for the plant.

10.8 CHLORINE APPLICATION

10.8.1 Mixing

The disinfectant shall be positively mixed as rapidly as possible, with a complete mix being affected in three seconds and prior to entering the contact chamber. This may be accomplished by the use of turbulent flow regime (hydraulic jump), mechanical flash mixer, or jet disinfection. The mixer shall be located at or immediately downstream from the point of chlorine injection and the mixing chamber shall be as small as possible.

10.8.2 Contact Period

For a chlorination system, a minimum period of 30 minutes detention at AWW flow or 15 minutes detention at PHWW flow, whichever is greater, shall be provided after thorough mixing. If dechlorination is required, no contact time is necessary after complete mixing of the effluent with the dechlorination chemical.

10.8.3 Contact Tank

10.8.3.1 The chlorine contact tank shall be constructed so as to reduce short-circuiting of flow to a practical minimum. "End-around" baffling for serpentine flow shall be provided to minimize short-circuiting. Baffles shall be designed to provide a length-to-width ratio of at least 40 to 1.

10.8.3.2 Duplicate tanks (each equal to half of the required volume), mechanical scrapers, or portable deck-level vacuum cleaning equipment shall be provided to facilitate maintenance and cleaning. Drainage from contact tanks shall be discharged to the head end of the plant. Baffles shall be provided to prevent the discharge of floating material and provision shall be made for removal of floating solids.

10.9 OZONE

10.9.1 Feed Equipment

Ozone dissolution is accomplished through the use of conventional gas diffusion equipment, with appropriate consideration of materials. When ozone is being produced from air, gas preparation equipment (driers, filters, compressors) is required. When ozone is being produced from pure oxygen, this equipment may not be needed.

10.9.2 Capacity

10.9.2.1 Required disinfection capacity will vary, depending on the uses and points of application of the disinfection chemical. For disinfection, the capacity shall be adequate to produce an effluent that will meet the department-specified limits for that installation. Ozone systems proposed to meet disinfection requirements will be reviewed on a case-by-case basis.

10.9.2.2 Equipment shall be provided to handle the entire range of expected flows and dosages throughout the design period.

10.9.3 Standby Equipment and Spare Parts

Where disinfection is required for the entire year, standby equipment of sufficient capacity shall be installed to provide disinfection with the largest unit out of service. Spare parts shall be available for all disinfection equipment to replace parts which are subject to wear and breakage.

10.9.4 Piping

10.9.4.1 Piping systems shall be as simple as possible, specifically selected and manufactured to be suitable for ozone service, with a minimum number of joints. Piping should be well supported and protected against temperature extremes.

10.9.4.2 The selection of material should be made with due consideration for ozone's corrosive nature. Copper or aluminum alloys should be avoided. Only materials at least as corrosion-resistant to ozone as Grade 304 L stainless steel should be specified for piping containing ozone in non-submerged applications. Unplasticized PVC, Type 1, may be used in submerged piping, provided the gas temperature is below 140°F and the gas pressure is low.

10.9.5 Housing

10.9.5.1 General

1. If ozone generation equipment is to be in a building used for other purposes, a gas-tight room shall separate this equipment from any other portion of the building. Doors to this room shall open only to the outside of the building, and shall be equipped with panic hardware.
2. Adequate room shall be provided for easy access to all equipment for maintenance and repair. The minimum acceptable clearance around and in the back of equipment is two feet.

10.9.5.2 Inspection Window - A clear glass window shall be installed in an exterior door or interior wall of the ozone generator room to permit the units to be viewed without entering the room. The window shall be gas-tight if installed in an interior wall. Windows in both the door and wall are recommended.

10.9.5.3 Heat - The temperature of the room containing the ozone generation units shall be maintained above 35°F at all times.

10.9.5.4 Ventilation - For ozonation systems, continuous ventilation to provide at least one complete air change every ten minutes should be installed. The inlet to the air exhaust duct from the room shall be near the floor and the point of discharge shall be so located as not to contaminate the air inlet to any buildings. Air inlets and exhausts shall be so located as to provide cross ventilation and at such temperature that will not adversely affect the ozone generation equipment.

10.9.5.5 Electrical Controls - Electrical controls for lights and fans should operate automatically when entrance doors are opened. Manually controlled override switches shall be located adjacent to and outside of all entrance doors with an indicator light indicating fan operation at each entrance. Electrical controls shall be excluded, insofar as possible, from ozone generation rooms.

10.9.6 Ozone Application

10.9.6.1 Mixing - The disinfectant shall be positively mixed as rapidly as possible, with a complete mix being affected in three seconds and prior to entering the contact chamber. This may be accomplished by the use of turbulent flow regime (hydraulic jump), mechanical flash mixer or jet disinfection. The mixer shall be located at or immediately downstream from the point of ozone injection and the mixing chamber shall be as small as possible.

10.9.6.2 Contact Period - The required contact time for an ozonation unit varies with the type of dissolving equipment used. Certain high rate devices require contact times less than one minute to achieve disinfection while conventional dissolving equipment may require contact times similar to chlorination systems.

10.9.6.3 Contact Tank

1. An ozone contact tank shall be constructed so as to reduce short-circuiting of flow to a practical minimum. "End-around" baffling for serpentine flow shall be provided to minimize short-circuiting. Baffles shall be designed to provide a length-to-width ratio of at least 40 to 1.
2. Duplicate tanks (each equal to half of the required volume), mechanical scrapers, or portable deck-level vacuum cleaning equipment shall be provided to facilitate maintenance and cleaning. Drainage from

contact tanks shall be discharged to the head end of the plant. Baffles shall be provided to prevent the discharge of floating material and provision shall be made for removal of floating solids.

10.10 BROMINE

Bromine has had limited use for disinfection, mostly due to high cost and handling difficulties. There has been successful use of bromine in stick form for swimming pool disinfection. The stick is a compound of both bromine and chlorine known as bromo-chloro-dimethylhydantoin (Dihalo), and is used in conjunction with a stick feeder. A discussion of bromine and its application for disinfection may be found in "White, George Clifford, Handbook of Chlorination, Van Nostrand Reinhold Company, 1972, pp. 707-713".

10.11 ULTRAVIOLET (UV) RADIATION

The following requirements shall apply for the use of UV radiation units for disinfection:

10.11.1 Design and Hydraulics

Designs with modular UV disinfection units that can be removed from the flow are required. At least two banks in series shall be provided for disinfection reliability and to ensure uninterrupted service during tube cleaning or other required maintenance. The system's hydraulic properties shall be designed to simulate plug flow conditions without short circuiting under the full operating flow range. In addition, water level control shall be provided to achieve the necessary exposure. Closed chamber units will be reviewed on a case-by-case basis.

10.11.2 Dosage

The UV dosage shall be based on the design peak hourly flow. A minimum dosage of $30 \mu\text{W}\cdot\text{s}/\text{cm}^2$ may be used after adjustments for maximum tube fouling, lamp output reduction after 8,760 hours of operation, and other energy absorption losses.

10.11.3 Operations, Safety and Alarm System

Operator safety (electrical hazards and exposure to UV radiation) and tube cleaning frequency shall be considered. An alarm system shall be provided to separately indicate lamp failure, low UV intensity, and any other cause of UV disinfection unit failure.

10.11.4 Electrical Controls

A programmable logic controller (PLC) shall be provided. Multiple PLCs should be provided as necessary to ensure rapid recovery and minimize the deterioration of effluent quality from the failure of a single controller. An uninterruptible power supply with electrical surge protection shall be provided for each PLC to retain program memory (i.e. process control program, last known set-points, and measured process/equipment status) through a power loss. A hard-wired backup for manual override shall be provided in addition to automatic process control. Both automatic and manual controls shall allow independent operation of each UV disinfection unit.

10.12 DECHLORINATION

10.12.1 General Requirements

Dechlorination shall be provided in accordance with discharge permit requirements. Dechlorination chemicals shall be rapidly mixed with the effluent.

10.12.2 Sulfur Dioxide

Sulfur dioxide dechlorination systems shall be designed with the same equipment as chlorination systems for maximum interchangeability.

10.12.3 Effluent Requirements

Effluent reaeration shall be provided after dechlorination if necessary to ensure adequate DO concentration in the receiving stream. Dechlorinated effluent shall be monitored for chlorine residual and DO in accordance with discharge permit requirements.

10.13 EVALUATION OF EFFECTIVENESS

10.13.1 Sampling

Facilities shall be included for sampling the disinfected effluent after contact. In large installations, or where stream conditions warrant, provisions should be made for continuous monitoring of effluent chlorine residual. All sample lines should be designed so that they can be easily purged of slimes and other debris.

10.13.2 Testing and Control

If chlorine is the disinfectant, appropriate equipment shall be provided for measuring chlorine residual using accepted test procedures.

CHAPTER 11: LAND APPLICATION OF WASTEWATER

11.1 APPLICABILITY AND SCOPE

This chapter is applicable to the construction, installation, or modification of any disposal system required to obtain a construction permit, and to the effluent from municipal and industrial wastewater treatment facilities discharged to land treatment and disposal systems that require an Iowa operation permit from the department under Iowa Code section 455B.183 and rules 567—60.2(455B) and 567—60.3(455B).

11.2 GENERAL SITE CONSIDERATIONS

The following design considerations apply to two methods for the land application of wastewater; slow rate (irrigation), and overland flow. The engineering report shall contain pertinent information on the proposed land application site(s), including location, geology, soil conditions, area for expansion, groundwater conditions, and any other factors which may affect the feasibility and acceptability of the proposal. The engineering report shall also include the necessary pretreatment and storage requirements, a management program stating the objectives of the land application, the design land application rates, and groundwater monitoring and reporting. Any information used by the consulting engineer in the design shall be clarified.

The information in this chapter shall be addressed in the facility plan. To expedite the review process, it is recommended that the consulting engineer address the items in the outline format presented within this chapter. If a particular item is not applicable to the project, the consulting engineer may indicate "NA" with an explanation.

11.3 RESPONSIBILITY

The owner/generator of the wastewater shall be responsible for the land application, except when an independent land application contractor has been issued an Iowa Operation permit for land application of the wastewater. When an independent contractor is issued an Iowa Operation permit, the contractor will be responsible for the disposal of the specified wastes to the land. An Iowa Operation permit must be obtained from the department prior to any wastewater land application.

11.4 EXCLUSIONS AND PROHIBITIONS

11.4.1 Exclusions

The following wastes are excluded from the provisions of this chapter:

1. Animal waste regulated under 567—Chapter 65;
2. Domestic waste handled and disposed of in accordance with 567—Chapter 68;
3. Domestic sewage defined as and regulated under 567—Chapter 69;
4. Sludges from POTWs regulated under 567—Chapter 67;
5. Sludges which are disposed of in a landfill or land disposal site in accordance with 567—Chapter 121;
6. Compost regulated under 567—Chapter 105;
7. Petroleum contaminated soil regulated under 567—Chapter 120;
8. Fertilizers and soil conditioners regulated under 21—Chapters 43 and 44; and
9. Any toxic or hazardous materials.

11.4.2 Prohibitions

The application of wastewater containing pathogens on fields growing crops or vegetables for human consumption is prohibited.

11.5 GENERAL LAND APPLICATION SITE INFORMATION

11.5.1 Site Identification

Legal description of the land application site.

11.5.2 Site Assessment

11.5.2.1 The location, use, and ownership of all existing and proposed residences, commercial or industrial developments, roads, ground or surface water supplies, and wells within one-half mile of the proposed site.

11.5.2.2 The available land area, both gross and net areas, excluding roads, right-of-way encroachments, stream channels, and unusable soils.

11.5.2.3 The distance from the pretreatment and storage facilities to the land application site, including elevation differential.

11.5.2.4 The proximity of the site to industrial, commercial and residential developments; surface water streams; potable water wells; and public use areas such as parks, cemeteries, or wildlife sanctuaries.

11.5.2.5 The location, depth, and outlet of known field drain tiles and storm sewers on the site.

11.5.2.6 The location of abandoned wells and shafts.

11.5.2.7 A summary describing the existing vegetation of the site.

11.5.2.8 A description, including maps showing elevations and contours, of the site and the adjacent areas which may be suitable sites for expansion. This shall include specific information on the maximum and average slopes of the site.

11.5.3 Groundwater Assessment

11.5.3.1 Fieldwork Determination

1. Depth to normal groundwater;
2. General groundwater flow conditions, including direction of flow; and
3. Depth, area, and duration of maximum groundwater.

11.5.3.2 Initial Groundwater Test - Groundwater tests for the following constituents shall be conducted to provide information on the initial groundwater quality. A minimum of two groundwater samples are required for each land application site that is 40 acres or less in size. For sites larger than 40 acres, one sample per 40 acres shall be collected in addition to the two minimum samples. In all cases, the samples shall represent the groundwater characteristics within, upgradient, and downgradient of the land application site.

- Total organic carbon (TOC)
- Total dissolved solids (TDS), sodium absorption ratio (SAR), and electrical conductivity
- Total nitrogen (Kjeldahl plus Nitrate)
- Total phosphorus
- Chloride
- pH
- Alkalinity
- Hardness
- Coliform Bacteria
- Trace Elements:
 - Aluminum
 - Antimony
 - Arsenic
 - Barium
 - Beryllium
 - Boron
 - Cadmium
 - Chromium
 - Copper
 - Cyanide
 - Fluoride
 - Iron
 - Lead
 - Lithium
 - Manganese
 - Mercury
 - Molybdenum
 - Nickel
 - Selenium
 - Vanadium
 - Silver
 - Selenium
 - Zinc

11.5.4 Geological and Soil Information and Testing

A description of the material underlying the proposed site is required to determine the site geology. This shall include stratigraphic sections based on one soil boring per 40 acres. Submit a drilling location plan and drilling log for each series of samples. Soil borings shall be conducted by a qualified geotechnical organization engaged in soil testing activities, and the report shall be certified by a professional engineer. Additional information, including additional borings, may be required for any additional locations of specific concern to the department.

11.5.4.1 Describe the stratigraphic sections from the surface to a depth of 25 feet or to the bedrock, or to normal groundwater level, whichever is less.

11.5.4.2 Identify the soil at a potential site in each soil layer in terms of all of the following hydraulic, physical, and chemical characteristics, from the surface to a depth of five feet. One composite soil sample is required for each land application site, unless the site is larger than 40 acres. In that case, one sample is required for each 40 acres or portion thereof.

1. Hydraulic characteristics are infiltration rate and permeability of the most restrictive layer.
2. Physical characteristics include texture, structure, and soil depth.
3. Chemical characteristics include pH, soil cation exchange capacity, nutrient levels, the adsorption and filtration capabilities for various inorganic ions, heavy metals, and phosphorus adsorption.

11.5.4.3 The geological information shall also include:

1. The degree of weathering of any shallow bedrock;
2. The local bedrock structure, including the presence of faults, fractures and joints; and
3. In limestone terrain, additional information about sinkholes and solution openings.

11.6 SITE DESIGN

11.6.1 Wetted Disposal Area

The wetted disposal area shall conform to the following criteria. For the distance requirements below, the wetted disposal area is the land and area which is normally wetted by wastewater application.

11.6.1.1 The wetted disposal area shall have a mantle of at least five feet overlaying any sand or gravel strata.

There shall be at least five feet of separation between the ground surface and the seasonal high water table.

11.6.1.2 On sites where tile drainage is installed, the depth to tile lines is considered the depth to the seasonal high-water table. Provide maps of the tile lines which indicate their depth and placement in the field.

11.6.1.3 Flood prone areas which flood at a frequency greater than once every ten years may not be the sole location for the land application of wastewater. Information on sites prone to flooding can be obtained from the USDA-NRCS Web Soil Survey.

11.6.1.4 The separation distances for land application wetted disposal areas are specified in Table I of 567—paragraph 60.2(2)“c.”

11.6.1.5 Signs indicating the presence of a wetted disposal area shall be posted along roads and public use areas. A minimum of one sign shall be placed on each side of the disposal area. The perimeter distance between any two signs may not exceed 500 feet. Each sign shall clearly identify the nature of the facility and advise against trespassing in letters not less than two inches high.

11.6.2 Crops and Other Vegetation

11.6.2.1 A report describing the crops or vegetation to be grown is required for all systems in which vegetation is to be an integral part of the treatment system. This includes all slow rate and overland flow systems. The use of wastewater for irrigation of farms growing vegetables and crops for direct human consumption is prohibited.

11.6.2.2 The following information shall be provided in the report:

1. Compatibility of the crop with site characteristics and design hydraulic loading rates;
2. Nutrient uptake;
3. Cultivation and harvesting requirements; and
4. Crop Management.

11.6.3 Nutrient Leaching

Nitrogen and phosphorus leaching control measures shall follow guidelines as set forth in the latest edition of the USDA-NRCS Iowa Nutrient Management Conservation Practice Standard.

11.6.4 Erosion Control Measures

The topography of the site and adjacent land shall be evaluated for areas of potential erosion.

11.7 WASTEWATER CHARACTERIZATION AND TREATMENT

11.7.1 Initial Wastewater Analysis

An initial analysis of the untreated wastewater shall be conducted. The analysis shall consist of at least one week of daily composite samples. The constituents to be monitored are listed in Subsection 11.5.3.2.

11.7.2 Wastewater Treatment Criteria

11.7.2.1 Treatment prior to land application is determined based on the wastewater composition and crop uptake requirements. If the selected treatment options are lagoon systems, including anaerobic, aerobic, or facultative controlled discharge lagoons, construction shall meet the requirements of IWFDS Chapter 8C.

1. The minimum drawoff level of the primary cell shall be at the two-foot level. Drawoff for direct land application of wastewater shall be from the secondary cell or from the storage cells. Piping shall be arranged such that the drawoff from the primary cell cannot be used for direct land application of wastewater.
2. Additional treatment may be required to obtain and maintain the limitations determined or stated in Sections 11.8.1 through 11.8.5. The additional treatment will be weighed against the alternative of increasing the area of the land application site.

11.7.2.2 Disinfection - Disinfection shall be provided for all effluent from municipal wastewater treatment facilities, and for the effluent from industrial facilities based on the wastewater characteristics and land application systems. Disinfection shall be designed in accordance with IWFDS Chapter 10.

11.8 LAND APPLICATION RATE DETERMINATION

11.8.1 Hydraulic Loading Rate

11.8.1.1 The hydraulic loading rate shall be determined by utilizing a water balance per month of operation.

The water balance includes precipitation, infiltration rate, evapotranspiration, soil storage capabilities, and subsoil permeability. Sufficient supporting information shall be provided to determine the hydraulic loading rate. Generally, the total monthly application is distributed uniformly, but considerations can be made for planting, harvesting, drying, and other non-application periods. The land application hydraulic loading rate is balanced as shown in the following equation:

$$L_w + Pr = ET + W_p + R$$

L_w = wastewater hydraulic loading rate, in./mo.

Pr = design precipitation, in./mo.

ET = evapotranspiration, in./mo.

W_p = percolating water, in./mo. [$W_p = 0$ for overland flow systems]

R = net runoff, in./mo. [$R = 0$ for slow rate system]

1. The relationship in the above equation can be used for a weekly balance, a monthly balance as shown, or an annual water balance. Design precipitation is calculated from a 10-year return frequency analysis of wetter-than-normal conditions using data available from the Soil Conservation Service, the National Oceanic and Atmospheric Administration (NOAA), local airports, or newspapers.
2. The option presented in IWFDS Section 11.9.4 may alter the above water balance. Use of that option will require a full explanation of changes to this water balance.
3. For slow rate systems, percolating water (W_p) shall be restricted to a maximum of 10 inches/month.

11.8.1.2 Application Restrictions Based on Sub-soil Permeability - The application rate shall not exceed one half of the design sustained sub-soil permeability rate, and in no case shall be greater than one inch/hour, totaling to a maximum limit of 10 inches/month.

11.8.2 Application of Nitrogen (N)

11.8.2.1 N Balance - The total nitrogen (N) from wastewater, commercial fertilizer or any other source has to be balanced against the expected N demand of the crop. The total poundage of N loading shall be calculated using the total volume of wastewater applied per year and the concentration of N (Kjeldahl plus nitrate) in the wastewater. Due to denitrification in soil, a maximum loss of 20% of the applied N annual loading is allowed. The annual N balance is calculated by the following equation:

$$L_n + K = U + D + 2.7W_pC_p$$

$L_n = 2.7C_nL_w$ = wastewater nitrogen loading, lbs/acre-yr.

C_n = applied N concentration from the pretreatment facility, mg/L

L_w = wastewater hydraulic loading, ft/yr.

2.7 = conversion factor

K = All other nitrogen sources, lbs/acre-yr. Mineralization rate of organic nitrogen.

U = Crop nitrogen uptake, lbs/acre-yr.

D = Denitrification, lbs/acre-yr.

W_p = Percolating water, ft/hr.

C_p = Percolate nitrogen concentration, mg/L

11.8.2.2 Percolate - The total N in the percolate shall not exceed 10 mg/L.

11.8.3 Application of Phosphorus (P)

The agronomic loading rate for the land application wastewater containing phosphorus (P) is based on the concentration of P in the soil, the P demand of the crop, and the risk of off-site P transport.

11.8.3.1 Concentration of P in Soil - Prior to each growing season (typically in the fall after harvest), a representative number of P soil tests shall be performed at each application site. Acceptable methods for testing P in the soil are the Bray P1, Mehlich-3, and Olsen tests. Soil-test values shall be classified in accordance with the General Guide for Crop Nutrient and Limestone Recommendations in Iowa, PM 1688.

11.8.3.2 Crop Demand for P - The General Guide for Crop Nutrient and Limestone Recommendations in Iowa, PM 1688, shall be used to determine removal amounts of P, unless actual yield levels are known in a field or portion of fields.

11.8.3.3 Off-site Transport - The risk of off-site P transport shall be assessed using the Iowa P Index. The index focuses on three possible pathways of off-site P transport: movement of P in eroded sediments, movement of P in surface water runoff, and movement of P in subsurface drainage water. A determination of the movement of P in eroded sediments will require the use of the latest revision of the Universal Soil Loss Equation (RUSLE2). An assessment of the Iowa P Index reports will determine if a site is suitable for the land application of wastewater containing P. See the following scenarios below.

1. If the risk of off-site transport is high or very high, land application of wastewater containing P is prohibited.
2. If the risk of off-site transport is low or very low and the mean value of soil-test P is in the very low, low, or optimum soil-test category, the total wastewater P application (plus any supplemental P fertilizer) may not exceed the application amounts of phosphorus pentoxide (P_2O_5) (lbs/acre) recommended in the *General Guide for Crop Nutrient and Limestone Recommendations in Iowa*, PM 1688.
3. If the risk of off-site transport is medium, the wastewater P application (plus any supplemental P fertilizer) shall be limited so that the annual application of P does not exceed the optimum application amount of P_2O_5 (lbs/acre) recommended in the *General Guide for Crop Nutrient and Limestone Recommendations in Iowa*, PM 1688.

11.8.4 Application of Salts - Salinity Restrictions

11.8.4.1 Wastewater - The wastewater classification C1-S1 (Figure 1) is an acceptable range for applying wastewater to soil. Classifications C1-S2, C2-S2, and C2-S1, will also be acceptable provided that the permittee demonstrates that there is sufficient leaching available to eliminate salinity problems. The remaining classifications will not be acceptable for land application in Iowa. Table 1, Table 3, and Figure 2 are to be used when determining leaching. Interpolation may be necessary to obtain the electric conductivity of the appropriate crop.

11.8.4.2 Soil - Soils with high levels of exchangeable sodium (Na) and low levels of total salts are called sodic soils. Growth of sensitive plants is impaired when the salt content of soil exceeds 0.1%. This can be a problem with land application of wastewater, because Na is typically present in all wastewaters. The Sodium Adsorption Ratio (SAR), which is the amount of Na relative to calcium (Ca) and Magnesium (Mg), is an indicator of the suitability of wastewater for use in agricultural irrigation. Concentrations of Na in soil in relation to Ca and Mg can affect the structure and lower the permeability of clay-bearing soils.

1. The SAR is defined by the following equation:

$$SAR = \frac{Na^+}{[(Ca^{+2} + Mg^{+2})/2]^{0.5}}$$

SAR = Sodium adsorption ratio

Na^+ = Sodium concentration, milliequivalents/L

Ca^{+2} = Calcium concentration, milliequivalents/L

Mg^{+2} = Magnesium concentration, milliequivalents/L

To convert a concentration from mg/L to milliequivalents/L, multiply the concentration in mg/L by Valence/Atomic Weight.

2. A SAR value of 10 or less may be acceptable on soils with 15% clay content or greater.
3. A SAR value of 20 will be acceptable if the soil is demonstrated to have little amounts of clay or non-swelling clays.
4. High SAR values of 20 or greater must be remediated by the surface application of gypsum or another acceptable source of Ca to sodic soils, not saline soils. On average, recovering a foot depth of sodic soil on one acre requires approximately 1.7 tons of pure gypsum ($\text{CaSO}_4 \cdot 2\text{H}_2\text{O}$) for each milliequivalent of exchangeable Na per 100 grams of soil. Once gypsum is applied, sufficient quality water must be added to leach the displaced Na beyond the root zone. Restoring sodic soils is a slow process. It is recommended to grow a salt tolerant crop in the early stages of reclamation (see Table 2) and to add organic matter to the soil to increase water infiltration and permeability to speed up the reclamation process.

Table 1. General Classification for Sodium Hazard of Soil Based on SAR Values

Classification	SAR ²	EC (ds/m) ¹	Soil pH	Soil Physical Condition
Sodic	≥ 13	< 4.0	> 8.5	Poor
Saline-Sodic ³	≥ 13	> 4.0	< 8.5	Varies
Slightly Saline	< 13	2 - 4	< 8.5	Normal
Saline	< 13	> 4.0	< 8.5	Normal
High pH	< 13	< 4.0	> 7.8	Normal

¹EC means electrical conductivity, and ds/m=mmhos/cm.

²If reported as exchangeable sodium % or ESP, use 15% as threshold value.

³The primary difference is that saline soils also have a high salt content, while sodic soils have high sodium content.

Table 2. The Salt Tolerance Forage Crops (as indicated by the electrical conductivity of saturated soil extract)

High Tolerance 18,000 micromhos/cm	Medium Tolerance 12,000 micromhos/cm	Low Tolerance 4,000 micromhos/cm
Saltgrass	White sweetclover	White Dutch clover
Bermuda grass	Yellow sweetclover	Meadow foxtail
Canada wildryr	Perennial ryegrass	Alsike clover
Barley (hay)	Sudan grass	Red clover
Birdsfoot trefoil	Hubam clover	Ladino clover
	Alfalfa (Calif. Common)	
	Tall fescue	
	Rye (hay)	
	Wheat (hay)	
	Oats (hay)	
	Orchard grass	
	Meadow fescue	
	Reed canary	
	Smooth brome	

12,000 micromhos/cm	4,000 micromhos/cm	2,000 micromhos/cm
Barley (grain)	Rye (grain)	Field beans
Sugar beet	Wheat (grain)	
Rape	Oats (grain)	
Cotton	Rice	
	Sorghum (grain)	
	Corn (field)	
	Flax	
	Sunflower	
	Castor beans	
10,000 micromhos/cm	6,000 micromhos/cm	

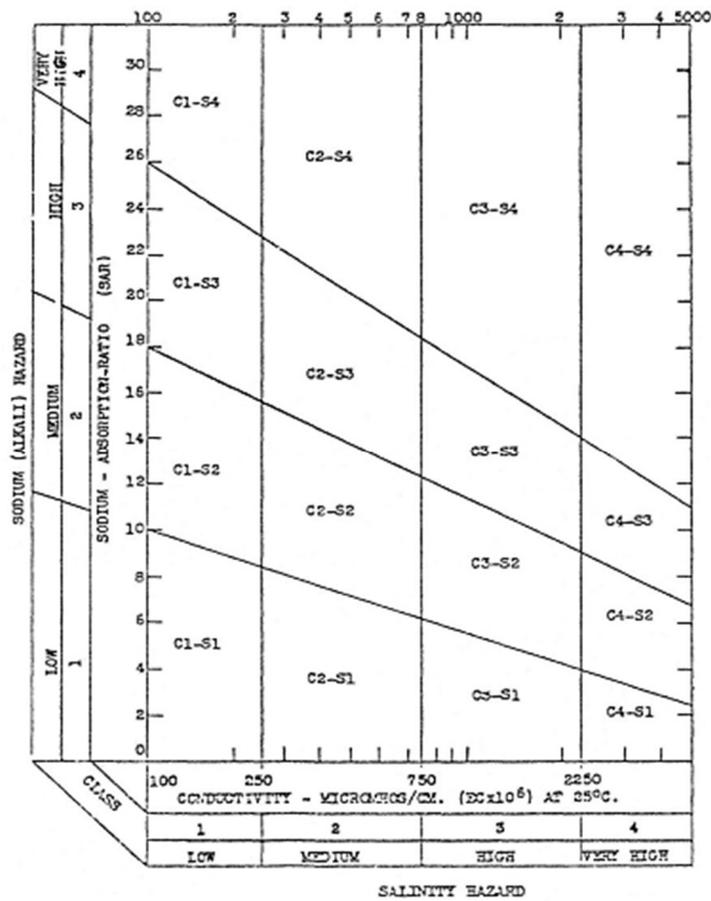


Figure 1. Diagram for the classification of irrigation waters.

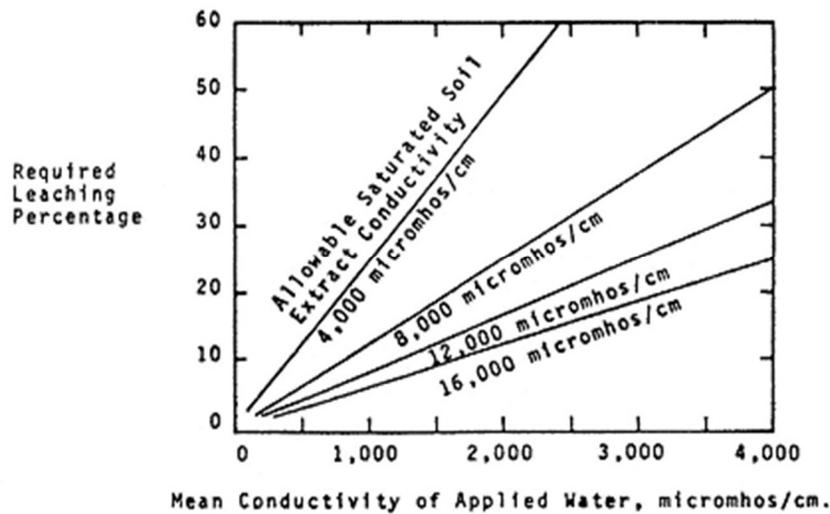


Figure 2. Required Leaching Percentage

11.8.5 Applications of Trace Elements

Heavy metals and other toxic elements from the storage or treatment facility shall not exceed the maximum concentrations specified in Table 3.

Table 3. Maximum Concentrations of Trace Elements in Applied Wastewater

Element	Limits mg/L	Element	Limits mg/L
Aluminum	10.0	Iron	10.0
Arsenic	0.20	Lead	10.0
Beryllium	0.20	Lithium	2.50
Boron	1.40	Manganese	0.40
Cadmium	0.02	Molybdenum	0.02
Chromium	0.20	Nickel	0.40
Cobalt	0.10	Selenium	0.04
Copper	0.40	Vanadium	0.10
Fluoride	1.80	Zinc	4.00

11.8.6 Information on the Application of Organic Compounds

11.8.6.1 If the facility is aware of any antibiotics, herbicides, fungicides, detergents, surfactants, or polychromatic carbons, the compounds shall be identified and the quantity disclosed.

11.8.6.2 The USDA Windows Pesticides Screening Tool (WIN-PST) may be utilized for pesticide screening and quantification.

11.8.6.3 The EPA Estimation Programs Interface Suite™ may be used to estimate the environmental fate of various organic compounds.

11.8.6.4 Currently, there are no available rules or specific standards for the application of organic compounds. Therefore, the purpose of this section is data collection for informational purposes only.

11.8.7 Reliability

11.8.7.1 General - The applicant shall submit a feasible alternative plan of wastewater treatment if and when the largest application area is out of service due to system breakdown or other unforeseen circumstances.

11.8.7.2 Equipment

1. Any spray application equipment specified shall minimize the formation of aerosols.
2. The system shall be designed to assure uniform distribution of wastewater over the land application site.

11.8.8 Operating Schedule

The land application cycle, or the combination of land application periods and resting periods, shall be defined in the form of an operating schedule. The cycle length and the ratio of wetting to drying shall depend on site-specific factors and may include seasonal variations.

11.8.9 Landowner Agreements

Any party utilizing the slow rate irrigation method on an area owned by another party shall provide the department with signed copies of documents establishing their legal rights to utilize the site for not less than five years. Such documents shall include optional renewal provisions which specify that at least one year's notice will be given to the party utilizing the site for disposal if the landowner does not intend to renew the agreement. If the documents are not signed within 18 months following the selection of a land application system as the treatment facility, the department may require the use of an alternative type of treatment.

11.9 STORAGE FACILITY DESIGN

11.9.1 Storage Period

Figure 3 depicts the minimum days of storage based on climatic restraints. In some cases, the minimum number of storage days must be increased to accommodate months in which the precipitation exceeds or equals the percolate plus evapotranspiration. An exception to this is a system where flows are generated only during the application period. A storage capacity of 45 days or the flow generated during the period of operation, whichever is less, shall be provided.

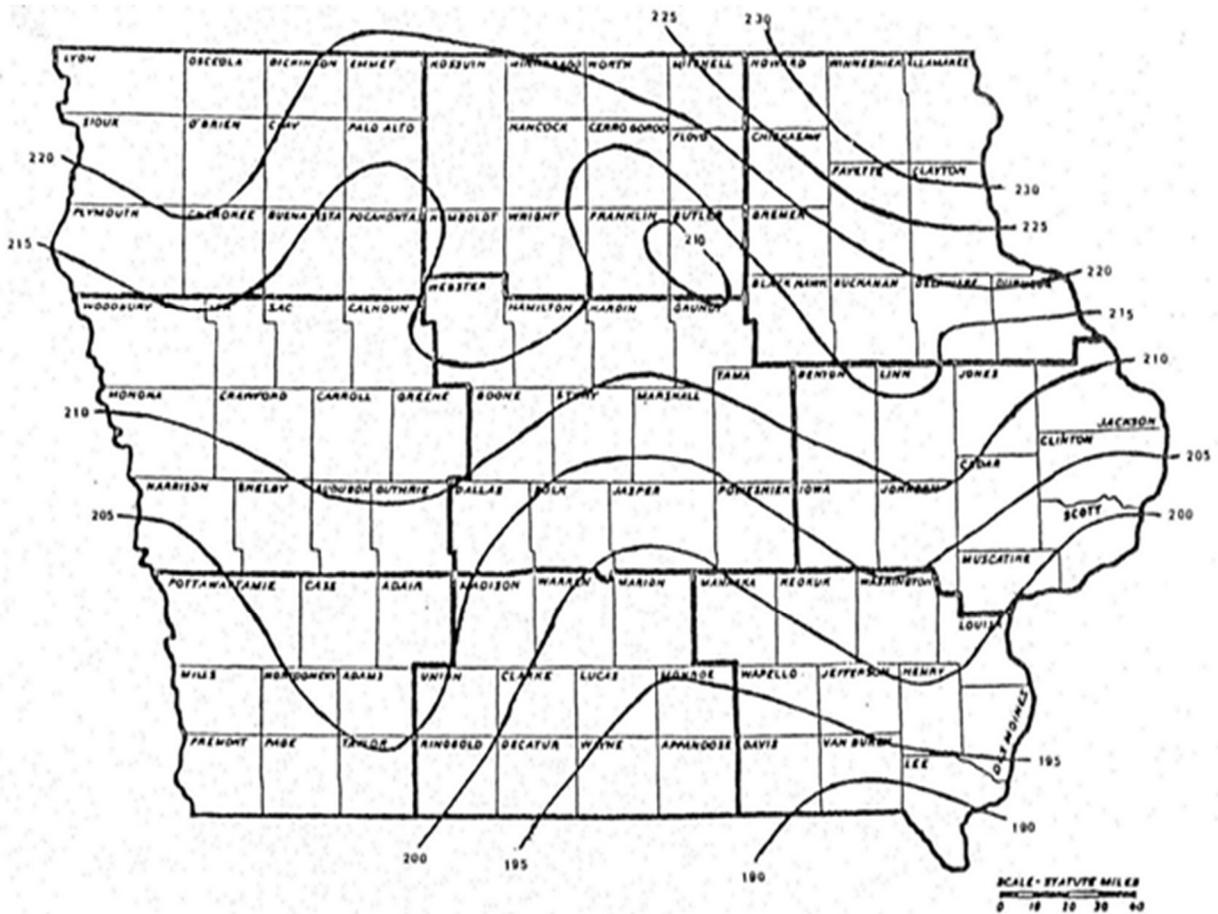


Figure 3. Minimum Days of Storage due to Climatic Restraints

11.9.2 Construction

The construction of a wastewater storage lagoon shall conform with IWFDs Chapter 8C and the maximum total water depth shall not exceed 10 feet with the minimum drawoff at the two-foot level.

11.9.3 Reliability

There shall be a minimum of two storage cells with the capability of series and parallel operation.

11.9.4 Discharge to Waterway

11.9.4.1 Because of the lengthy wastewater storage requirement, an option to discharge from the storage facility to a receiving waterway on a periodic basis may, in some cases, be cost effective. To utilize this option, the applicant will be required to provide storage for 180 days of AWW flow and the storage facility is designed in accordance with IWFDS Chapter 8C. This option will require an NPDES permit and a schedule noting the expected discharge time and volume. The volume discharged must not reduce the volume of the remaining wastewater to less than that necessary for full utilization of land application.

11.9.4.2 Discharge from a storage facility to a waterway will be acceptable only if the storage facility has obtained an NPDES permit, the limitations listed in the NPDES permit are met, and land application has already been utilized to its maximum potential.

11.10 MONITORING REQUIREMENTS**11.10.1 Applied Wastewater**

11.10.1.1 Land applied wastewater shall be sampled after any treatment and before it is land applied. The parameters in Sections 11.8.1 through 11.8.5 shall be monitored unless the applicant has demonstrated their insignificance in the influent wastewater concentration, as specified in Subsection 11.10.2.2. Additional parameters may require monitoring if found in significant concentration in the wastewater.

11.10.1.2 Sampling Frequency - Wastewater samples shall be taken prior to every application and results shall be included in the annual report.

11.10.2 Groundwater Monitoring

11.10.2.1 Groundwater Monitoring Systems - All land disposal systems regulated under this chapter shall have a groundwater monitoring system that complies with the requirements of 567—subrule 113.10(2), except as noted herein.

11.10.2.2 Groundwater Monitoring Locations and Frequency

1. A minimum of three groundwater monitoring wells are required for each land application site 40 acres or less in size. Sites greater than 40 acres shall to collect one sample per 40 acres in addition to the three samples. In all cases, the samples shall represent the groundwater characteristics within the land application site and upgradient and downgradient of the land application site.
2. The parameters stated in Subsection 11.5.3.2, unless the applicant has demonstrated their concentration in the influent is less than 50% of the concentration listed in Section 11.8.5 or in the National Primary and Secondary Drinking Water Standards. Additional parameters may require monitoring if found in significant concentration in the wastewater.

11.10.3 Data Collection and Reporting

11.10.3.1 The minimum data collection and frequency shall be:

1. Every three months for less than 0.5 mgd;
2. Every two months for 0.5 - 2.0 mgd; or
3. Every month for greater than 2.0 mgd.

11.10.3.2 Data Recording and Reporting - The following data shall be recorded prior to each application of wastewater:

1. Date of land application;
2. Location of area and acreage used for the week;
3. Precipitation, snow cover, and temperature on the day of application;
4. Volume of wastewater applied from pretreatment facility;
5. Volume of wastewater applied from storage facility;
6. Total volume of wastewater applied;
7. Duration of application for each cycle;
8. Type of crop grown;
9. Harvesting of crop; and
10. Ultimate use of crop.

11.10.3.3 Annual Reporting - Evaluate the collected data and generate a detailed annual report as required by the operating permit. The report shall be submitted to the appropriate local department field office prior to January 15 of each calendar year.

11.10.3.4 Groundwater Limitations - The following requirements apply to all subsurface waters.

1. The groundwater resulting from the land application of wastewater after dilution with the affected native groundwater shall meet the National Primary and Secondary Drinking Water Standards in 567—Chapter 41. If the existing concentration of a parameter in the native groundwater exceeds the drinking water standards, there shall not be an increase in the concentration of the parameter due to land application of wastewater;
2. Any significant detrimental change in the groundwater at or near the site may constitute reasons for requiring additional pretreatment and/or abandonment of the disposal site; and
3. The applicant shall submit a feasible alternate plan of wastewater treatment if and when the contaminant levels in the groundwater exceed the maximum allowable concentration.

11.10.3.5 Surface Water Discharge of Groundwater - If discharged to a stream, monitoring of the recovered water from pumped withdrawal, underdrains, or collected runoff from overland flow shall meet the requirements of the department-issued NPDES permit.**11.10.3.6 Soil Monitoring** - The soil at each application site shall be sampled and analyzed once every three years for the following analytes:

- USDA Textural Soil Classification;
- Organic matter;
- Phosphorus, extractable in soil;
- Potassium, exchangeable in soil;
- pH; and
- Salts, water soluble in soil.

11.10.3.7 Sample Type - One composite sample is required for each land application site, unless the site is larger than 40 acres. In that case, one sample is required for each 40 acres or portion thereof.**11.10.3.8 Reporting** - Soil sampling reporting shall be included in the annual report.**11.11 SLOW-RATE LAND APPLICATION****11.11.1 General**

In a slow rate land treatment system, land applied wastewater is treated as it flows throughout the soil matrix. A portion of the flow is taken up by the vegetation and the remaining flow percolates to the groundwater. Vegetation is a critical component for managing water and nutrients. The goal for slow rate systems is to obtain even distribution through the entire land application site. Table 4 below describes various types of distribution systems utilized by slow rate systems.

Table 4. Description of advantages and disadvantages of surface application distribution systems

System Type	System Description	Advantages and Disadvantages
Ridge & Furrow	Application to a graded field via small ditches between crop rows.	Primarily for row crops. Careful leveling is required. Uniform application is difficult on coarse-textured soils.
Border Strip Flooding	Application to a leveled field in 20 to 100-foot wide strips, bordered by dikes.	Primarily for grass or perennial crops. Careful leveling is required. Uniform application is difficult on coarse-textured soils.
Wheel Line	Engine moveable sprinklers cover the field in sets.	Less labor than hand moved sprinkler lines. Labor requirements to move sprinklers makes long sets common. Only suitable for low-height crops and rectangular fields. Inexpensive equipment.
Big Gun	Large diameter orifices operating at a high pressure spread water, and traveling hose reels allow big guns to irrigate strips over uneven ground.	Requires high pressure for maximum area coverage. Water impact can damage crops and cause soil erosion even at low pressure. Relatively high irrigation rate.

System Type	System Description	Advantages and Disadvantages
Center Pivot	Mechanical sprinkler system with a fixed central water supply moves in a circle to irrigate.	Moderate initial capital expense but less labor. Flexible and efficient irrigation with proper design. Frequent light irrigation of fields is used in the winter to reduce storage. May not be suitable for boggy or sticky soils. High instantaneous application rate.
Linear Move	Mechanical sprinkler system with end or center feed water supply moves in a straight line to irrigate fields up to 5,000 ft long.	High initial capital cost but less labor. Efficient irrigation with proper design. May not be suitable for boggy or sticky soils. High instantaneous application rate. Covers large rectangular fields.
Surface Drip	Low-flow emitters placed on the ground surface apply water to the crop root zone but not between rows.	Easier to observe emitter performance and system plugging than with subsurface emitters.
Subsurface Drip	Emitters are buried at 6-12 inches in a semi-permanent installation.	More difficult to observe system performance. Buried lines are sometimes damaged by tillage operations. Eliminates exposure to wastewater.

11.11.2 Topography

The maximum allowable slope of the wetted disposal area shall meet the following criteria:

11.11.2.1 Cultivated Fields - Slopes on cultivated fields shall be limited to 5% unless runoff control measures such as berms, collection ditches, or check dams are provided.

11.11.2.2 Sodded Fields and Forested Areas - Slopes on sodded fields and forested areas shall be limited to 8% unless runoff control measures such as berms, collection ditches, or check dams are provided.

11.11.2.3 Steep Slopes - For slopes steeper than those covered under the subsections above, the engineering documents shall include the runoff control measure recommendations of the Soil Conservation Service (SCS) or county soil conservation district.

11.11.3 Groundwater Table

The maximum anticipated elevation of the groundwater table shall be at least five feet below the surface within the wetted disposal area. Identify the following factors for all slow rate systems:

- The extent of the recharge mound;
- The need for underdrainage or pumped withdrawal; and
- The effects of the system on direction and rate of groundwater flow.

11.11.4 Tile Drainage Location Map

A detailed map indicating where the site is to be underlain by field tile shall be included in the facility plan.

11.11.5 Wetted Disposal Area

The wetted disposal area for the slow rate system shall meet the site criteria in Section 11.6.1.

11.11.6 Vegetation Management

A statement about all growing vegetation at the time of application and during the harvest period shall be included in the facility plan.

11.11.7 Additional Storage Requirements

The minimum amount of storage following pretreatment shall be determined using Figure 3. These storage days are considered minimums and are increased by adding days required for crop planting, crop management, land management, and crop harvesting.

11.11.8 Additional Application Restrictions

11.11.8.1 Soil Permeability - Soils having infiltration rates of 0.52 inches/hour or greater are suitable for irrigation. Values below 0.52 inches/hour will generally require artificial drainage or an overland flow approach.

11.11.8.2 Application Rate - The application rate may not exceed one half the design sustained sub-permeability rate, and in no case should be greater than one inch/hour, totaling to a maximum limit of 10 inches/month.

11.11.8.3 Nutrient Loading

1. If N or P is the limiting factor for the application, the land application of wastewater shall be stopped or reduced upon crop harvesting to assimilate the removal rate of the soil.

2. If water is the limiting factor for the application, the land application of wastewater may continue until such a time that another limiting factor is reached, such as N or field capacity.
3. The addition of wastewater after harvest will evaluate the following year limitation. That is, if corn is planted this year and the limiting parameter is hydraulics, and the N application is 20 lbs/acre less than the upper limit of crop uptake, then the N addition of 20 lbs/acre following harvest would be acceptable provided that some other limiting value is not exceeded.

11.11.8.4 Frost, Freezing, or Precipitation - The land application of wastewater shall not be allowed during periods of ground frost or during rainfalls.

11.11.8.5 Public Use Areas

1. The public is prohibited from entering an area when the land application is being conducted.
2. Any drinking water fountains located on or near the land application site shall be protected from direct or windblown reclaimed wastewater spray.
3. The land application of wastewater on golf courses shall meet the requirements of 567—subrule 62.5(2).

11.12 OVERLAND FLOW LAND APPLICATION

Overland flow distribution is accomplished by land applying wastewater uniformly over relatively impermeable, vegetated sloped surfaces. Part of the flow percolates into the ground and a portion is lost to evapotranspiration while the remaining is collected and either discharged to a stream or reapplied on land.

11.12.1 Topography

The land slope should be relatively uniform to prevent ponding and be in the range of 2% to 8%. If slopes greater than 8% exist, terracing shall be provided. For all overland flow systems, the slope must be as nearly equal to a plane surface as possible and sloped in such a way as to prevent short-circuiting of the wastewater. No swales, depressions, or gullies are allowed.

11.12.2 Groundwater

The maximum groundwater elevation at a land application site shall be at least two feet below the application surface.

11.12.3 Soils

The soil at each application site shall be sampled and analyzed once every three years for the following analytes:

- USDA Textural Soil Classification;
- Organic matter;
- Phosphorus, extractable in soil;
- Potassium, exchangeable in soil;
- pH; and
- Salts, water soluble in soil.

One composite sample is required for each land application site, unless the site is larger than 40 acres. In that case, one sample is required for each 40 acres or portion thereof.

11.12.4 Wetted Disposal Area

The wetted disposal area for the overland flow system shall meet the site criteria in Section 11.6.1.

11.12.5 Length of Travel

300 feet is the maximum length over which distribution of wastewater can be maintained.

11.12.6 Distribution System

11.12.6.1 General - The system shall be valved and manifolded to allow a portion of each application area to be taken out of service for grass mowing and/or harvesting.

11.12.6.2 Sprinklers - Sprinklers shall be placed downslope from the highest point on the application area at a distance equal to the radius of the sprinkler, unless one-half circle sprinklers are used.

11.12.6.3 Surface Distribution - For surface distribution methods such as gated pipe or bubbling orifice, gravel may be necessary to dissipate energy and ensure uniform distribution of the water.

11.13 VEGETATION MANAGEMENT

11.13.1 Vegetation Cover

Grasses shall be selected for their resistance to continuously wet root conditions. The growth cannot be in

clumps, as this will result in the formation of rivulets of flow rather than a uniform sheet flow. Common grasses for this purpose are reed canary grass, Italian rye, reed top, tall fescue, and Bermuda grass. The land application of wastewater is not allowed until a full grass cover has been established.

11.13.2 Vegetation Removal

Vegetation harvest and removal from land application sites is required.

11.14 ADDITIONAL STORAGE REQUIREMENTS

The minimum amount of wastewater storage following pretreatment shall be determined using Figure 3. The storage facility capacity shall be increased as necessary to accommodate rainfall on the application site and any recirculation needed to comply with the limitations in the Iowa operation permit.

11.15 ADDITIONAL APPLICATION RESTRICTIONS

11.15.1 Soil Permeability

Wastewater shall not be applied to soils having a percolation rate greater than 0.2 inches/hour.

11.15.2 Application Rate

The maximum hydraulic application rate of wastewater is three inches/week. The distribution system shall be designed to allow land application on each field for six to eight hours/day. Optimum wetting to drying cycles range from a maximum of six to eight hours on and a minimum of 16-18 hours off.

11.15.3 Nutrient Loading

For overland flow systems, the denitrification of 20% of the applied nitrogen may be conservative. To utilize a value greater than 20%, the applicant shall either provide documentation from an agronomist and soil specialist, or run a pilot plant to verify a greater denitrification value. If a value greater than 20% is verified, the applicant shall submit data specifying the percent denitrification expected for the various temperatures in which the system will be operated.

11.15.4 Frost, Freezing, or Precipitation

The land application of wastewater shall not be allowed during periods of ground frost or during rainfalls.

11.15.5 Public Use Areas

Public use of land application areas shall follow the criteria in Subsection 11.11.8.5.

11.16 SITE ACCESS

Site access requires special equipment with broad tires inflated at low pressure (less than 10 psi) to avoid creating ruts that could short-circuit the wastewater flow.

11.17 COLLECTION DITCHES

11.17.1 General

A network of ditches shall be constructed to intercept any runoff and channel it to a point of discharge or storage. Ditches shall be graded to prevent erosion, and, at the same time have sufficient slope to prevent ponding in low spots. Collection ditches shall be designed to accept the added flow from rainfall runoff.

11.17.2 Surface Discharge Requirements

11.17.2.1 If the collection ditches will discharge to a water of the United States, an NPDES permit is required prior to the discharge.

11.17.2.2 If the discharge from the collection ditches cannot comply with the water quality standards in 561—Chapter 61 or the NPDES permitting requirements, the flow shall either be returned to the top of the land application site for additional treatment or transmitted to storage.

11.18 NEW TECHNOLOGY DISPOSAL OPTION

Wastewater land application disposal mechanisms and emerging new technologies that are not currently specified in this chapter will be evaluated on a case-by-case basis. In such instances, the design engineer shall submit detailed specifications of the proposal with adequate data and available documentation to the department for review and consideration, in accordance with IWFDS Section 4.4.3.