DESIGN CRITERIA FOR SEWAGE WORKS

Design Criteria for Sewage Works

State of Tennessee

Department of Health and Environment

Division of Water Pollution Control

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CONTENTS

CHAPTER 1

General Engineering Requirements

GENERAL ENGINEERING REQUIREMENTS

1.1 General Information

1.1.1 Purpose

The purpose of this chapter is to describe the engineering and procedural steps required by the Tennessee Department of Health and Environment from beginning to completion of a sewerage project. These criteria apply to the development of the following facilities:

1.1.1.1 Municipal sewerage systems, subdivisions, trailer parks, apartments, resorts, etc.

1.1.1.2 Publicly or privately owned sewerage systems required to obtain a charter from (certificate of need and convenience) the Tennessee Public Service Commission.

1.1.1.3 Public corporation sewerage systems organized under the General Corporation Act of Tennessee.

1.1.1.4 Public sewerage systems organized under the Federal Housing Authority Title bond.

1.1.1.5 All sewerage systems owned by the State of Tennessee.

1.1.1.6 Industrial waste systems.

1.1.1.7 Industrial sewerage systems.

1.1.1.8 Federally owned systems.

1.1.1.9 Sewerage systems for schools, service stations, shopping centers, truck stops, or motels.

1.1.1.10 Sewerage and industrial waste systems for laundries and car wash facilities.

It should be understood that these criteria may not be sufficiently comprehensive to apply to all waste treatment and disposal problems in the State. The design engineer should rely upon his experience and judgement in supplementing these criteria. Additionally, these criteria may prove too comprehensive (for example, in the treatment of industrial wastes); in either case, the Department will consider variances to the requirements provided the engineer can justify the variances requested.

In an effort to be consistent the following procedures have been established:

a. Upon receipt of a letter requesting planning limits of a proposed discharge, the Division of Water Pollution Control will investigate the proposed point of discharge and may establish appropriate planning limits. Planning limits do not approve point of discharge the actual plant site will be investigated and the owner and consulting engineer will be informed of the standards in an official letter of site review.

b. Divisional review of the final engineering report and preliminary plans will commence only after the issuance of the effluent planning limits and the site approval.

Detailed information is found in "Wastewater Discharge Checklist", Appendix 1-A.

1.1.2 Requirements

The technical engineering information must be certified by an engineer licensed to practice within the State of Tennessee, representing the municipality, industry, or owner and submitted to the Department in two parts:

a. An engineering report and, if the design engineer feels it necessary, preliminary plans. (If preliminary plans are submitted, approval should be obtained before final plans are started.)

b. Final construction plans and specifications.

In addition, a Preliminary Engineering Conference may be necessary on large or complex treatment plant projects. This will be determined by the Division of Water Pollution Control during or prior to the site visit for planning limits.

Following these steps will reduce the time needed for approval of the project.

The engineers of the Department cannot act as consulting engineers for industries, municipalities, or owners, but assistance will be given insofar as possible in developing a suitable and economical project.

1.1.3 Sewage Treatment Works, General Requirements

1.1.3.1 Plant Location

a. General

The following items shall be considered when selecting a plant site:

1) Proximity to residential areas.

2) Direction of prevailing winds.

3) Necessary routing to provide accessibility by all weather roads.

4) Area available for expansion.

5) Local zoning requirements.

6) Local soil characteristics, geology and topography available to minimize pumping.

7) Access to receiving stream.

8) Compatibility of treatment process with the present and planned future land use, including noise, potential odors, air quality, and anticipated sludge processing and disposal techniques.

b. Critical Sites

Where a site must be used which is critical with respect to the items in subsection (a), appropriate measures shall be taken to minimize adverse impacts.

c. Flood Protection

The treatment works structures, electrical and mechanical equipment shall be protected from physical damage by the maximum 100 year flood. Treatment works shall remain fully operational during the 25 year flood. This requirement applies to new construction and to existing facilities undergoing major modification. Flood plain regulations of State and Federal agencies shall be considered.

d. Plant Accessibility

All plant facilities shall be accessible by an all weather road.

1.1.3.2 Quality of Effluent

The required degree of wastewater treatment shall be established by reference to applicable effluent criteria issued by the Division of Water Pollution
Control for all projects involving new plants, new discharge locations or major upgrades.

1.1.3.3 Design

The goal of the preparers of this Design Criteria is to promote the simplest treatment scheme available that will meet the requirements of the permit while providing maximum ease of operation. While cost comparisons are important, long term operability and reliability should be an overriding influence in developing new sewerage collection and treatment works.

a) Type of Treatment

1) As a minimum, the following items shall be considered in the selection of the type of treatment:

A) Present and future effluent requirements.

B) Location and local topography of the plant site.

C) The effects of industrial wastes likely to be encountered.

D) Ultimate disposal of sludge.

E) System capital costs.

F) System operating and maintenance costs and basic energy requirements.

G) Existing unit process performance and capacity.

H) Process complexity governing operating personnel requirements.

I) Environmental impact on present and future adjacent land use.

2) The plant design shall provide the necessary flexibility to perform satisfactorily within the expected range of waste characteristics and volumes

b. Required Engineering Data for New Process Evaluation

1) The policy of the Agency is to encourage rather than obstruct the development of any methods or equipment for treatment of wastewaters. The lack of inclusion in these standards of some types of wastewater treatment processes or equipment should not be construed as precluding their use. The Agency may approve 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 a suitably-sized prototype unit operating at its design load conditions, to the extent required.

2) To determine that such new processes and equipment have a reasonable and substantial change of success, the Agency will require the following:

A) Monitoring observations, including test results and engineering evaluations, demonstrating the efficiency of such processes.

B) Detailed description of the test methods.

C) 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 performance under climatic and other conditions which may be encountered in the area of the proposed installations.

D) Other appropriate information.

3) The Agency will require that appropriate testing be conducted and evaluations be made under the supervision of a competent process engineer other than those employed by the manufacturer or developer.

1.2 Engineering Report and Preliminary Plans

1.2.1 Purpose

Before plans and specifications are prepared for new wastewater facilities or for changes to existing facilities, every owner or an authorized agent shall submit an engineering report to the Department. The purpose of the engineering report is to outline the goals and objectives of the project and to determine whether the proposed project follows the Department's treatment guidelines and satisfies the applicable minimum requirements set by these guidelines. The report should also serve as a comprehensive guide to the municipality in the decision to adopt a project.

1.2.2 Contents

The engineering report shall assemble the basic information, present design criteria and assumptions, evaluate alternative solutions, and offer conclusions and recommendations. The report must be sufficiently complete to facilitate further plans and specifications development.

As a minimum, the engineering report shall include the following information where appropriate:

1.2.2.1 Purpose and need for the proposed project.

1.2.2.2 Present and design population with the method of determination.

1.2.2.3 Nature and extent of the area to be served, including immediate and probable future development.

1.2.2.4 Description of the existing collection and/or treatment system, including its condition and problems, renovation and rehabilitation or replacement requirements.

1.2.2.5 Present basis of design, including reliable measurements or analysis of flow and wastewater constituents and hydraulic, organic and solids loadings attributed to residential, commercial, and industrial users. (See Chapter 2, Appendix 2-A.)

1.2.2.6 Treatment process and schematic flow diagrams giving the plant unit design parameters.

1.2.2.7 Solids handling and disposal options and recommendations.

1.2.2.8 The 25- and 100-year flood conditions.

1.2.2.9 Soil and geologic conditions

Sufficient soils and geologic data shall be submitted with the engineering report (or, if the design engineer feels it to be more appropriate depending upon the project scope, with the plans) to evaluate site conditions for all new or major

upgrades to treatment plants. At a minimum, the following is required:

a. Soil tests performed sufficient to provide moisture and compaction data for construction.

b. Borings for representative subsurface conditions. A minimum of 10 feet below the bottom footing grade of major structures is recommended.

c. Boring logs or schematic drawings indicating changes of soil types and/or refusal depths.

d. Unsuitable soil conditions must be identified and correction or removal contingencies shall be provided.

e. Karst features must be noted with an evaluation of surface water drainage.

f. Where rock is encountered above the bottom footing grade of structures, representative core data shall be provided to 5 feet below grade. Weathered rock conditions shall be indicated along with mud seams or weathered bedding planes.

1.2.2.10 Domestic potable wells within 1000 feet of a plant shall be located along with land use of the surrounding area (residential, agricultural, industrial).

1.2.2.11 Perched water tables shall be noted with construction contingencies provided.

1.2.2.12 An evaluation of alternative solutions and the rationale for recommending the chosen alternative, considering economics of operations and effectiveness.

1.2.2.13 A mass balance must be submitted for all plants. The mass balances must include loadings to each unit process and operation, including all recycle and sidestream flows. Mass balances must include the following initial and design operating conditions: maximum, minimum, and average flow, BOD and suspended solids loadings; and maximum, minimum, and average nutrient loadings, especially nitrogen for plants with considerable industrial loadings where appropriate or where nutrient removal is employed.

The report shall identify and be consistent with all applicable areawide projects, drainage basins, service areas,
comprehensive, and metropolitan area plans; e.g. 208, and 303(e) plans.

The design period should be for 20 years unless growth of the area dictated other design parameters.

Preliminary plans can be included with the engineering report. Preliminary plans will be reviewed for adequacy, but will not be approved for construction.

1.2.3 Submission of Engineering Report and Preliminary Plans

The engineering report shall be submitted to the appropriate Division of the Tennessee Department of Health and Environment. The Department will

review and either approve or comment on the report within 30 days. In the event of a delay, the owner will be notified and the reason given. A conference may be scheduled at the owner's or municipality's request after review has been completed.

1.3 Plans and Specifications

1.3.1 General Content of Final Engineering Plans

All plans and specifications must be in accordance with the approved engineering report, unless modifications are justified based on newly discovered data or problems. If this is the case, a supplement to the engineering report shall be submitted with the plans. All plans for sewerage systems or sewage treatment works shall bear a title showing the name of the municipality, sewer district, institution, or other owner and the seal and signature of the design engineer. The title should show the scale in feet, the north direction, and the date. The cover sheet and all other sheets should bear a general title and be logically numbered. Appropriate subtitles should be included on plan sheets.

The plans should be clear and legible and drawn to a scale which permits all necessary information to be shown plainly. The size of the plans should be approximately 24 inches by 36 inches, and the data used should be indicated. All plans shall include appropriate design data, including, but not limited to initial and design flow. A location map must be included with each set of plans. The cover letter or letter of transmittal should clearly indicate the system and design engineer with addresses.

Detail plans should include plan views, elevations, sections, profiles, and supplementary views. Plans should also specify dimensions and relative elevations of structures, the location and outline form of equipment, location and size of piping, water levels, ground elevations, and erosion control
facilities.

1.3.2 Plans of Sewers

The plans shall show the location, size, and direction of flow of all proposed and existing sewers draining to the concerned treatment facility. Hydraulic calculations are required for all lines in the project. All receiving lines must be shown to be adequate for the proposed project. Topography and elevations, both existing and any changes proposed, and all bodies of water (including direction of flow and high water elevations) should be clearly shown. Hydraulic calculations of pumping stations must also be furnished, taking into consideration existing loading plus projected loading from developments under construction as well as projected loading from the proposed extension. Hydraulic and organic loadings of the proposed project shall be examined with respect to the treatment facility and its present treatment capacity.

Profiles for sewer detail 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 views should be drawn to a corresponding horizontal scale.

Plans and profiles should show:

1.3.2.1 Locations of streets and sewers.

1.3.2.2. Lines of ground surface, pipe type and size, manhole stationing, invert and surface elevation at each manhole, and grade of sewer between adjacent manholes. Manholes should be labeled

on the plan and also on the profile correspondingly. Where there is any question of the sewer being sufficiently deep to serve any residence or other source, the elevation and location of the basement floor or other low point source shall be plotted on the profile of the sewer which is to serve the house or source in question.

1.3.2.3 Locations of all special features such as inverted siphons, concrete incasements, elevated sewers, and flow monitoring key manholes.

1.3.2.4 Location of all existing structures below and above ground which might interfere with the proposed construction; particularly water mains, gas mains, storm drains, etc.

1.3.2.5 Detail drawings of all stream crossings with elevations of the stream bed and of normal and extreme high and low water levels to include 25- and
100- year flood plain. See Section 2.4.3.

1.3.2.6 Detail drawings of special sewer joints, cross sections, and appurtenances such as manholes, flush valves, inspection chambers, etc.

1.3.2.7 Location of adjacent streams and the extent of streamside vegetation.

1.3.2.8 An analysis of existing infiltration/inflow should be submitted (and may be required) where I/I is known to be a problem in the existing sewer, and extensions are proposed.

1.3.2.9 General topography including trees within 25 feet of center line of the proposed sewer main.

1.3.3 Plans of Sewage Pumping Stations

Plans must be submitted on all sewage pump stations that serve more than two residences. Any pump station of this size or larger is considered a "sewerage system" by the State of Tennessee and, as such, must be designed and built in conformance with this criteria. Although it is desirable for the station to be owned and maintained by a municipality, public utility or a utility district, private ownership of small stations is permissable. Larger stations (serving more than 50 residences shall be owned by a utility or operate under the terms of a State Operation Permit.

1.3.3.1 A general layout plan must be submitted for projects involving construction or substantial modification of pumping stations. The plan should show:

a. The location and extent of the tributary area.

b. A contour map of the property to be used.

c. Any municipal boundaries within the tributary area.

d. The location of the pumping station and force main, and pertinent elevations.

e. A site plan showing the forms of land use (commercial, residential, and agricultural) existing or proposed for the near future within a 100-foot radius of the pumping

station. Existing buildings and their types within 100 feet of the pumping station property lines should be included.

1.3.3.2 Detail plans must be submitted showing:

a. The proposed pumping station, including provisions for installation of future pumps or ejectors.

b. Elevation of known high groundwater at the site and maximum elevation of sewage in the collection system upon occasion of power failure.

c. Test boring locations and test boring information, including groundwater elevation, if encountered above the bottom of the proposed excavation.

d. Plan and elevation views of the pump suction (from the wet well), and discharge piping showing all isolation valves and gates.

1.3.4 Plans of Sewage Treatment Plants

1.3.4.1 General

A plan must be submitted showing the sewage treatment plant in relation to the collection system. Sufficient topographic features should be included to indicate the plant's location in relation to streams and the point of discharge of treated effluent. The forms of land use (industrial, commercial, residential, and agricultural) existing or proposed for the near future within a 700-foot radius of the plant site property lines should be indicated.

Existing buildings and their types within 700 feet of the plant site property should be adequately described, by items such as topographic maps, aerial photos, and drawings.

1.3.4.2 Layouts of the proposed sewage treatment plant should be submitted, showing:

a. Topography of the site.

b. Size and location of plant structures.

c. A schematic flow diagram including main and side stream or recycles with unit and pipe sizing through various plant units, in plan view.

d. A summary of design and initial wasteloads, unit sizes, and design parameters for each unit process, from the engineering report; noting particularly any changes in design assumptions.

e. Piping, the materials handled and the direction of flow through the pipes, and any arrangements for bypassing individual units.

f. Minimum, average, and maximum hydraulic profiles showing flow of sewage, supernatant liquor, and sludge.

g. Test borings and groundwater elevations, if encountered.

h. Ultimate disposal of sludge.

1.3.4.3 Detail plans must show the following:

a. Location, dimensions, and elevations of all existing and proposed plant facilities.

b. Elevation of high-water level of the body of water into which the plant effluent is to be discharged, at the 100-year flood, if known.

c. Elevation of the low-water level of the body of water into which the plant effluent is to be discharged.

d. Pertinent data concerning the rated capacity of all pumps, blowers, motors and other mechanical devices. All or part of such data can be included in the specifications if the equipment is identified on the plans.

1.3.5 Specifications

The objective of the specifications is to supplement the plans by describing the intended project in sufficient detail for competitive bidding and construction.

The specifications shall include, but not be limited to, all construction information which is not shown on the drawings and is necessary to inform the builder in detail of the design requirements as to: the quality of materials, workmanship and fabrication of the project, and the type, size, operating characteristics, and rating of equipment; allowable leakage; machinery; valves, piping, and jointing of pipe; electrical apparatus, wiring, and meters; laboratory fixtures and equipment; operating tools; construction materials; special materials such as stone, sand, gravel or slag; miscellaneous appurtenances; instructions for testing materials and equipment as necessary to meet design standards; and operating tests for the completed works and component units.

The specifications and/or plans must contain sufficient information to construct an all-weather access road to all plants, major pump stations and inverted siphons. As a minimum, this road shall be gravel for pump stations and inverted siphons and paved for treatment plants. The road shall be maintained by the owner for the life of the plant, pump station or siphon. Where necessary, the road to the property line of the site should be upgraded to the minimum standard.

All wastewater treatment plants shall be surrounded by a fence. The fence shall be constructed of fabric that is at least six feet high, is of a type that is difficult to climb and shall be topped with at least two strands of barbed wire. The exceptions to this type of fencing are lagoons and land application systems. Such treatment plants can use livestock fence, provided that a sufficient number of signs are attached which contain a warning against trespassing and indicate that the fenced area is used for

treating sewage. Generally, pumping stations shall be fenced similarly to plants with the exception that the entrance tube to "canned" lift stations need not be fenced.

The plans and/or specifications shall indicate what methods are to be taken by the contractor to minimize erosion during the construction period.

1.3.6 Review and Approval Procedure

Every owner or his authorized representative, before installing wastewater or industrial waste facilities, or for changes in the existing system, shall submit no less than three copies of complete plans and specifications of the proposed facilities to the Department. Approval must be obtained before construction can begin. A maximum of four sets of plans will be stamped approved.

If the owner of the project is not the ultimate recipient of the wastewater, the recipient must approve the plans and specifications and must agree to receive wastes and provide treatment, before construction begins.

All plans and specifications shall be prepared under the supervision of a professional engineer. All copies of plans and specifications submitted for review shall bear the seal and signature of the professional engineer, licensed to practice in the State of Tennessee, who supervised their preparation. Each sheet of the plans shall be hand dated with a copy of the seal and signature of the engineer. Only the title sheet and front cover of the specifications are required to be marked with original seal, signature and date.

The Department will review and either approve or comment on the final plans and specifications within 30 days. One copy of plans and specifications will be retained for the record, with the remaining returned to the owner.

The Department requires that one stamped copy of the approved plans and specifications be on the construction site and ready to show to the state inspector. Failure to do so may result in a shut down of construction until an approved copy of the plans is available on site.

1.3.7 Revisions to Approved Plans

Any deviations from approved plans or specifications affecting capacity, flow, operation of units, or point of discharge shall be approved in writing, before any 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 permit sufficient time for review and approval. Minor structural revisions will be permitted during construction with the concurrence of the design engineer. However, "as built" plans clearly showing all alternations shall be submitted to the reviewing agency at the completion of the work.

1.3.8. Construction Supervision

The importance of frequent, comprehensive, and sound inspection of construction cannot be overly emphasized. The owners shall ensure that competent and experienced personnel, preferably the design engineer or his representative, carefully monitor the progress of construction to see that all work conforms to the approved plans and specifications. The owner or his representative shall maintain records of inspection activities, and, based on those records, certify that the project has been constructed as designed and approved. Continuous on-site inspection is recommended.

Any modifications to the plans or specificationsduring construction must have approval by the Division (Section 1.3.7).

1.3.9 Operation During Construction

In order to minimize damage to the environment from inadequately treated wastewater due to construction activities, all construction shall be performed in accordance
with the Policy Statement found at the end of this Chapter in Appendix 1-B.

1.3.10 Final Inspection of Treatment Facilities

The Department must receive a written request for final inspection approval of the treatment facilities at least two weeks in advance of the requested date.

This final inspection will be performed by State personnel accompanied by the engineer and the agent or agents for the entity responsible for the operation and maintenance of the treatment facilities. There should be no discharge from the facility until the final inspection has been completed and final approval given.

Where a plant has been upgraded or modified, individual units may be allowed to operate prior to final inspection in order to facilitate construction. Prior approval to do so must be obtained from the Division of Water Pollution Control (see Section 1.3.9).

1.3.11 Reliability Classification

1.3.11.1 General

Reliability standards establish minimum levels of reliability for three classes of sewerage works. The reliability classification shall be established by the State and will be a major consideration for discussion at the preliminary engineering conference described earlier in this chapter (Section 1.1.2). Pump stations associated with, but physically removed from, the actual treatment works may have a different classification than the treatment works itself. The reliability classification will be based on the water quality and public health consequences of a component or system failure. Specific requirements pertaining to treatment plant unit processes for each reliability class are described in EPA's technical bulletin, Design Criteria for Mechanical, Electric, and Fluid System and Component Reliability, EPA 430-99-74-001; available from Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402. (Portions of this document are noted below.)

The reliability classification will be assigned by the Division of Water Pollution Control during the planning limits/site approval phase of the project.

1.3.11.2 Guidelines for classifying sewerage works as follows:

a. Reliability Class I

Works which discharge into navigable waters that could be permanently or unacceptably damaged by effluent which was degraded in quality for only a few hours. Examples of Reliability Class I works might be those discharging near drinking water reservoirs, into shellfish waters, or in close proximity to areas used for water contact sports.

b. Reliability Class II

Works which discharge into navigable waters that would not be permanently or unacceptably damaged by short-term effluent quality degradations, but could be damaged by continued (on the order of several days) effluent quality degradation. An example of a Reliability Class II works might be one which discharges into recreational waters.

c. Reliability Class III

These are works not otherwise classified as Reliability Class I or Class II.

1.3.11.3 Component Backup Requirements

Requirements for backup components for the main wastewater treatment system are specified below for Reliability Class I, II, and III works.

Alternate methods of sludge disposal and/or treatment shall be provided for each sludge treatment unit operation without installed backup capability.

Except as modified below, unit operations in the main wastewater treatment system shall be designed such that, with the largest flow capacity unit out of service, the hydraulic capacity (not necessarily the design-rated capacity) of the remaining units shall be sufficient to handle the peak wastewater flow. There shall be system flexibility to enable the wastewater flow to any unit out of service to be distributed to the remaining units in service.

Equalization basins or tanks shall not be considered a substitute for component backup requirements.

a. Reliability Class I

For components included in the design of Reliability Class I works, the following backup requirements apply.

Mechanically-Cleaned Bar Screens or Equivalent Devices

A backup bar screen shall be provided. It is permissible for the backup bar screen to be designed for manual cleaning only. Works with only two bar screens shall have at least one bar screen designed to permit manual cleaning.

Pumps

A backup pump shall be provided for each set of pumps which performs the same function. The capacity of the pumps shall be such that, with any one pump out of service, the remaining pumps will have the capacity to handle the peak flow. It is permissible for one pump to serve as backup to more than one set of pumps.

Comminution Facility

If comminution of the total wastewater flow is provided, then an overflow bypass with an installed manually- or mechanically-cleaned bar screen shall be provided. The hydraulic capacity of the comminutor overflow bypass shall be sufficient to pass the peak flow with all comminution units out of service.

Primary Sedimentation Basins

There shall be 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 design flow capacity of at least 50 percent of the total design flow to that unit operation.

Final and Chemical Sedimentation Basins, Trickling Filters, Filters and Activated Carbon Columns

There shall be 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 design flow capacity of at least 75 percent of the total design flow to that unit operation.

Activated Sludge Process Components

Aeration Basin

A backup basin shall not be required; however, at least two equal volume basins shall be provided. (For the purpose of this criterion, the two zones of a contact stabilization process are considered as only one basin.)

Aeration Blowers or Mechanical Aerators

There shall be a sufficient number of blowers or mechanical aerators to enable the design oxygen transfer to be maintained with the largest capacity unit out of service. It is permissible for the backup unit to be an uninstalled unit, provided that the installed unit can be easily removed and replaced. However, at least two units shall be installed.

Air Diffusers

The air diffusion system for each aeration basin shall be designed such that the largest section of diffusers can be isolated without measurably impairing the oxygen transfer capability of the system.

Disinfectant Contact Basins

There shall be 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 design flow capacity of at least 50 percent of the total design flow to that unit operation.

b. Reliability Class II

The Reliability Class I requirements shall apply except as modified below.

Primary and Final Sedimentation Basins and Trickling Filters

There shall be 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 design flow capacity of at least 50 percent of the design basis flow to that unit operation.

Components Not Requiring Backup

Requirements for backup components in the wastewater treatment system shall not be mandatory for components which are used to provide treatment in excess of typical biological (i.e., activated sludge or trickling filter), or equivalent physical/chemical treatment, and disinfection. This may include such components as:

Chemical Flash Mixer

Flocculation Basin

Chemical Sedimentation Basin

Filter

Activated Carbon Column

c. Reliability Class III

The Reliability Class I requirements shall apply except as modified below.

Primary and Final Sedimentation Basins

There shall be at least two sedimentation basins.

Activated Sludge Process Components

Aeration Basin

A single basin is permissible.

Aeration Blowers or Mechanical Aerators

There shall be at least two blowers or mechanical aerators available for service. It is permissible for one of the units to be uninstalled, provided that the installed unit can be easily removed and replaced.

Air Diffusers

The Reliability Class I requirements shall apply.

Components Not Requiring Backup

Requirements for backup components in the wastewater treatment system shall not be mandatory for components which are used to provide treatment in excess of primary sedimentation and disinfection, except as modified above. This may include such components as:

Trickling Filter

Chemical Flash Mixer

Flocculation Basin

Chemical Sedimentation Basin

Filter

Activated Carbon Column

1.3.11.4 Component Design Features and Maintenance Requirements

Provisions for Isolating Components

Each component shall have provisions to enable it to be isolated from the flow stream to permit maintenance and repair of the component without interruption of the works' operation. Where practicable, simple shutoff devices, such as slide gates, shall be used.

Main Wastewater System Pump Isolation

The use of in-line valves to isolate the main wastewater pumps shall be minimized. It is permissible to place shutoff valves on the suction and discharge lines of each pump. However, in such a case, alternate means shall be provided for stopping flow through the pump suction or discharge lines to permit maintenance on the valve.

Example: Pump discharge isolation and check valves are not needed if the pumps have a free discharge

into an open channel rather than discharging into a pressurized discharge header. Pump suction isolation valves can be maintained if the plant has a two compartment wetwell design and if the plan can continue operation (during the diurnal low-flow period, for example) with one part of the wetwell isolated.

1.3.11.5 Electric Power System

The following criteria shall apply to those portions of the system supplying power to vital components. A vital component is one whose operation or function is required to prevent a controlled diversion, is required to meet effluent parameters, or is required to protect other vital components from damage. Vital components should be identified in the permit/site approval phase, depending on the reliability class and treatment scheme employed. Further information is found in Chapter 14, Instrumentation, Control and Electrical Systems.

Power Sources

Two separate and independent sources of electric power shall be provided to the works from either two separate utility substations or from a single substation and a works (plant and/or main pump station) generator. If available from the electric utility, at least one of the works' 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 geographical areas where it is projected that sometime during the design period of the works, the electric utility may reduce the rated line voltage (i.e., "brown out") during peak utility system load demands, a works-based generator shall be provided as an alternate power source, where practicable. As a minimum, the capacity of the backup power source for each class of treatment works shall be:

Reliability Class I

Sufficient to operate all vital components, during peak wastewater flow conditions, together with critical lighting and ventilation.

Reliability Class II

Same as Reliability Class I, except that vital components used to support the secondary processes (i.e., mechanical aerators or aeration basin air compressors) need not be included as long as treatment equivalent to sedimentation and disinfection is provided.

Reliability Class III

Sufficient to operate the screening or communication facilities, the main wastewater pumps, the primary sedimentation basins, and the disinfection

facility during peak wastewater flow condition, together with critical lighting and ventilation.

Note: This requirement concerning rated capacity of electric power sources is not intended to prohibit other forms of emergency power, such as diesel-driven main wastewater pumps.

Power Distribution External to the Works

The independent sources of power shall be distributed to the works' transformers in a way to minimize common mode failures from affecting both sources.

Example: The two sets of distribution lines shall not be located in the same conduit or supported from the same utility pole. The two sets of overhead distribution lines, if used, should not cross or be located in an area where a single plausible occurrence (e.g., fallen tree) could disrupt both lines. Devices should be used to protect the system from lightning.

Transformers

Each utility source of power to the works shall be transformed to usable voltage with a separate transformer. The transformers shall be protected from common mode failure by physical separation or other means.

Power Distribution Within the Works

Service to Motor Control Centers

The internal power distribution system shall be designed such that no single fault or loss of a power source will result in disruption (i.e., extended, not momentary) of electric service to more than one motor control center associated with the Reliability Class I, II, or III vital components requiring backup power.

Division of Loads at Motor Control Centers

Vital components of the same type and serving the same function shall be divided as equally as possible between at least two motor control centers. Nonvital components shall be divided in a similar manner, where practicable.

Power Transfer

Where power feeder or branch circuits can be transferred from one power source to another, a mechanical or electrical safety device shall be provided to assure that the two power sources cannot be cross-connected, if unsynchronized. Automatic transfer shall be provided in those cases when the time delay required to manually transfer power could result in a failure to meet effluent limitations, a failure to process peak influent flow, or cause damage to equipment. Where automatic pump control is used, the control panel power source and pump power source shall be similarly transferred.

The actuation of an automatic transfer switch shall be alarmed and annunciated.

Example: The two power sources from utility substations are connected to the motor control centers through circuit breakers. A circuit breaker is provided to cross-connect the two motor control centers in the event one of the two normally energized power feeders fail. Additional backup capability has been achieved for the main pump by connecting one of the three pumps to the motor control center cross-connect. This assures that two out of three pumps will be available in the event of a panel fire or panel bus short circuit.

Breaker Settings or Fuse Ratings

Breaker settings or fuse ratings shall be coordinated to effect sequential tripping such that the breaker or fuse nearest the fault will clear the fault prior to activation of other breakers or fuses
to the degree practicable.

Equipment Type and Location

Failures resulting from plausible causes, such as fire or flooding, shall be minimized by equipment design and location. The following requirements apply:

Switchgear Location

Electric switchgear and motor control centers shall be protected from sprays or moisture from liquid processing equipment and from breaks in liquid handling piping. Where practicable, the electric equipment shall be located in a separate room from the liquid processing equipment. Liquid handling piping shall not be run through this room. The electric switchgear and motor control centers shall be located above ground and above the one hundred (100) year flood (or wave action) elevation.

Conductor Insulation

Wires in underground conduits or in conduits that can be flooded shall have moisture resistant insulation as identified in the National Electric Code.

Motor Protection from Moisture

All outdoor motors shall be adequately protected from the weather. Water-proof, totally enclosed or weather-protected, open motor enclosures shall be used for exposed outdoor motors. Motors located indoors and near liquid handling piping or equipment shall be, at least, of splash-proof design. Consideration shall be given to providing heaters in motors located outdoors or in areas where condensation may occur.

The following criteria shall apply to motors (and their local controls) associated with vital components. All outdoor motors, all large indoor motors (i.e., those not

readily available as stock items from motor suppliers), and, where practicable, all other indoor motors, shall be located at an elevation to preclude flooding from the one hundred (100) year flood (or wave action) or from clogged
floor drains. Indoor motors located at or below the one hundred year flood (or wave action) elevation shall be housed in a room or building which is protected from flooding during the one hundred year flood (or wave action). The building protection shall include measures such as no openings (e.g., doors, windows, hatches) to the outside below the flood elevation and a drain sump pumped to an elevation above the flood elevation.

Explosion Proof Equipment

Explosion proof motors, conduit systems, switches and other electrical equipment shall be used in areas where flammable liquid, gas or dust is likely to be present.

Routing of Cabling

To avoid a common mode failure, conductors to components which perform the same function in parallel shall not be routed in the same conduit or cable tray. Conduits housing such cables shall not be routed in the same underground conduit bank unless the conduits are protected from common mode failures (such as by encasing the conduit bank in a protective layer of concrete).

Motor Protection

Three-phase motors and their starters shall be protected from electric overload and short circuits on all three phases.

Large motors shall have a low-voltage protection device which, on the reduction or failure of voltage, will cause and maintain the interruption of power to that motor.

Consideration shall be given to the installation of temperature detectors in the stator and bearings of large motors in order to give an indication of overheating problems.

Provisions of Equipment Testing

Provisions shall be included in the design of equipment requiring periodic testing, to enable the tests to be accomplished while maintaining electric power to all vital components. This requires being
able to conduct tests, such as actuating and resetting automatic transfer switches, and starting and loading emergency generating equipment.

Maintainability

The electric distribution system and equipment shall be designed to permit inspection and maintenance of individual items without causing a controlled diversion or causing violation of the effluent limitations.

Emergency Power Generator Starting

The means for starting a works-based emergency power generator shall be completely independent of the normal electric power source. Air starting systems shall have an accumulator tank(s) with a volume sufficient to furnish air for starting the generator engine a minimum of three (3) times without recharging. Batteries used for starting shall have a sufficient charge to permit starting the generator engine a minimum of three (3) times without recharging. The starting system shall be appropriately alarmed and instrumented to indicate loss of readiness (e.g., loss of charge on batteries, loss of pressure in air accumulators, etc.).

1.3.12 New Technology

New technology is defined as any method, process, or equipment which is used to treat or convey wastewater and which is not discussed in this manual. This does not refer to innovative technology as defined by EPA.

After review of treatability data and the complete engineering report, the Department may approve the plans if it is satisfied that the method, process or equipment will efficiently operate and meet the treatment requirements. Pilot plants may be required or special restrictions may be placed on the system in terms of operational control aspects, sampling, monitoring, etc. Additionally, the number of systems approved initially may be limited until the technology is demonstrated to the satisfaction of the Department.

Appendix 1-A

Wastewater Discharge Checklist

1. Applicant contacts Field Office, discusses proposed project and is advised of information required for submittals.

2. On all proposed discharges in the smaller flow ranges, the applicant must first investigate subsurface disposal (even at a remote site) and transferance to a public sewer system. Only if the Division is satisfied that these option's are not feasible will consideration be given to a discharge to waters of the State.

3. Applicant submits required information and requests site inspection/planning limits. Field Office responds to applicant on results, including the assigned reliability classification.

4. Applicant submits NPDES application with associated information; i.e., owner/operator, financial information and preliminary engineering report to the Field Office. As part of preliminary engineering report development, a meeting of all concerned parties should be made to discuss selection of the appropriate technology which would maximize the reliability and design operability of the selected technology. Field Office advises applicant when information is complete and forwards same to Permit Section.

5. Permit Section forwards draft permit to Field Office and applicant and issues public notice of intent to (not to) issue NPDES permit.

6. Permit Section evaluates responses to draft permit and public notice, makes decision on necessity for public hearing, issues public notice of hearing, if required, conducts public hearing, evaluates comments, makes and publicizes issuance decision.

7. Final engineering report submitted, reviewed and approved.

8. Final plans and specifications submitted, reviewed and approved for construction.

9. Construction proceeds and applicant requests final inspection by the Field Office. Field Office advises Permit Section when construction has been completed in substantial compliance with final plans and specifications. Permit Section issues final permit.

APPENDIX 1B
POLICY STATEMENT
DIVISION OF WATER POLLUTION CONTROL
FLOW DIVERSION DURING CONSTRUCTION

April 1987

In order to reduce the occurrence of permit violations due to construction activities, the following statement or its equivalent should be included in all State and EPA project specifications:

> "No discharge of untreated wastewater or reduction in existing hydraulic capacity or organic treatment capacity, due to activities of the contractor, will be permitted under this contract."

If this statement cannot be included in the specifications, then prior to our approval of the plans and specifications, the following should be accomplished.

1. The municipality shall develop a Project Plan including but not limited to the following.

   a. The Project Plan shall be a part of the plans and specifications and evaluate economically all identifiable options to by-passing such as temporary lagoons, use of portable treatment units, trucking waste, flow diversion back to collection system, etc.

   b. Prior to by-pass, sufficient 24-hour influent flow monitoring data should be evaluated to determine flow patterns; by-passing should be scheduled for periods of lowest flow, often 10:00 p.m. till 5:00 a.m.

   c. The method of disinfection should be discussed. We have had success with gas chlorination from a portable unit with injection directly into the sewer line 3-4 blocks up-line of the point of discharge. The discharge should be screened through a rotating wire mesh drum or other screening device. The receiving area should be equipped with floating booms to trap floating materials.

   d. A monitoring program shall be implemented. At a minimum effluent fecal coliform and total chlorine monitoring will be required. Other parameters such as a dissolved oxygen and ammonia may be required during warm months. All other parameters and scheduling requirements will be approved on a case by case basis.

   e. A schedule of approximate data and duration of each occurrence should be included.

   f. This plan shall be sent to the appropriate field office of Water Pollution Control (WPC) for concurrence. A copy shall be sent to the Division of Construction Grants and Loans (CGL) on all projects where CGL moneys are involved.

2. The municipality shall issued public notice 14 days prior to any by-pass event. This notice shall contain but not be limited to the project impact zone, the date, and the duration of each bypass.

3. As a function of monitoring, care should be taken by the municipal staff to discourage water contact activities. In areas of frequent recreational use, temporary posting may be required.

4. Where economically feasible by-pass operation should be confined to cold weather months. On flow regulated streams, TVA can provide additional flow to help mitigate adverse impacts.

5. The burden of co-ordination, communication, and notification is the responsibility of the municipality including written notification. The state does not approve by-pass activities and reserves enforcement options should significant water quality degradation occur.

6. Upon completion of all of the above, the reviewer can proceed with review/approval of the plans and specifications.

Kenneth Bunting, Director
Water Pollution Control

Date

Elmo L. Lunn, Administrator
Office of Water Management

Date

RDL:E3079053

18 July 1995

THIS IS CHAPTER 2

CHAPTER 2

Sewers and Sewage Pump Stations

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Appendix 2-B
Appendix 2-C

SEWERS AND SEWAGE PUMP STATIONS

2.1 General Requirements for Collection Systems

2.1.1 Construction Approval

In general, construction of new sewer systems or extensions of existing systems will be allowed only if the downstream conveyance system and the receiving sewage treatment plant is either

a. Capable of adequately conveying or processing the added hydraulic and organic load, or
b. Capable of providing adequate conveyance or treatment facilities on a time schedule acceptable to the Department.

2.1.2 Ownership

Sewer systems including pumping stations will not be approved unless ownership and responsibility for operation are by a public entity or other acceptable long term operation or maintenance scheme is approved in advance by the Department.

2.1.3 Design

Sewer systems shall be designed and constructed to achieve total containment of sanitary wastes and maximum exclusion of infiltration and inflow. No combined sewers will be approved.

2.1.4 Emergency High Level Overflows

For use during possible periods of extensive power outages, mandatory power reductions, or uncontrollable emergency conditions, consideration should be given to providing a controlled, high-level overflow to supplement alarm systems and emergency power generation in order to prevent backup of sewage into basements, or other discharges which may cause severe adverse impacts on public interests, including public health and property damage. Where a high level overflow is utilized, consideration shall also be given to the installation of storage /detention tanks, or basins, which shall be made to drain to the station wet well where possible. All such constructed overflow structures must be telemetered to the control authority's headquarters where records must be maintained as to frequency and duration of the overflow.

2.1.5 Calculations

Computations and other data used for design of the sewer system shall be submitted to the Department. The Engineer shall utilize the format shown in Appendix 2-B or an approved equivalent.

2.1.6. SLOPE PROTECTION AND EROSION CONTROL

2.1.6.1 GENERAL

A. This Section shall consist of temporary control measures as shown in the Plans or directed by the Engineer during the life of the Contract to control erosion and pollution through the use of berms, dikes, dams, sediment basins, fiber mats, netting, mulches, grasses, slop drains, temporary silt fences, and other control devices.

B. The temporary pollution control provisions contained herein shall be coordinated with the permanent erosion control features, to assure economical, effective, and continuous erosion features, to assure economical, effective, and continuous erosion control throughout the construction and post-construction period.

2.1.6.2: MATERIALS

2.1.6.2.1 TEMPORARY BERMS

A. A temporary berm is constructed of compacted soil, with or without a shallow ditch, at the top of fill slopes or tranverse to centerline on fills.

B. These berms are used temporarily at the top of newly constructed slopes to prevent excessive erosion until permanent controls are installed or slopes stabilized.

2.1.6.2.2 TEMPORARY SLOPE DRAINS: A temporary slope drain is a facility consisting of stone gutters, fiber mats, plastic sheets, concrete or asphalt gutters, half-round pipe, metal pipe, plastic pipe, sod or other material acceptable to the Engineer that may be used to carry water down slopes to reduce erosion.

2.1.6.2.3 SEDIMENT STRUCTURES: Sediment basins, ponds and traps, are prepared storage areas constructed to trap and store sediment from erodible areas in order to protect properties and stream channels below the constructed areas from excessive siltation.

2.1.6.2.4 CHECK DAMS

A. Check dams are barriers composed of logs and poles, large stones or other materials placed across a natural or constructed drainway.
B. Stone check dams shall not be utilized where the drainage area exceeds fifty (50) acres. Log and pole structures shall not be used where the drainage area exceeds five (5) acres.

2.1.6.2.5 TEMPORARY SEEDING AND MULCHING

Temporary seeding and mulching are measures consisting of seeding, mulching, fertilizing and mating utilized to reduce erosion. All cut and fill slopes including waste sites and borrow pits shall be seeded when and where necessary to eliminate erosion.

2.1.6.2.6 BRUSH BARRIERS

A. Brush barriers shall consist of brush, tree trimmings, shrubs, plants, and other approved refuse from the clearing and grubbing operations.

B. Brush barriers are placed on natural ground at the bottom of fill slopes, where the most likely erodible areas are located to restrain sedimentation particles.

2.1.6.2.7 BALED HAY OR STRAW CHECKS

A. Baled hay or straw erosion checks are temporary measures to control erosion and prevent siltation. Bales shall be either hay or straw containing five (5) cubic feet or more of material.

B. Baled hay or straw checks shall be used where the existing ground slopes toward or away from the embankment along the toe of the slopes, in ditches or other areas where siltation erosion or water run-off is a problem.

2.1.6.2.8 TEMPORARY SILT FENCES Silt fences are temporary measures utilizing woven wire or other approved material attached to post with filter cloth composed of burlap, plastic filter fabric, etc., attached to the upstream side of the fence to retain the suspended silt particles in the run-off water.

2.1.6.3 EXECUTION

2.1.6.3.1 PROJECT REVIEW Prior to the pre-construction conference the Contractor shall meet with the Engineer and go over in detail the expected problem areas in regard to the erosion control work. Different solutions should be discussed so that the best method might be determined. It is the responsibility of the Contractor to develop an erosion control plan acceptable to the Engineer.

2.1.6.3.2 PRE-CONSTRUCTION CONFERENCE At the pre-construction conference the Contractor shall submit for acceptance his schedule for accomplishment of temporary and permanent erosion control work, as are applicable for clearing and grubbing, grading, bridges and other structures at water courses, construction and paving. He shall also submit for acceptance his proposed method for erosion control on haul roads and borrow pits and his plan for disposal of waste materials. No work shall be started until the erosion control schedules and methods of operations have been accepted by the Engineer.

2.1.6.3.3 CONSTRUCTION REQUIREMENTS

A. **The Engineer has the authority to limit the surface area of erodible earth material exposed by clearing and grubbing, the surface of erodible earth material exposed by excavation, borrow and fill operations and to direct the Contractor to provide immediate permanent or temporary pollution control measures to prevent contamination of adjacent streams or other watercourses, lakes, ponds or other water impoundment. Such work may involve the construction of temporary berms, dikes, dams, sediment basins, slope drains and use of temporary mulches, mats, seeding or other control devices or methods to control erosion. Cut and fill slopes shall be seeded and mulched as the excavation proceeds to the extent directed by the Engineer.**

B. **The Contractor shall be required to incorporate all permanent erosion control features into the project at the earliest practicable time as outlined in his accepted schedule. Temporary pollution control measures shall be used to correct conditions that develop during construction that were not forseen during the design stage; that are needed prior to installation of permanent pollution control features; or that are needed temporarily to control erosion that develops during normal construction practices, but are not associated with permanent control features on the project.**

C. **Where erosion is likely to be a problem, clearing and grubbing operations should be so schedule and performed that grading operations and permanent erosion control features can follow immediately thereafter if the project conditions permit; otherwise erosion control measures may be required between successive construction stages. Under no conditions shall the surface area of erodible earth material exposed at one time by clearing and grubbing exceed 750,000 square feet without approval of the Engineer.**

D. **The Engineer will limit the area of excavation, borrow and embankment operations in progress commensurate with the contractor's capability and progress in keeping the finish grading, mulching, seeding and other such permanent pollution control measures current in accordance with the accepted schedule. Should seasonal limitations make such coordination unrealistic, temporary erosion control measures shall be taken immediately to the extent feasible and justified.**

E. **Under no conditions shall the amount of surface area or erodible earth material exposed at one time by excavation or fill within the project area exceed 750,000 square feet without prior approval by the Engineer.**

F. **The Engineer may increase or decrease the amount of surface area of erodible earth material to be exposed at one time by clearing and grubbing, excavation, borrow and fill operations as determined by his analysis of project conditions.**

G. **In the event of conflict between these requirements and pollution control laws, rules or regulations, or other Federal, State or Local agencies, the more restrictive laws, rules or regulations shall apply.**

2.1.7 SEPTIC TANK EFFLUENT PUMP OR GRAVITY (STEP/STEG) SEWER PROJECTS

2.1.7.1 APPLICABILITY

These criteria apply to STEP units discharging to pressurized common sewers, and to STEP or STEG units discharging to small-diameter gravity systems. Pressurized and small-diameter collectors have interactive hydraulic effects and solids handling limitations which warrant a comprenensive engineering design.

These criteria do not apply to individual or single dwelling septic tank or grinder pump units discharging a conventional gravity sewer.

Septic tanks discharging to a drainfield.

Vacuum sewer collection systems.

2.1.7.2 STEP SYSTEMS

In a typical STEP system, household sewage is pretreated in a watertight septic tank where gross solids and grease are held back. A "clear" effluent from the mid-depth of the tank is transported to a common or lateral sewer. Usually the effluent is pumped from the septic tank under pressure to a small-diameter, pressurized collector sewer.

Effluent may also flow by gravity, where terrain allows, to small-diameter gravity collector lines.

2.1.7.3 SCOPE

A STEP/STEG system is considered to include all of its components beginning with the septic tanks, and ending at the point(s) of discharge into a conventional gravity sewer or treatment plant.

2.1.7.4 ADMINISTRATIVE REQUIREMENTS

All additions and extensions to existing STEP (or STEG) systems, as well as new systems, must be reviewed by the DIVISION OF WATER POLLUTION CONTROL.

The OWNER is defined as the municipality, sanitary district, private sewage utility or sanitary authority which is responsible for the operation of the system. The property being served is defined as the "USER".

Legal title to tanks, pumps, or other components must be vested with the OWNER. The objective of having title invested to the OWNER rather than the USER is to avoid potential for cost disputes over equipment selection and repair methods.

Regardless of where title is vested, the OWNER shall completely control all tanks, pumps, service lines and other components of the system on private property. This requirement is essential to assure operable hydraulics and overall system reliability.

The OWNER shall possess a recorded general easement or deed restriction to enter the private property being served, and to access the system and its components. Access must be guaranteed to operate, maintain, repair, restore service and remove sludge.

No system shall be operated without the direct field supervision of qualified collection operator certified by the STATE OF TENNESSEE. An operations and maintenance manual shall be submitted for review prior to startup.

OWNERS shall operate and maintain STEP/STEG facilities without interruption, sewage spills on the grounds, sewage backup into buildings, or other unhealthy conditions.

2.2 Design Considerations

2.2.1 Design Period

2.2.1.1 Collection Sewers (Laterals and Submains)

Collection sewers should be designed for the ultimate development of the tributary areas.

2.2.1.2 Main, Trunk and Interceptor Sewers

Selection of the design period for trunk and interceptor sewers should be based on evaluation of economic, functional, and other considerations. Some of the factors that should be considered in the evaluation are:

a. **Possible solids deposition, odor, and pipe corrosion that might occur at initial flows**
b. **Population and economic growth projections and the accuracy of the projections.**
c. **Comparative costs of staged construction alternatives.**
d. **Effect of sewer sizing on land use and development.**

2.2.2 Design Basis

New sewer systems shall be designed on the basis of per capita flows or alternative methods. Documentation of the alternative methods shall be provided.

2.2.2.1 Per Capita Flow

New sewer systems designed on the basis of an average daily per capita flow may be designed for flow equal to that set forth in Appendix 2-A. These figures are assumed to cover normal infiltration and inflow, but an additional allowance should be made where conditions are unfavorable. If there is an existing water system in the area, water consumption figures can be used to help substantiate the selected per capita flow. Generally, the sewers should be designed to carry, when running full, not less than the following:

a. **Lateral and Submains: Minimum peak design flow should be not less than 400 percent of the average design flow.**

   "Lateral" is defined as a sewer that has no other common sewers discharging into it.

   "Submain" is defined as a sewer that receives flow from one or more lateral sewers.

b. Main, Trunk, and Interceptor Sewers: Minimum peak design flow should be not less than 250 percent of the average design flow.

"Main" or "trunk" is defined as a sewer that receives flow from one or more submains.

"Interceptor" is defined as a sewer that receives flow from a number of main or trunk sewers, force mains, etc.

2.2.2.2 Alternative Methods

New sewer systems may be designed by alternative methods other than on the basis of per capita flow rates. Alternative methods may include the use of peaking factors of the contributing area, allowances for future commercial and industrial areas, separation of infiltration and inflow from the normal sanitary flow, and modification of per capita flow rates (based on specific data). Documentation of the alternative method used shall be provided When infiltration is calculated separately from the normal sanitary flow, the maximum allowable infiltration rate shall be 25 gallons per day per inch diameter of the sewer per mile of sewer.

2.2.3 Design Factors

The following factors must be considered in the design of sanitary sewers:

a. Peak sewage flows from residential, commercial, institutional, and industrial sources
b. Groundwater infiltration and exfiltration
c. Topography and depth of excavation
d. Treatment plant location
e. Soils conditions
f. Pumping requirements
g. Maintenance, including manpower and budget
h. Existing sewers
i. Existing and future surface improvements
j. Controlling service connection elevations

2.2.4 Design Definitions

2.3 Design and Construction Details

2.3.1 Gravity Sewers

2.3.1.1 Minimum Size

No sewer shall be less than 8 inches in diameter except that, in special cases, 6-inch-diameter sewer lines may be approved by the Department if they meet the following criteria:

a. The maximum number of services should not exceed 40 residences. This applies to 6" service lines as well as 6" mains.

b. A manhole shall be provided where the 6-inch connects to 8-inch or larger line. This does not include a 6-inch side sewer to serve 1 or 2 single-family dwellings.
c. A manhole or cleanout shall be provided at the end of the 6-inch line. This requirement shall be at the discretion of the Division.
d. Extension of the 6-inch line will not be possible at a later date.
e. The minimum slope allowable for 6-inch lines will be 0.60 feet per 100 feet.
f. Small diameter gravity (SDG) systems will be considered on a case by case basis. These systems should be discussed with TDEC personnel prior to initiation of detailed design work.

2.3.1.2 Depth

Generally, sewers should not be less than 2 ½ feet deep, but should be sufficiently deep to prevent freezing and physical damage and should receive sewage from existing dwellings by gravity.

2.3.1.3 Roughness Coefficient

The roughness coefficient should be documented for the type of pipe used. However, for ease of calculations, an "n" value of 0.0115 may be used in Manning's formula for the design of all sewer facilities.

2.3.1.4 Slope

All conventional gravity sewers shall be designed and constructed to give mean velocities, when flowing full, of not less than 2.0 feet per second. The following minimum slopes should be provided; however, slopes greater than these are desirable:

Table 2-1

Sewer Size (inches)	Minimum Slope (feet per 100 feet)
6	0.38
8	0.26
10	0.193
12	0.151
14	0.123
15	0.112
16	0.103
18	0.088
21	0.072
24	0.060
27	0.051
30	0.045
36	0.035
42	0.028
48	0.024

Under special conditions, slopes slightly less than those required for the 2.0-feet-per-second velocity when flowing full may be permitted. Such decreased slopes will only be considered where the depth of flow will be 0.3 of the diameter or greater for design average flow. Whenever such decreased slopes are proposed, the design engineer shall furnish with his report his computations of the depths of flow in such pipes at minimum, average, and daily or hourly rates of flow. The maintaining sewage agency must recognize and accept in writing the problems of additional maintenance caused by decreased slopes.

Sewers shall be laid with uniform slope between manholes.

Sewers on 18 percent slope or greater shall be anchored securely with concrete anchors or equal. Suggested minimum anchorage spacing is as follows:

1. **Not over 36 feet center to center on grades 18 percent and up to 25 percent.**
2. **Not over 24 feet center to center on grades 25 percent and up to 35 percent.**
3. **Not over 16 feet center to center on grades 35 percent and over.**

2.3.1.5 Alignment

Generally, gravity sewers shall be designed with straight alignment between manholes. However, curved sewers may be approved where circumstances warrant, but only in large (i.e., 36" and larger) diameter segments.

2.3.1.6 Increasing Size

Where a smaller sewer joins a larger one, 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.

2.3.1.7 High-Velocity Protection

Where velocities greater than 15 feet per second are expected, special provision shall be made to protect against internal erosion or displacement by shock.

2.3.2 Materials

Any generally accepted material for sewers will be given consideration. The material selected should be adapted to local conditions such as character of industrial wastes, possibility of septicity, soil characteristics, abrasion and similar problems. Careful consideration should be given to pipes and compression joint materials subjected to corrosive or solvent wastes. Such pipe and compression joint material should be evaluated for vulnerability to chemical attack, chemical/stress failure and stability in the presence of common household chemicals such as cooking oils, detergents and drain cleaners.

The specifications shall stipulate that the pipe interior, sealing surfaces, fittings and other accessories should be kept clean. Store pipe bundles on flat surfaces with uniform support. Stored pipe should be protected from prolonged exposure (six months or more) to sunlight with a suitable covering (canvas or other opaque material). Air circulation should be provided under the covering. Gaskets should not be exposed to oil, grease, ozone (produced by electric motors), excessive heat and direct sunlight. Consult with the manufacturers for specific storage and handling recommendations.

2.3.2.1 Rigid Pipe

Shall include, but not be limited to, vitrified clay, concrete, and cast iron pipe. Any rigid pipe shall have a minimum crushing strength of 2000 pounds per lineal foot. All pipe should meet the appropriate ASTM and/or ANSI specifications.

2.3.2.2 Semi-rigid Pipe

Shall include, but not be limited to, <u>Polyvinyl Chloride (PVC) composite (truss) pipe and</u> ductile iron. <u>PVC</u> composite pipe ends shall be sealed. <u>Rubber gasket</u> joints shall be specified. All pipe should meet the appropriate ASTM and/or ANSI specifications.

2.3.2.3 Flexible Pipe

Shall include, but not be limited to, polyvinyl chloride pipe (PVC), polyethylene pipe (PE), fiberglass composite pipe, reinforced plastic mortar pipe (RPM) and reinforced thermosetting resin pipe (RTR). PVC pipe should have a maximum Standard Dimension Ratio (SDR) of 35. All other flexible pipe that is not classified by the SDR system should have the same calculated maximum deflection under identical conditions as the SDR 35 PVC pipe.

Flexible pipe deflection under earth loading may be calculated using the formula presented in the ASCE/WPCF publication, <u>Design and Construction of Sanitary and Storm Sewers</u>.

All pipe should meet appropriate ASTM and/or ANSI specifications. It should be noted that ASTM D-3033 and D-3034 PVC pipes differ in wall thickness and have non-interchangeable fittings.

2.3.3 Pipe Bedding

All sewers shall be designed to prevent damage from superimposed loads. Proper allowance for loads on the sewer shall be made because of the width and depth of trench. Trench widths should be kept to a minimum. Backfill material up to three feet above the top of the pipe should not exceed 6 inches in diameter at its greater dimension.

As a general rule, in roadways where cover is less than 4 feet, ductile iron pipe, solid wall flexible plastic pipe, or concrete encasement shall be used. In such cases, a minimum cover of six inches (12 inches for solid wall flexible plastic pipe) is required. For structural reasons, ductile iron pipe, concrete encasement, or relocation shall be required when culverts or other conduits are laid such that the top of the sewer is less than 18 inches below the bottom of the culvert or conduit.

Uncased borings are not permitted for pipe larger than 3 inches.

Special care shall be used in placing bedding in the haunch region.

2.3.3.1 Rigid Pipe

Bedding Classes A, B, or C as described in ASTM C-12 or WPCF MOP No. 9 (ASCE MOP No. 37) shall be used for all rigid pipe, provided the proper strength pipe is used with the specified bedding to support the anticipated load. Bedding and backfield shall be placed as described in ASTM C-12.

2.3.3.2 Semi-rigid Pipe

Bedding Classes, I, II, III or IV (ML and CL only) as described in ASTM D-2321 shall be used for all semi-rigid pipe provided with the specified bedding to support the anticipated load.

Underground installation of Ductile iron shall be installed as per ASTM A-746.

2.3.3.3 Flexible Pipe

Bedding Classes I, II, or III as described in ASTM D-2321 shall be used for all flexible pipe provided, the proper strength pipe is used with the specified bedding to support the anticipated load.

Bedding, haunching, initial backfill, and backfill shall be placed in accordance to ASTM D-2321.

It is recommended that polyethylene pipe be installed with Class I bedding material for bedding, haunching, and initial backfill as described in 2.3.3.4.

2.3.3.4 Alternate Bedding Option

As an alternative to sub-sections 2.3.3.1, 2.3.3.2 and 2.3.3.3, all sewers shall be bedded and backfilled with a minimum of six inches of Class I material over the top and below the invert of the pipe.

2.3.3.5 Deflection Testing

Deflection testing of all flexible pipe shall be required. The test shall be conducted after the backfill has been in place at least 24 hours.

No pipe shall exceed a deflection of 5%.

The test shall be run with a rigid ball or an engineer-approved 9-arm mandrel having a diameter equal to 95% of the inside diameter of the pipe. The test must be performed by manually pulling the test device through the line.

2.3.3.6 Check Dams

Check dams shall be installed in the bedding and backfill of all new or replaced sewer lines to limit the drainage area subject to the french drain effect of gravel bedding. Major rehabilitation projects should also include check dams in the design. Dams shall consist of compacted clay bedding and backfill at least three (3) feet thick to the top of the trench and cut into the walls of the trench two (2) feet. Alternatively, concrete may be used, keyed into the trench walls. Dams shall be placed no more than 500 feet apart. The required location is upstream of each manhole. All stream crossings will include check dams on both sides of the crossing.

2.3.4 Joints

The method of making joints and the materials used should be included in the specifications. Sewer joints shall be designed to eliminate infiltration and exfiltration to prevent the entrance of roots.

Elastomeric gaskets, other types of pre-molded (factory made) joints are required. The butt fusion joining technique is acceptable for polyethylene pipe. On concrete pipe of 36" and greater diameter, the Anderson type joint shall be required. Cement mortar joints are not acceptable. Field solvent welds for PVC, PVC Truss and PE pipe and fittings are not acceptable.

2.3.5 Leakage Testing

Leakage tests shall be specified.

2.3.5.1 Testing Methods

Testing methods may include appropriate water or low pressure air testing. The use of television cameras for inspection prior to placing the sewer into service and prior to acceptance is recommended.

2.3.5.2 Low Pressure Air Testing

Low pressure air-testing shall be performed as per ASTM C-828 on all gravity pipe. The time required for the pressure to drop from the stabilized 3.5 psig to 2.5 psig should be greater than

or equal to the minimum calculated test time (the test criteria should be based on the air loss rate. The testing method should take into consideration the range in groundwater elevations projected and the situation during the test. The height of the groundwater should be measured from the top of the invert (one foot of H_20 = 0.433 psi).

Table 2-2 gives the minimum test times and allowable air loss values for various pipe size per 100 ft.:

Table 2-2

Pipe Size (inches)	Time, T (sec/100 ft)	Allowable Air Loss, Q (ft3/min)
6	42	2.0
8	72	2.0
10	90	2.5
12	108	3.0
15	126	4.0
18	144	5.0
21	180	5.5
24	216	6.0
27	252	6.5
30	288	7.0

2.3.6 Low Pressure Systems

Low pressure sewer systems are considered Developmental Technology.

2.3.6.1 Application

Low-pressure systems should be considered for situations in which gravity sewers are extremely costly or impractical, such as rock or high groundwater table.

2.3.6.2 Grinder Pumps

All raw wastewater should be collected from individual buildings/dwellings and transported to the pressure or gravity system by appropriately sized grinder pumps. A SEPTIC TANK/GREASE TRAP MUST BE USED PRIOR TO THE GRINDER PUMP FOR RESTAURANTS.

Grinder pumps do not require a septic tank except when used at restaurants..

All pumps shall have operating curves that do not allow backflow under maximum head conditions.

Pumps shall be watertight and located above the seasonal groundwater table where possible.

Odor considerations must be evaluated.

2.3.6.3 Septic Tank Effluent Pump (STEP) System

All STEP installations require careful attention to design details and construction techniques. The following criteria must be considered:

A. There are two methods of designing the STEP. The preferred method is to have the effluent pump in the septic tank itself and the other method is to have a separate enclosure for the effluent pump.

B. All STEPs must have a watertight designed septic tank. Retrofitting a septic tank to meet the requirements of a STEP is not acceptable.

C.. If a STEP is to be retrofitted to an existing septic tank and drain field, a positive means of preventing groundwater from backing up through the drainfield to the STEP shall be provided.

D. The STEP shall be located as close as possible to the septic tank.

E. Electrical power should be supplied through the main circuit box. Electricity is furnished to a separate circuit box installed on the exterior wall of the building, near the STEP.

2.3.6.4 Provision for Maintenance

Approval of a low-pressure sewer system shall be contingent on the following minimum provisions being made for operation and maintenance.

A. An adequate reserve stock of replacement pumping units shall be maintained by the municipality or utility.

B. There shall be qualified grinder pump or STEP maintenance personnel available as long as the system exists.

C. There shall be a written service agreement with the manufacturer assuring the availability of factory-trained maintenance personnel, the continued availability of standby equipment and replacement parts, other provisions assuring the Department that breakdowns will be repaired within 24 hours, and a written preventive maintenance plan.

D. STEPs shall be owned by the municipality and shall be maintained by the municipality or its assignee but, in any case, under supervision of the municipality.

E. The owner of each building served by a grinder pump or STEP will give an easement and/or right-of-way to the municipality for maintenance and inspection services. All persons exercising rights under this document shall be suitably bonded against theft and/or damages to the building and its contents. Notification of entry shall be a matter between owner/occupant/user and the municipality.

F. Replacement parts should be available for the entire life of the pumping unit. If parts become unavailable, provision should be made to replace pumps that fail with improved or updated models. A sinking fund should be established for this replacement and should take into account life expectancy of the pumping unit and regular maintenance cost.

2.3.6.5 Hydraulic

Calculations are of extreme importance, due to the fact that head losses within the low-pressure system will change each time a pump is activated. For this reason, future connections to a low-pressure system may not be feasible.

2.3.6.6 Minimum Velocity

The minimum operating velocity in the pressure system shall be 2 feet per second.

2.3.6.7 Flushing

There shall be a means of cleaning the system, particularly to clear any settleable solids or grease accumulation.

2.3.6.8 Pressure Testing

There shall be means for isolating and pressurizing sections of the system to detect and locate leaks.

2.3.6.9 Alarms

There should be a dual audio and visual warning system both inside the building and out, indicating malfunction or nonfunction of the pump. The high-level (in storage tank) warning system should also be a dual system. The warning systems should be an audio/visual one.

2.3.6.10 Cleanouts

Cleanouts should be provided at maximum of 400- foot intervals.

2.3.6.11 Ventilation

Ventilation of the pump station should be provided via house vents where allowable or through a separate system.

2.3.7 Manholes

2.3.7.1 Location

Manholes shall be installed at the end of each line of 8-inch diameter or greater unless the 8-inch line is expected to be extended in the forseeable future; in which case a cleanout shall be installed at the end of the line; at all changes in grade, size, or alignment; at all intersections; and at distances not greater than 400 feet for sewers 15 inches or less and 500 feet for sewer 18 inches to 30 inches (except that distances up to 600 feet may be approved in cases where adequate modern cleaning equipment for such spacing is provided). Greater spacing may be permitted in larger sewers and in those carrying a settled effluent. Cleanouts may be used in lieu of manholes at the end of lines 6 or 8 inches in diameter and not more than 150 feet long.

With prior municipality or utility approval greater distances between manholes may be allowed.

2.3.7.2 Drop Connection

An outside drop connection shall be provided for a sewer entering a manhole at an elevation of 24 inches or more above the manhole invert. Where the difference in elevation between the incoming sewer and the manhole invert is less than 24 inches, the invert should be filleted to prevent solids deposition.

2.3.7.3 Diameter

The minimum diameter of manholes should be 48 inches; larger diameters are preferable. The minimum clear opening in the manhole frame should be 24 inchs to provide safe access for emergencies.

Manholes connecting significant industries to the system should be larger, to provide space for monitoring and sampling equipment.

2.3.7.4 Flow Channels

Flow channels in manholes shall be of such shape and slope to provide smooth transition between inlet and outlet sewers and to minimize turbulence. A minimum slope of 0.1 ft. drop across the bottom of the manhole must be provided to maintain cleaning and the hydraulic gradient. Channeling height shall be to the crowns of the sewers. Benches shall be sloped from the manhole wall toward the channel to prevent accumulation of solids.

2.3.7.5 Watertightness

Watertight manhole covers shall be used wherever the manhole tops may be flooded. Manholes of brick or segmented block are not acceptable.

2.3.7.6 Testing

All new or rehabilitated manholes shall be vacuum tested to assure watertightness before backfilling. The exterior surface must be painted with waterproofing material as the vacuum is being pulled to seal the pores of the concrete.

2.3.7.7 Connections

Line connections directly to the manholes or to short stubs integral with the manholes should be made with flexible joints. Flexible joints are joints which permit the manholes to settle without destroying the watertight integrity of the line connections.

2.3.7.8 Ventilation

Ventilation of gravity sewer systems should be considered where continuous watertight sections greater than 1,000 feet in length are incurred. Vent height and construction must consider flood conditions.

2.3.7.9 Frames, Covers, and Steps

Frames, covers, and steps shall be of suitable material and designed to accommodate prevailing site conditions and to provide for a safe installation. Materials used for manhole steps should be highly corrosion-resistant. The use of galvanized steel should be avoided and aluminum or plastic with reinforcing bar is preferred.

2.4 Special Details

2.4.1 Protection of Water Supplies

2.4.1.1 Water Supply Interconnections

There shall be no physical connection between a public or private potable water supply system and a sewer or appurtenance thereto.

2.4.1.2 Relation to Waterworks Structures

It is generally recognized that sewers shall be kept remote from public water supply wells or other water supply sources and structures.

2.4.1.3 Relation to Water Mains

Horizontal Separation: Whenever practical, sewers should be laid at least 10 feet horizontally from any existing or proposed water main. The distance should be measured edge to edge. Should local conditions prevent a lateral separation of 10 feet, a sewer may be laid closer than 10 feet to a water main if it is laid in a separate trench and if the elevation of the top (crown) of the sewer is at least 18 inches below the bottom (invert) of the water main.

Vertical Separation: Whenever sewers must cross under water mains, the sewer shall be laid at such elevation that the top of the sewer is at least 18 inches below the bottom of the water main. When the elevation of the sewer cannot be varied to meet the above requirement, the water main shall be relocated to provide this separation or reconstructed with mechanical-joint pipe for a distance of 10 feet on each side of the sewer. One full length of water main should be centered over the sewer so that both joints will be as far from the sewer as possible.

When it is impractical to obtain proper horizontal and vertical separation as stipulated above, the sewer shall be designed and constructed equal to the water main pipe and shall be pressure-tested to assure water-tightness (see drinking water criteria). Such arrangements are discouraged and adequate reason shall be provided to justify the design. Any variations from this statement must be approvesd by the DIVISION OF WATER POLLUTION CONTROL prior to construction..

2.4.2 Backflow Preventers

State approved reduced pressure backflow prevention devices are required on all potable water mains serving the wastewater treatment plant or lift station. A list of approved backflow preventers may be obtained from the Division of Water Supply.

Backflow preventers shall be installed as per the Design Criteria for Community Public Water Systems, Division of Water Supply. Below-ground pit installations are not acceptable.

2.4.3 Sewers in Relation to Streams

2.4.3.1 Location of Sewers in Streams

The top of all sewers entering or crossing streams shall be at a sufficient depth below the natural bottom of the stream bed to protect the sewer line. In general, the following cover requirements must be met:

a. One (1) foot of cover (poured in place concrete) is required where the sewer is located in rock.
b. Three (3) feet of cover is required in stabilized stream channels.
c. Seven (7) feet of cover or more is required in shifting stream channels.

Sewers located along streams shall be located outside of the stream bed and sufficiently removed therefrom to minimize disturbance or root damage to streamside trees and vegetation.

Sewer outfalls, headwalls, manholes, gateboxes or other structures shall be located so they do not interfere with the free discharge of flow of the stream.

Sewers crossing streams shall be designed to cross the stream as nearly perpendicular to the stream flow as possible and shall be free from change in grade. To prevent the french drain effect of the sewer crossing the stream , check dams must be installed up stream and down stream in the pipe conduit trench. This must be separate from any concrete encasement.

2.4.3.2 Construction

Sewers entering or crossing streams shall be constructed of ductile iron pipe with mechanical joints, concrete encased, or shall be so otherwise constructed that they will remain watertight and free from changes in alignment or grade. Sewer systems shall be designed to minimize the number of stream crossings. The construction methods that will minimize siltation shall be employed. Upon completion of construction, the stream shall be returned as nearly as possible to its original condition. The stream banks shall be seeded, planted or other erosion prevention methods employed to prevent erosion. Stream banks shall be sodded, if necessary, to prevent erosion. Where tree canopy has been removed, replacement trees shall be planted of natural species. The consulting engineer shall specify the specific method or methods to be employed in the construction of the sewers in or near the stream to control siltation.

During construction of sewerage projects, the contractor shall be prohibited by clauses in the specifications from unnecessarily disturbing or uprooting trees and vegetation along the stream bank and in the vicinity of the stream, dumping of soil and debris into streams and/or on banks of streams, changing course of the stream without encroachment permit, leaving cofferdams in streams, leaving temporary stream crossings for equipment, operating equipment in the stream, or pumping silt-laden water into the stream.

Provisions shall be made in the specifications to retard the rate of runoff from the construction site and control disposal of runoff, including liberal use of entrenched silt fencing to trap sediment resulting from construction in temporary or permanent silt-holding basins, including pump discharges resulting from dewatering operations; to deposit out of the flood plain area all material and debris removed from the stream bed.

Specifications shall require that cleanup, grading, seeding, planting or restoration of the work area shall be carried out as early as practical as the construction proceeds.

Uncased borings are not permitted.

The design engineer is encouraged to read and become familiar with the Tennessee Erosion and Sediment Control Handbook available from the Department.

2.4.3.3 Special Construction Requirements

Special design requirements shall be employed to prevent stream drainage from sinking at the crossing and following along the sewer pipe bedding. This can be accomplished with an in- trench impounding structure of compacted clay or other impermeable materials. Other proposals will be considered.

2.4.3.4 Aerial Crossings

Sewers laid on piers across ravines or streams shall be allowed when it can be demonstrated that no other practical alternative exists or, in the design engineers judgement, other methods will not be as reliable.

Support shall be provided for all joints. All supports shall be designed to prevent frost heave, overturning or settlement. Precautions against freezing, such as insulation or increased slope, shall be provided. Expansion jointing shall be provided between above-ground and below-ground sewers. 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 fifty (50) year flood stage.

2.4.3.5 Permits

It is the owner's responsibility to obtain all necessary permits along streams or rivers; i.e., Corps of Engineers, TVA, or the Natural Resources Section of the Division of Water Pollution Control.

2.4.4 Inverted Siphons

Under normal conditions inverted siphons should not be used; but if they are, then the following conditions must be met:

Inverted siphons shall have a minimum of two barrels, with a minimum pipe size of six inches and shall be provided with necessary appurtenances for convenient flushing and maintenance. The manholes shall have adequate clearances for rodding. Sufficient head shall be provided and pipe sizes selected to secure velocities of at least 3.0 feet per second for average flows.

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. When inverted siphons are used,

the design engineer must furnish hydraulic calculations the plans. Proper access must be

maintained.

2.5 General Requirements for Pump Stations

2.5.1 Location and Flood Protection

Sewage pump stations should be located as far as practicable from present or proposed built-up residential areas, and an all-weather road should be provided. Noise control, odor control, and station architectural design should be taken into consideration. Sites for stations shall be of sufficient size for future expansion or addition, if applicable. The station site (larger stations) shall also be fenced and locked.

The station's operational components shall be located at an elevation that is not subject to the 100-year flood or shall otherwise be adequately protected against the 100-year flood damage.

Where the wet well is at a depth greater than the watertable elevation, special provisions shall be made to ensure water tight construction of the wet well. Any connections to the pump station should be made at an elevation higher than the maximum watertable elevation, where possible.

2.5.2 Pumping Rate and Number of Units

At least two pump units shall be provided, each capable of handling the expected maximum flow. Pump head and system head curves shall be submitted to the Department for review purposes.

Where three or more units are provided, they shall be designed to fit actual flow conditions and must be of such capacity that, with any one unit out of service, the remaining units will have capacity to handle the maximum sewage flow. The number of pump units may be controlled by the reliability classification of the adjacent receiving waters. See Chapter 1.3.11.3.

When the station is expected to operate at a flow rate less than one half the average design flow for an extended period of time, the design shall address measures taken to prevent septicity due tolong holding times in the wet well.

Consideration should be given to the use of variable-speed or multiple staged pumps, particularly when the pump station delivers flow directly to a treatment plant, so that sewage will be delivered at approximately the same rate as it is received at the pump station.

2.5.3 Grit and Clogging Protection

Where it may be necessary to pump sewage prior to grit removal, the design of the wet well should receive special attention, and the discharge piping should be designed to prevent grit settling in pump discharge lines of pumps not operating.

For large pump stations (generally, larger than 1 MGD) handling raw sewage, consideration should be given to installation of readily accessible bar racks with clear openings not exceeding 2-1/2 inches, unless pneumatic ejectors are used or special devices are installed to protect the pumps from clogging or damage. Where the size of the installation warrants, a mechanically cleaned bar screen with grinder or comminution device is recommended. Where screens are

located below ground, convenient facilities must be provided for handling screenings. For the larger or deeper stations, duplicate protection units, each sized at full capacity, are preferred.

2.5.4 Pumping Units

2.5.4.1 Pump Openings

Pumps shall be capable of passing spheres of at least 3 inches in diameter. Pump suction and discharge openings shall be at least 4 inches in diameter.

2.5.4.2 Priming

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

2.5.4.3 Intake

Each pump should have an individual intake. Wet well design should be such as to avoid turbulence near the intake.

2.5.4.4 Controls

Control float switches should be so located as not to be affected by the flows entering the wet well or by the suction of the pumps. Controls must be able to activate additional pumps if water in the wetwell continues to rise. Air-operated pneumatic controls are preferred for all sewage pump stations. Provisions should be made to automatically alternate the pumps in use. Pump stations with motors and/or controls below grade should be equipped with a secure external disconnect switch. If float switches are used, an "intrinsically safe" power source must be considered.

2.5.5 Flow Measurement

Suitable devices for measuring sewage flow should be provided at pumping stations with flow capacity greater than 1.0 million gallons per day (mgd). Hour timers (totalizers) shall be installed on all pumps unless otherwise approved by the Department.

2.5.6 Alarm System

An alarm system should be provided for all pumping stations. Consideration of telemetry alarm to 24-hour monitoring stations or telephone alarms to duty personnel should be given when reliability classification or property damage warrants it. When telemetry is not used, an audiovisual device should be installed at the station for external observation.

An alarm system may not be needed, in certain cases, where a utility has adopted a daily inspection routine. A statement from the utility, indicating that is has a daily inspection program, will be required. In certain cases, an alarm system may be required regardless of any other practices.

Alarms for high wet well and power failure shall be provided, as a minimum, for all pump stations. For larger stations, alarms signalizing pump and other component failures or malfunctions should also be provided.

A backup power supply, such as a battery pack with an automatic switchover feature, should be provided for the alarm system, such that a failure of the primary power source

will not disable the alarm system. Test circuits should be provided to enable the alarm system to be tested and verified that it is in good working order.

2.5.7 Emergency Overflow Pumping

Regardless of the type of emergency power standby system provided, a riser from the force main with rapid connection capabilities and appropriate valving shall be provided for all lift stations to hook up portable pumps.

2.6 Special Details

2.6.1 General

2.6.1.1 Materials

In the selection of materials, consideration should be given to the presence of hydrogen sulfide and other corrosive gases, greases, oils, and other constituents frequently present in sewage.

2.6.1.2 Electrical Equipment

Electrical systems and components (e.g., motors, lights, cables, conduits, switchboxes, control circuits) in enclosed or partially enclosed spaces where flammable mixtures occasionally may be present (including raw sewage wet wells) shall comply with the National Electrical Code requirements for Class I Division 1 locations.

2.6.1.3 Water Supply

There shall be no physical connection between any potable water supply and a sewage pumping station which under any conditions might cause contamination of the potable water supply. If a potable water supply is brought to the station, it shall comply with conditions stipulated in section 2.4.2.

2.6.1.4 Lighting

Adequate lighting for the entire pump station shall be provided.

2.6.1.5 Pump and Motor Removal

Provisions shall be made to facilitate removing pumps, motors, and other equipment, without interruption of system service.

2.6.1.6 Access

Suitable and safe means of access should be provided to equipment requiring inspection or maintenance. Stairways and ladders shall satisfy all OSHA requirements. Consideration should be given to fencing pump stations to discourage the entrance of unauthorized persons.

2.6.1.7 Valves and Piping

Suitable shutoff valves shall be placed on suction and discharge lines of each pump for normal pump isolation. A check valve should be placed on each discharge line between

the shutoff valve and the pump. Pump suction and discharge piping should not be less than 4 inches in diameter except where design of special equipment allows. The velocity in the suction line should not exceed 6 feet per second and, in the discharge piping, 8 feet per second. A separate shutoff valve is desirable on the common line leaving the pump station.

2.6.1.8 Ventilation

Ventilation should be provided for all pump stations during all periods when the station is manned. Where the pump is below ground, mechanical ventilation is required and should be arranged so as to independently ventilate the dry well. If screens or mechanical equipment, which might require periodic maintenance and inspection, are located in the wet well, then it should also be mechanically ventilated. There should be no interconnection between the wet well and the dry well ventilation systems. In pits over 15 feet deep, multiple inlets and outlets are desirable. Dampers should not be used on exhaust or fresh air ducts, and fine screens or other obstructions in air ducts should be avoided to prevent clogging. Switches for operation of ventilation equipment should be marked and conveniently located above grade and near the pump station entrance. Consideration should be given also to automatic controls where intermittent operation is used. The fan wheel should be fabricated from nonsparking material. In climates where excessive moisture or low temperature is a problem, consideration should be given to installation of automatic heating and/or dehumidifying equipment. Where heat buildup from pump motors may be a problem, consideration should be given to automatic ventilation to dissipate motor heat.

2.6.2 Wet Well - Dry Well Stations

2.6.2.1 Separation

Wet and dry wells, including their superstructures, should be completely separated.

Where continuity of pump station operation is necessary, consideration should be given to dividing the wet well into two sections, properly interconnected, to facilitate repairs and cleaning.

2.6.2.2 Wet Well Size

The effective capacity of the wet well should be evaluated based on pumping requirements and reliability classifications.

2.6.2.3 Floor Slope

The wet well floor should have a minimum slope of 1-to-1 in the hopper bottom. The horizontal area of the hopper bottom should be no greater than necessary for proper installation and function of the inlet.

2.6.2.4 Ventilation

Wet well ventilation may be either continuous or intermittent. Ventilation, if continuous, should provide at least 12 complete air changes per hour; if intermittent, at least 30 complete air changes per hour. Such ventilation should be accomplished by introduction of fresh air into the wet well by mechanical means.

Dry well ventilation may be either continuous or intermittent. Ventilation, if continuous, should provide at least 6 complete air changes per hour; if intermittent, at least 30 complete air changes per hour.

Portable ventilation equipment is acceptable for small pump stations where occupancy is rare.

2.6.2.5 Dry Well Dewatering

A separate sump pump should be provided in the dry wells to remove leakage or drainage with the discharge above the high water level of the wet well. Water ejectors connected to a potable water supply will not be approved. All floor and walkway surfaces should have an adequate slope to a point of drainage.

2.6.3 Suction Lift Stations

2.6.3.1 Priming

Conventional suction-lift pumps should be of the self-priming type, as demonstrated by a reliable record of satisfactory operation. The maximum recommended lift for a suction lift pump station is 15 feet, using pumps of 200 gallons per minute (gpm) capacity or less.

2.6.3.2 Capacity

The capacity of suction lift pump stations should be limited by the net positive suction head and specific speed requirements, as stated on the manufacturer's pump curve, for the most severe operating conditions.

2.6.3.3 Air Relief

a. Air Relief Lines

All suction lift pumps must be provided with an air relief line on the pump discharge piping. This line should be located at the maximum elevation between the pump discharge flange and the discharge check valve to ensure the maximum bleed-off of entrapped air. Air relief piping shall be sized appropriately. A separate air relief line shall be provided for each pump discharge. The air relief line should terminate in the wet well or suitable sump and be open to the atmosphere.

b. Air Relief Valves

Air relief valves should be provided in air relief lines on pumps not discharging to gravity sewer collection systems. The air relief valve should be located as close as practical to the discharge side of the pump.

2.6.3.4 Pump Location

Suction lift pumps should not be located within the wet well.

2.6.3.5 Access to Wet Well

Access to the wet well should not be through the dry well, and the dry well should have a gastight seal when mounted directly above the wet well.

2.6.4 Submersible Pumps

2.6.4.1 Pump Removal

Submersible pumps should be readily removable and replaceable without dewatering the wet well or requiring personnel to enter the wet well. Continuity of operation of the other units should be maintained.

A hoist and accessories for removing the pumps from the wet well should be provided.

2.6.4.2 Controls

The control panel should be located outside the wet well and suitably protected from weather, humidity, and vandalism.

2.6.4.3 Valves

All control valves on the discharge line for each pump should be placed in a convenient location outside the wet well in separate pits and be suitably protected from weather and vandalism. Outside valve covers should not be installed.

2.6.4.4 Submergence

Positive provision, such as backup controls, should be made to assure submergence of the pumping units.

2.7 Operability and Reliability

2.7.1 Objective

The objective of reliability is to prevent the discharge of raw or partially treated sewage to any waters and to protect public health by preventing backup of sewage and subsequent discharge to basements, streets, and other public and private property.

2.7.2 Backup Units

A minimum of two pumps shall be provided in each station in accordance with section 2.5.2.

2.7.3 Emergency Power Supply

2.7.3.1 General

Provision of an emergency power supply for pumping stations (and treatment plants) should be made, and may be accomplished by connection of the station to at least two independent public utility sources, or by provision in-place internal combustion engine equipment that will generate electrical or mechanical energy, or by the provision of portable pumping equipment. Emergency power must be provided for all stations which are 1 MGD or larger, or as determined by the reliability classification. See Chapter 1.3.11.5.

Emergency power shall be provided that, alone or combined with storage, will prevent overflows from occurring during any power outage that is equal to the maximum outage in the immediate area during the last 10 years. If available data are less than 10 years, an evaluation of a similar area served by the power utility for 10 years would be appropriate.

2.7.3.2 In-Place Equipment

Where in-place internal combustion equipment is utilized, the following guidelines are recommended:

A. Placement

The unit should be bolted in place. Facilities should be provided for unit removal for purposes of major repair or routine maintenance.

B. Controls

Provision should be made for automatic and manual startup and cut-in.

C. Size

Unit size should be adequate to provide power for lighting and ventilating systems and such further systems that affect capability and safety as well as the pumps.

D. Engine Location

The unit internal combustion engine should be located above grade, with suitable and adequate ventilation of exhaust gases.

E. Underground Fuel Storage Tank

If the fuel tank for the generator is to be placed below ground level, design and construction must conform to the applicable requirements of Federal Regulations 40 CFR 280 and 281. Contact the Tennessee Division of Superfund, Underground Storage Tank Program, for guidance.

2.7.3.3 Portable Equipment

Where portable equipment is utilized, the following guidelines are recommended:

Pumping units should have connections to operate between the wet well and the discharge side of station, and the station should be provided with permanent fixtures that will facilitate rapid and easy connection of lines. Electrical energy generating units should be protected against burnout when normal utility services are restored, and should have sufficient capacity to provide power for lighting and ventilating systems and any other station systems affecting capability and safety, in addition to the pumping units.

2.7.4 Storage

Where storage is provided in lieu of an emergency power supply, wet well and tributary main capacity above the high-level alarm should be sufficient to hold the peak flow expected during the maximum power outage duration during the last 10 years.

2.8 Force Mains

2.8.1 Size

Minimum size force mains should be not less than 4 inches in diameter, except for grinder pumps, septic tank effluent or vacuum applications.

2.8.2 Velocity

At pumping capacity, a minimum self-scouring velocity of 2 feet per second (fps) should be maintained unless flushing facilities are provided. Velocity should not exceed 8 feet per second.

2.8.3 Air Relief Valve

An air relief valve shall be placed at the necessary high points in the force main to relieve air locking.

2.8.4 Termination

The force main shall enter the receiving manhole with its centerline horizontal and 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 1 foot above the flow line of the receiving manhole. The design should minimize turbulence at the point of discharge.

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

2.8.5 Materials of Construction

The pipe material should be adapted to local conditions, such as character of industrial wastes, soil characteristics, exceptionally heavy external loadings, internal erosion, corrosion, and similar problems.

Installation specification 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, not create excessive side fill pressures or ovalation of the pipe, nor seriously impair flow capacity.

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

2.8.6 Pressure Tests

Before backfilling, all force mains shall be tested at a minimum pressure of at least 50 percent above the design operating pressure for at least 30 minutes. Leakage shall not exceed the amount given by the following formula:

$$L = \frac{ND(P)^{.5}}{7{,}400}$$

Where L is allowable leakage in gallons per hour,
N is the number of pipe joints,
D is the pipe diameter in inches,
P is the test pressure in psi.

2.8.7 Anchorage

Force mains shall be sufficiently anchored within the pump 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.

2.8.8 Friction Losses

A C factor shall be used that will take into consideration the conditions of the force main at its design usage. A pipe that is coated with grease after several years will not have the same C factor as it did when it was first placed into operation.

2.8.9 Water Hammer

The force main design shall investigate the potential for the existence of water hammer.

Appendix 2C:

Sample Specifications

VACUUM TESTING OF MANHOLES

The method of vacuum testing manholes REQUIRES the use of the following criteria:

1. This method is applicable to all manholes.
2. All lifting holes and exterior joints shall be filled and pointed with non-shrink grout for concrete manholes or sealed with compatiable sealant for other materials. The exterior of the manhole must be painted as the vacuum is being applied to seal the pores of the concrete.
3. Manholes are to be tested immediately after assembly or construction and before backfilling. No standing water shall be allowed in the manhole excavation which may affect the accuracy of the test.
4. All pipes and other openings into the manhole shall be suitably plugged in such a manner as to prevent displacement of the plugs while the vacuum is pulled.
5. Installation and operation of the vacuum equipment and indicating devices shall be in accordance with equipment specifications and instructions provided by the manufacturer.
6. The test head may be placed in the cone section of the manhole. The rim-cone is not usually tested.
7. A vacuum of 10.0 inches of mercury shall be drawn. The time for the vacuum to drop to 9.0 inches of mercury shall be recorded.
8. Acceptance for 4 ft. diameter manholes shall be defined as when the time to drop to 9 inches of mercury meets or exceeds the following:

MANHOLE DEPTH	DIAMETER	TIME TO DROP 1" HG
4 ft to 10 ft	**4 ft**	**75 seconds**
10 ft. to 15 ft.	**4 ft.**	**90 seconds**
15 ft. to 25 ft.	**4 ft.**	**105 seconds**

9. For manholes 5 ft. in diameter, add an additional 15 seconds and for manholes 6 ft. in diameter, add an additional 30 seconds to the time requirements for four foot diameter manholes.

10. If the manhole fails the test, neccessary repairs shall be made and the vacuum test repeated until the manhole passes the test.
11. If the manhole joint mastic or gasket is displaced during the vacuum test, the manhole shall be disassembled and the seal replaced.

Appendix 2C

Appendix- 2-A
Table for
DESIGN BASIS FOR NEW SEWAGE WORKS

Discharge Facility	Design Units	Flow (gpd)	BOD (lb/day)	TSS (lb/day)	Flow Duration (hr)
Dwellings	per person	100	0.17	0.2	24
School with showers and cafeteria	per person	16	0.04	0.04	8
School without showers and with cafeteria	per person	12	0.025	0.025	8
Boarding School	per person	75	0.2	.2	16
Motels at 65 gal/person (rooms only)	per person	130	0.26	.26	16
Trailer courts at 3 persons/trailer	per trailer	225	0.6	0.6	24
Restaurants	per seat	40	0.2	0.2	16
Interstate or through highway restaurants	per seat	180	0.7	0.7	16
Interstate rest areas	per person	5	0.01	0.01	24
Service stations	per vehicle serviced	10	0.01	0.01	16
Factories	per person per 8 hr shift	25	0.05	0.05	Operating Period
Shopping center (no food)	per 1,000 sq. Ft. Of ultimate floor	150	0.01	0.01	12
Hospitals	per bed	300	0.6	0.6	24
Nursing home (add 75 gals for laundry	per bed	120	0.3	0.3	24
Homes for the Aged	per bed	60	0.2	0.2	24
Child Care Center	per child and adult	10	0.01	0.01	Operating period
Laundromats, 9 to 12 machines	per machine	250	0.3	0.3	16
Swimming pools	per swimmer	10	0.001	0.001	12
Theaters, auditorium type	per seat	5	0.01	0.01	12
Picnic areas	per person	5	0.01	0.01	12
Resort camps, day & night with limited plumbing	per campsite	50	0.05	0.05	24
Luxury camps with flush toilets	per campsite	100	0.1	0.1	24
Churches (no kitchen)	per seat	3	.005	0.005	Operating period

* **Includes normal infiltration**

Note: In all cases use actual data from similar facilities when possible. Note variations due to factors such as age, water conservation, etc. Submit all design data used.

Hydrolic Design Criteria

PROJECT				AREA SERVED	TOTAL AREA SERVED	AVE SEWAGE FLOW	MAX SEWAGE FLOW	PIPE DIAMETER	INVERT ELEVATIONS		SHEET ___ OF ___			
											SEWER GRADE	SEWER FLOW	VELOCITY FLOWING FULL	CAPACITY FLOWING FULL
STREET	FROM MH	TO MH	LENGTH		ACRES	CFS	CFS	IN	UPPER MH	LOWER MH	%	FT	FPS	CFS

Appendix 2-A
Table for
DESIGN BASIS FOR NEW SEWAGE WORKS

Discharge Facility	Design Units	Flow (gpd)	BOD (lb/day)	TSS (lb/day)	Flow Duration (hr)
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Schools without showers and with cafeterias	per person	12	0.025	0.025	8
Boarding Schools	per person	75	0.2	0.2	16
Motels at 65 gal/person (rooms only)	per person	130	0.26	0.26	16
Trailer courts at 3 persons/trailer	per trailer	225	0.6	0.6	24
Resturants	per seat	40	0.2	0.2	16
Interstate or through highway resturants	per seat	180	0.7	0.7	16
Interstate rest areas	per person	5	0.01	0.01	24
Service stations	per vehicle serviced	10	0.01	0.01	16
Factories	per person per 8-hr shift	25	0.05	0.05	Operating Period
Shopping centers (no food)	per 1000 sq. ft. of ultimate floor	150	0.01	0.01	12
Hospitals	per bed	300	0.6	0.6	24
Nursing home (add 75 gal for laundry)	per bed	120	0.3	0.3	24
Homes for the Aged	per bed	60	0.2	0.2	24
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Churches (no kitchen)	per seat	3	0.005	0.005	Operating Period

* Includes normal infiltration

Note: In all cases use actual data from similar facilities when possible. Note variations due to factors such as age, water conservation ect. Submit all design data used.

Appendix 2a

CHAPTER 3

Laboratory, Personnel, Maintenance Facilities and Safety Design

LABORATORY, PERSONNEL, MAINTENANCE FACILITIES & SAFETY DESIGN

3.1 General

Suggested considerations are presented in this chapter for laboratory, personnel, maintenance facilities, and safety. If testing is contracted out (particularly for lagoon systems) minimal maintenance facilities will only be required.

3.2 Laboratory Facilities

3.2.1 General

A guide to provision of laboratory facilities is the EPA publication Estimating Laboratory Needs for Municipal Wastewater Treatment Facilities, EPA-430/9-74-002.

Lab work involves a significant portion of a small facility's work tasks. Each facility should estimate work tasks by obtaining the following documents:

a. "Minimum sampling schedule" should be obtained from the Permit Section of the Division of Water Pollution Control, containing compliance parameters from NPDES Permit as well as operation test.

b. List of Approved Analytical Procedures. See Code of Federal Regulations (CFR), June 30, 1986, pp. 23693-23700 for lab methods and preservation procedures for NPDES data.

c. Tennessee "Lab Manual" 1986. Contact the Julian Fleming Training Center in Murfreesboro.

d. Tennessee "Laboratory Equipment and Supplies for Wastewater Treatment Plants." Contact the Julian Fleming Training Center in Murfreesboro.

3.2.2 Space Requirements

Specific laboratory facilities should be based on the needs of the treatment plant. Minimum suggested space for one MGD facilities is:

Floor space of 200 sq. ft.

Percent of floor space required for bench area is 40%

Cabinet volume of 200 cubic foot.

These figures apply to a typical treatment plant monitoring program. If laboratory testing will be performed for other sources, such as industrial discharges, receiving waters, and sewer overflows, appropriate space increases should be provided. If some of the
plant monitoring tests are performed at other facilities, the space required could be significantly less.

3.2.3. Design

The following factors should be key considerations in design of plant laboratories:

Flexibility, which provides for changes in use requirements

Adaptability, for changes in occupancy requirements

Expandability, for changes in space requirements

3.2.3.1 Location

The laboratory should be located at ground level and easily accessible to all sampling points. To assure sufficient environmental control, the laboratory should be located away from vibrating machinery, corrosive atmospheres, or equipment which might have adverse effects on the performance of laboratory instruments or the analyst.

3.2.3.2 Layout

New lab layouts should be modeled after proven exemplary layouts. Efficient laboratory operation depends largely on the physical layout of the laboratory. The physical layout includes items such as working area arrangement, the number and location of sinks and electrical outlets, the arrangement of laboratory equipment, materials of construction, and lighting. The details of the layout can affect the accuracy of the laboratory tests. For example, tests that include identification of a colorimetric end point, as in heavy metals determinations, can be drastically affected by the type of lighting and the finishes on laboratory facilities.

The following factors should be considered when laying out a laboratory:

a. A northern exposure is preferred for colorimetric analysis.

b. Adequate lighting should be provided. Color-corrected fluorescent lighting is suggested.

c. Wall and floor finishes should be nonglare-type and light in color. Flat-finish wall paint is suggested. Floor finishes should be of a single color for ease of locating small items that have been dropped.

d. Floor covering, in addition to being nonglare, should be easy to clean and comfortable.

e. Doors shall have large glass windows for visibility into and out of the laboratory. There should be no obstructions near the doors.

f. Aisle width between work benches should be at least 4 feet. Adequate spacing should be provided around free-standing equipment, workbenches, and file cabinets to facilitate cleaning.

g. Storage space for reagent stock should be under workbenches. Reagent containers removed from storage areas under workbenches are less likely to be dropped than reagent containers removed from storage in the inconvenient and hard-to-reach areas above the workbenches. Only items that are infrequently used or chemicals of a nonhazardous nature should be stored above workbenches. Strong acids or bases should be stored within convenient reach of the laboratory personnel, preferably beneath or adjacent to the fume hood.

h. Sufficient cabinet and drawer space should be provided for the storage of equipment and supplies. Wall cabinets should be no more than 30 inches above the workbench top so that the contents of the top shelving can be reached. The base cabinets under the

workbenches should contain a combination of drawers and storage spaces for large items. All cabinets and drawers should be acid resistant.

i. One sink with a large gooseneck faucet, large enough to wash laboratory equipment, should be provided for every 25 to 30 feet of bench length. One sink should be sufficient when total bench length is less than 25 feet. The sink should be made of chemical-resistant material.

Cup sinks, also of chemical-resistant material, should be provided at strategic locations on the bench surface to facilitate laboratory testing. The number of cup sinks depends largely on the type of tests that will be run; the general rule is one cup sink for every 25 to 30 feet of bench length. Cup sinks should be alternated with the wash sinks at 12- to 15-foot intervals.

Where workbench assemblies are provided in the center of the laboratory, a trough-type sink down the center of the workbench may be provided in lieu of cup sinks. A hot and cold water tap should be placed at approximately every 5 to 10 feet along the trough.

The use of an automatic dishwasher should be considered. Where dishwashers are provided, some of the sinks can be replaced by cup sinks.

j. Electrical receptacles should be provided at strategic points for convenient and efficient operation of the laboratory. Duplex-type receptacles should be spaced at intervals along benches used for laboratory tests. Strip molding receptacles may be used. All receptacles must be elevated to prevent spills from entering the receptacles.

k. Gas and vacuum fixtures should be provided at convenient locations.

l. Bench tops should be suitable for heavy-duty work and resistant to chemical attack. Resin-impregnated natural stone and other manmade materials provide such a surface and should be used.

m. Bench surfaces should be approximately 36 inches high for work done from a standing position and 30 inches high for work done while sitting.

n. Bench surfaces should be approximately 30 inches wide.

o. Equipment arrangement should be given special consideration in laying out the laboratory facility in conjunction with the facility's owner and operators. Plumbing, and/or electrical connections should be provided for units such as the distillation apparatus, drying ovens or other wall-mounted equipment. Pieces of equipment used for making common tests should be in proximity. For example, the drying oven used in making total, suspended, and dissolved solids tests should be close to the muffle furnace for use in determining total volatile solids and volatile suspended solids from the samples dried in the drying oven. The drying oven and the muffle furnace should be near the balance table because the balance is used in the weight determinations for the various solids tests.

p. Safety is a prime consideration of a laboratory. The first aid kit, fire extinguisher, eye wash, and emergency shower should be near the main working area of the laboratory. If the safety shower is not provided in a separate shower stall, a floor drain should be nearby.

q. Sources of loud or startling noises, such as alarms or composite sampling equipment,should be located at sites remote or otherwise isolated from the laboratory.

r. The analytical balance should be on a separate table at least 30 inches long and 24 inches deep. The table should not transmit vibrations that would adversely affect the operation of the balance.

s. A separate table is desirable for microscopes. This table should be about 30 inches long, 24 inches deep, and 27 inches high.

t. Fume hoods, if provided, should be near the area where most laboratory tests are made.

u. All labs which run BOD_5 require air-conditioning to achieve a sufficiently high, stable D.O. in the dilution water. Laboratories should be separately air-conditioned, with external air supply for 100-percent makeup volume. Separate exhaust ventilation should be provided. Window air-conditioning should not blow directly on the analytical balance or furnaces.

v. Panic hardware should be provided for doors opening to the outside to allow for rapid exiting in an emergency.

3.3 Personnel Facilities

Personnel facilities are generally located in the administration building. This building serves the needs of the supervisory staff, the operation and maintenance personnel, and often the laboratory staff. Sewer maintenance personnel may also share the administration building. However, facilities for the laboratory and operations and maintenance staff need not be provided in the administration building, even though this is customary.

A wastewater treatment plant staffed for 8 hours or more each day should contain support facilities for the staff. Toilets shall be provided in conformance with applicable building codes. The following should be provided:

a. Wash-up and changing facilities: Showers, lockers, sinks, and toilets sufficient for the entire staff at design conditions. A heated and ventilated mudroom is desirable for changing and storage of boots, jackets, gloves, and other outdoor garments worn on the job. Each staff member should have separate lockers for street clothes and plant clothes. Separate wash-up and changing facilities should be available for men and women, with the exception of the mudroom.

b. Eating Facilities: A clean, quiet area with facilities for storage and eating of light meals.

c. Meeting facilities: A place to assemble the plant staff and visitors. In many cases, meeting facilities and the eating facilities will be the same.

d. Supervisors' facilities: A place where discussion and writing can be carried out in private. A desk station should be provided for data entry.

Facilities should be provided for the storage of analytical methods and records, catalogs, as-built plans, operation and maintenance manual(s), etc.

Small mechanical treatment plants that are not manned 8 hours per day need not contain all of the personnel facilities required for larger plants, but shall contain a lavatory, and a storage area.

3.4 Maintenance Facilities

To assure adequate maintenance of equipment, convenient maintenance facilities should be available. Such facilities generally include a maintenance shop, a garage, storage space, and yard maintenance facilities.

Access to nearby municipal garages and other maintenance centers should be considered. Duplication of facilities should be avoided where possible.

3.4.1 Maintenance Shop

A separate maintenance shop should be designated where treatment plant equipment and vehicles can be repaired. The maintenance shop should be provided with the following facilities:

a. Work space with adequate area and lighting, including a workbench with vise.

b. Conveyances to move heavy items from the point of delivery to the appropriate work space.

c. Storage for small tools and commonly used spare parts.

d. Adequate power outlets and ratings for the equipment.

3.4.2 Storage Requirements

Storage space should be provided for paints, fuels, oils and lubricants, grounds maintenance equipment, spare parts, and collection system equipment.

In larger facilities, it may be desirable to have a separate storage building for things such as paints, fuel, oils and lubricants, spare parts, and yard supplies. For storage of flammable materials, the requirements of the uniform building code shall be met. In smaller facilities, it might be desirable to combine storage with the shop or garage so that the stored material can be protected against unauthorized use.

Where underground tanks are to be used to store controlled substances, the Division of Ground Water Protection shall be contacted regarding Underground Storage Tank (UST) requirements.

3.4.3 Yard Requirements

A landscaped yard helps to soften the visual impact of a treatment facility. Shrubs and treees judiciously located can screen unsightly areas from public view. Care must be taken that the plantings do not become a hindrance to operation. Deciduous leaves falling in clarifiers can hinder skimming and add unnecessarily to the digester loading. Roots from trees too close to pipes can cause clogging. Fencing should be adequate to prevent unauthorized or unattended entry.

3.5 Safety Design

The field of wastewater treatment has always been one of the most hazardous fields of employment. This fact is accented by job-related deaths and accidents which happen each year. Safety designs are needed which should be supplemented by yearly inspections to gain awareness.

Adequate provisions shall be included in the design of all wastewater treatment facilities to minimize exposure of facility personnel and visitors to safety hazards. Treatment facilities shall be designed in full compliance with the Occupational Safety and Health Standards of the State of Tennessee, Division of Occupational Safety and Health (TOSHA).

Pertinent safety design requirements as well as safety design practices are included in the attached on-site checklist for wastewater treatment plants (Appendix 3-A).

To gain awareness each operator should have other safety resources such as:

1.) Safety & Health in Wastewater Systems (MOP-1 by WPCF)
2.) Individual safety manual adopted by each plant's safety committee.
3.) Safety meetings with city.

Any unsafe practices or incidents should be reported to TOSHA and each facility's safety committee. As a last resort, complaints can be made anonymously by the operator or any other concerned citizen.

Appendix 3-A

On-Site Checklist

STANDARD SAFETY

1. Personnel Protective Clothing:

    a. Safety helmets (for operators and visitors)

    b. Ear protectors for high noise areas

    c. Goggles

    d. Gloves

    e. Rubber boots with steel toes

2. Safety Devices Available for Use:

    a. Non-sparking tools in areas where flammable or explosive gases may be present

    b. Fire extinguishers readily available

    c. Oxygen deficiency/explosive gas indicator

    d. Self-contained breathing apparatus near entrance to chlorine room, away from fan discharge

    e. Safety harness

    f. First aid kits readily available

    g. Ladders to enter manholes or wetwells (fiberglass or wooden for around electrical work)

    h. Traffic control cones

    i. Safety buoy at activated sludge plants

    j. Live preservers for around lagoons

    k. Portable crane/hoist

3. General Plant Safety:

    a. Railing around all tanks, with openings chained off

    b. No uncovered pits or wells

    c. Explosion-proof fixtures, where needed

    d. Equipment guards in place

e. Emergency telephone numbers posted

f. Proper flammable liquid storage

g. Covered trash cans

h. Ladders have safety cages or equiped with safety slide rail

i. Portable hoists for equipment removal; e.g., pumps, aeration equipment

4. Are plant personnel immunized for typhoid and tetanus?

5. No cross connections exist between a potable water supply and a non-potable source:

a. Pump and mixer seals

b. Digester heating system make-up water

c. Vacuum filter water sprays

d. Chemical mixing tank

e. Chlorinator water source

f. Yard hydrants

g. Properly installed backflow preventers

6. If anaerobic digesters are used, are the following present?:

a. Pressure/vacuum relief valves

b. "No smoking" signs

c. Explosimeter

d. Drip trap

e. Flame traps within 25' of the flame source

7. Electrical Safety:

a. All electrical circuitry enclosed and identified

b. Electrical test equipment available, such as a voltmeter and amperage meter

c. Rubber mats present for electrical work

d. The personnel are familiar with the electrical work to be performed

e. All personnel are trained in electrical safety, such as lockout procedures

f. Warning and/or caution signs present

g. Rubber gloves available

h. Ground fault interrupter used

8. Chlorine Safety:

a. NIOSH-approved self-contained 30 minute air pack

b. All standing chlorine cylinders are chained in place

c. All personnel are trained in the use of chlorine

d. Chlorine repair kit is available

e. Chlorine leak detector tied into the plant alarm system

f. Ammonia for checking chlorine leaks is present

g. Ventilator fan with an outside switch is present

h. Safety precautions posted

i. Doors open outward and are equipped with "panic" hardware

9. Process Chemical Safety:

a. Respirator to protect the operator against dust inhalation, when needed

b. All personnel are trained to handle the chemicals properly

c. Proper safety clothing for the chemical to be handled, such as rubber aprons, boots and gloves for handling ferric chloride

d. Has complied with the Tennessee Department of Labor, Hazardous Chemical Right To Know Law, T.C.A. 50-3-2001 thru 2019.

e. Emergency Action Plan on file with local Fire Department and appropriate Emergency Agency

f. Containment of chemical storage areas, including curbing and floor drains to appropriate areas

10. Laboratory Safety:

a. Eye wash and shower station is present

b. Fume hood is present

c. All chemicals properly labeled and stored

d. Laboratory safety devices such as pipette suction bulbs

INNOVATIVE SAFETY

1. Warning Signs:
    a. Non-potable water
    b. Chlorine hazard
    c. No smoking
    d. High Voltage
    e. "Watch your step" signs in certain areas
    f. Exit signs
    g. Piping signs
2. Safety programs
3. Operators provided with a shower and a locker for their work clothes
4. Are the operators trained in first aid and CPR?

CHAPTER 4

Preliminary and Pretreatment Facilities

4.1 Screening and Grinding

- 4.1.1 General
- 4.1.2 Location
- 4.1.3 Bar Screens
- 4.1.4 Fine Screens
- 4.1.5 Communition
- 4.1.6 Operability
- 4.1.7 Disposal

4.2 Grit Removal

- 4.2.1 General
- 4.2.2 Location
- 4.2.3 Design
- 4.2.4 Disposal
- 4.2.5 Operability

4.3 Pre-aeration

4.4 Flow Equalization

- 4.4.1 General
- 4.4.2 Location
- 4.4.3 Design and Operability

4.5 Swirls and Helical Bends

PRELIMINARY AND PRETREATMENT FACILITIES

4.1 Screening and Grinding

4.1.1 General

Some type of screening and/or grinding device shall be provided at all mechanical wastewater plants. The effective removal of grit, rocks, debris, excessive oil or grease and the screening of solids shall be accomplished prior to any activated sludge process. Any grinding which does not dispose of the shredded material outside of the wastewater stream must be evaluated with regard to the influent characteristics (rags, combined sewers) of the waste prior to any activated sludge process.

4.1.2 Location

4.1.2.1 Indoors

Screening devices installed in a building where other equipment or offices are located shall be accessible only through an outside entrance. Adequate lighting, ventilation and access for maintenance or removal of equipment and screenings shall be provided.

4.1.2.2 Outdoors

The removal point for screenings should be as practical as possible for the plant personnel, preferably at ground level. Ladder access is not acceptable unless hoisting facilities for screenings are provided. Separate hoisting is not required for bar screens in manual bypass channels.

4.1.2.3 Deep Pit Installations

Stairway access, adequate lighting and ventilation with a convenient and adequate means for screenings removal shall be provided.

4.1.3 Bar Screens

4.1.3.1 Manually Cleaned

Clear openings between bars shall be from 1 to 2 inches. Slope of the bars shall be 30 to 60 degrees from the vertical. Bar size shall be from 1/4 to 5/8 inches with 1 to 3 inches of depth, depending on the length and material to maintain integrity. A perforated drain plate shall be installed at the top of the bar screen for temporary storage and drainage.

4.1.3.2 Mechanically Cleaned

Mechanically cleaned bar screens are recommended for all plants greater than 1 MGD. Both front cleaned or back cleaned models may be acceptable. Clear openings no less than 5/8 inch are acceptable. Protection from freezing conditions should be considered.

Other than the rakes, no moving parts shall be below the water line.

4.1.3.3 Velocities

Approach velocities no less than 1.25 fps nor a velocity greater than 3.0 fps through the bar screen is desired.

4.1.4 Fine Screens

4.1.4.1 General

Fine screens shall be preceeded by a trash rack or coarse bar screen. Comminution shall not be used ahead of fine screens. A minimum of two fine screens shall be provided, each capable of independent operation at peak design flow. The design engineer must fully evaluate a proposal where fine screens are to be used in lieu of primary sedimentation. Fine screens shall not be considered equivalent to primary sedimentation or grit removal, but will be reviewed on a case-by-case basis. Oil and grease removal must be considered.

4.1.4.2 Design

The operation should be designed to not splash operating personnel with wastewater or screenings. Fine screens will generally increase the dissolved oxygen content of the influent which may be beneficial in certain circumstances. The screens must be enclosed or otherwise protected from cold weather freezing conditions. Disposal of screenings must be addressed. To be landfilled, screenings must be dried to approximately 20% solids. Odors may be a problem in sensitive locations.

4.1.5 Comminution

4.1.5.1 General

In-line comminution may not be acceptable prior to an activated sludge process for facilities with a history of problems with rags. Out-of-stream comminution or disintegration is acceptable for activated sludge processes; however, screenings should not return to the wastewater stream.

4.1.5.2 Design

A coarse bar screen with an automatic bypass shall precede comminution for all mechanical plants. Gravel traps shall precede comminution which is not preceded by grit removal. Clear openings of 1/4 inch are prefered in the comminution device. An automatic unit bypass or other means of protection shall be provided to protect the comminutor motor from flooding. The design shall incorporate a method for removing the equipment from service and for repairs or sharpening of the teeth.

4.1.6 Operability

All screening devices shall have the capability of isolation from the wastewater stream. Sufficient wash water shall be available for cleanup of the area. All mechanical screening devices shall be provided with a manually cleaned bar screen bypass. Multiple bar screens should be considered for plants with rag problems instead of comminutors.

Adequate space must be provided for access to each screening or comminution device. This is critical in elevated, indoor or deep pit installations.

4.1.7 Disposal

All screenings shall be disposed of in an approved manner. Suitable containers shall be provided for holding the screenings. Run-off control must be provided around the containers, where applicable. If fine screens are proposed, consideration must be given to the wastewater overflow if the screens clog or blind. Overflows must be contained and bypassed around the screens by dikes or other means.

4.2 Grit Removal

4.2.1 General

Grit removal is recommended for all mechanical wastewater plants and is required in duplicate for plants receiving wastewater from combined sewers. Systems with a history of substantial grit accumulations may be required to provide for grit removal. Where a system is designed without grit removal facilities, the design shall allow for future installation by providing adequate head and area. Grit washing may be required.

4.2.2 Location

Wherever circumstances permit, grit removal shall be located prior to pumps and comminution when so equiped. Bar screens shall be prior to grit removal. Adequate lighting, ventilation and access for maintenance and removal of grit shall be provided. Stairway access is required if the chamber is above
or below ground level. Adequate and convenient means of grit removal shall be provided.

4.2.3 Design

4.2.3.1 Channel Type

A controlled velocity of one foot per second is recommended. Control by either sutro or proportional weir should be used. If a Parshall flume is used for control, the grit chamber must be designed to approach a parabolic cross-section. The length of the channel depends on the size of grit to be removed. The design engineer shall provide this information. Inlet and outlet turbulence must be minimized.

4.2.3.2 Square Type

Square-type basins or similar arrangements should be sized for an overflow rate of 46,300 (WPCF) gallons per day per square foot at the peak flow based on 65-mesh grit at a specific gravity of 2.65. Other overflow rates may be used when the design incorporates particle travel distance and detention. Inlet and outlet turbulence must be minimized.

4.2.3.3 Aerated Type

Aerated grit chambers shall be designed on the basis of detention and/or particle travel distance. Detention time of 2-5 minutes at peak flow is acceptable. Control of the air shall be provided for flexibility. Skimming equipment must be provided in the aerated grit chamber if the outlet is below the water surface.

4.2.3.4 Other Types

Cyclone or swirl-type grit removal processes may be acceptable. The design engineer will be expected to provide a complete treatment analysis for approval.

4.2.4 Disposal

Temporary storage containers shall be provided to hold the grit. Run-off control shall be provided. Attention should be given to operations which may splash waste or grit on operating personnel. Grit washing is required before removal to drying beds. If not washed, the grit shall be disposed of in an approved landfill.

4.2.5 Operability

Adjustable control valves shall be included in each diffuser air line to control mixing and particle segregation. Variable speed arrangements should be provided in cyclone or mechanical type systems. Provisions shall be made for isolation and dewatering each unit or units.

4.3 Pre-Aeration

Pre-aeration is desirable in certain instances, such as to reduce septicity. Pre-aeration may be required where pressure or small diameter collection systems are used. Long detention times in pump stations or collection lines should also be considered. Units shall be designed so that removal from service will not interfere with normal plant operations.

4.4 Flow Equalization

4.4.1 General

Equalization may be used to minimize random or cyclic peaking of organic or hydraulic loadings when the total flow is ultimately processed through the plant. Either in-line or side-line equalization is acceptable. Equalization may be required where peak flows are greater than 2 times the average design flow.

4.4.2 Location

Tanks are generally located after screening and grit removal. Care should be taken in design to minimize solids deposition if located upstream of primary clarifiers. Equalization downstream of primary clarifiers should be investigated, as primary clarifier performance is less sensitive to flow peaking when compared to other processes. Other locations will be evaluated on a case-by-case basis.

4.4.3 Design and Operability

Generally, aeration will be required. Minimum requirements are to maintain 1.0 mg/l of dissolved oxygen. Odor consideration must be addressed when a plant is located in a sensitive area or large equalization basins are used. Large tanks must be divided into compartments to allow for operational flexibility, repair and cleaning. Each compartment shall be capable of dewatering and access. In plant upgrades, existing units which are otherwise to be abandoned may be used for equalization, where possible. Sizing the tankage and compartments will depend on the intended use; i.e., when equalization is for periodic high organic loadings, peak flow events, toxics, etc. A complete analysis shall accompany all engineering report (or plan)

submission. The tank must be capable of being drained and isolated. Controlling the flow rate from the equalization tank to the plant is desirable.

4.5 Swirls and Helical Bends

General

These units are not to be used in lieu of primary clarification unless special design considerations are used. They are primarily designed for 'coarse' floating and settleable solids removal and will be considered only on a case-by-case basis for in-plant processes. They will, however, be approved for replacing regulators in combined sewer systems, as an interim measure until separation of the sanitary and storm flows is completed. Treatability studies will be required as part of the design. A separate NPDES permit will be required for each of these units that will discharge to a surface water.

CHAPTER 5

Clarifiers

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CLARIFIERS

5.1 General Criteria

5.1.1 Purpose

Clarifiers (sedimentation basins, settling tanks) are designed to perform three (3) functions in a treatment scheme:

A. Remove solids from liquids by sedimentation
B. Remove scum from liquid by flotation
C. Thicken solids for removal and further treatment

Specific application of clarifier functions will be dependent upon the treatment process employed. This chapter does not attempt to set criteria for all types of clarifiers. If a unique clarifier is proposed, the design engineer shall submit operational and design data justifying its use.

5.1.2 Number of Units

Multiple units capable of independent operation shall be provided in all facilities where design flows exceed 250,000 gallons per day. Otherwise, the number of units required shall satisfy reliability requirements (see Section 1.3.11). Facilities not having multiple units shall include other methods to assure adequate operability and flexibility of treatment.

5.1.3 Arrangements

Clarifiers shall be arranged for greatest operating and maintenance convenience, flexibility, economy, continuity of maximum effluent quality, and ease of installation of future units.

5.1.4 Tank Configurations

Consideration should be given to the probable flow pattern in the selection of tank size and shape and inlet and outlet type and location.

5.1.5 Flow Distribution

Effective flow measuring devices and control appurtenances (i.e., valves, gates, splitter boxes, etc.) shall be provided to permit proper proportion of flow to each unit (see Section 13.2.1).

5.2 Design Loading

5.2.1 Primary Clarifiers

Primary clarifier designs are primarily based upon surface overflow rate. The following criteria are recommended for design:

Hydraulic Loading Rate	Surface Overflow Rate
Average Design Flow	800-1200 gpd/sq. ft.
Peak Design Flow	2000-3000 gpd/sq. ft.

If WAS is returned to the primary then

Hydraulic Loading Rate	Surface Overflow Rate

Average Design Flow	600-800 gpd/sq. ft.
Peak Design Flow	1200-1500 gpd/sq. ft.

Primary clarifier sizing shall be calculated for both flow conditions and the larger surface area derived shall be utilized. A properly designed primary clarifier should remove 30 to 35% of the influent BOD. However, anticipated BOD removal for wastewater containing high quantities of industrial wastewater should be determined by laboratory tests and considerations of the quantity and characteristics of the wastes.

5.2.2 Intermediate Clarifiers

Surface overflow rates for intermediate clarifiers should be based upon the following criteria:

Hydraulic Loading Rate	Maximum Surface Overflow Rate
Average Design Flow	1000 gpd/sq. ft.
Peak Design Flow	2500 gpd/sq. ft.

5.2.3 Final Clarifiers

Final clarifier designs shall be based upon the type of secondary treatment application used. Surface overflow and solids loading rates shall be the general basis for clarifier designs. Pilot studies of biological treatment is recommended when unusual wastewater characteristics are evident or when the proposed loading exceeds those noted in this section.

Table 5-1 depicts the criteria established for final clarifier surface overflow and solids loading rates. In activated sludge systems, the surface overflow rate for final clarifiers should be based on influent wastewater flows and not include return activated sludge flows (RAS). Solids loading rate criteria assume sludge recycle is 100% of the average design flow and the design mixed liquor suspended solids (MLSS) concentration.

TABLE 5-1
FINAL CLARIFIER DESIGN PARAMETERS

Type of Process	Maximum Surface Overflow Rate gpd/sq. ft.		Solids Loading Rate lb/day/sq. ft.	
	Average Design Flow	Peak Design Flow	Average Design Flow	Peak Design Flow
Trickling Filter	600	1200	25	40
Activated Sludge	800 (600 for plants less than 1 MGD)	1200	30	50
Extended Aeration	400	1000	25	35
Nitrification	400	800	25	35
Pure Oxygen	700	1200	25	40

5.2.4 Weir Loading Rates

Weir loadings should not exceed 15,000 gallons per day per linear feet (gpd/li ft).

5.2.5 Depth/Detention Time

The sidewater depth (SWD) for clarifier designs associated with design surface overflow rates should dictate the hydraulic detention time of the clarifier. For design purposes, the following criteria in Table 5-2 are established specific to clarifier application:

TABLE 5-2
CLARIFIER DEPTH

Type of Process	Diameter (ft)	Minimum Sidewater Depth (ft)
*Primary	-	8
Trickling Filter	-	10
**Activated Sludge	less than 40	11
	40 - 70	12
	71 - 100	13
	101 - 140	14
	over 140	15

*The hydraulic detention time in primary clarifiers is not recommended to be greater than 2.5 hours as a function of the surface overflow rate and SWD, since septic conditions resulting in poor performance and odor conditions can occur.

**For rectangular-shaped clarifiers following activated sludge treatment, the recommended SWD shall be no less than 12 feet at the shallow end.

5.3 Design Details

5.3.1 Inlets

Inlets should be designed to dissipate the influent velocity, to distribute the flow equally in both the horizontal and vertical vectors, and to prevent short-circuiting. Channels should be designed to maintain an inlet velocity of at least one (1) foot per second at one-half the design flow. Corner pockets and dead ends should be eliminated and corner fillets or channeling used where necessary. Provisions shall be made for elimination or removal of floating materials in inlet structures having submerged ports.

5.3.2 Submerged Surfaces

The tops of troughs, beams, and similar submerged construction elements shall have a minimum slope of 1.75 vertical to 1 horizontal. The underside of such structures should have a slope of 1 to 1 to prevent accumulation of scum and solids.

5.3.3 Weir Troughs

Weir troughs shall be designed to prevent submergence at maximum design flow, and to maintain a velocity of at least one (1) foot per second at one-half design flow.

5.3.4 Freeboard

Walls of clarifiers shall extend at least six (6) inches above the surrounding ground surface and shall provide not less than twelve (12) inches of freeboard.

5.4 Sludge and Scum Removal

5.4.1 Scum Removal

Effective scum collection and removal facilities, including baffling ahead of the outlet weirs, shall be provided for all clarifiers. Provisions may be made for discharge of scum with sludge; however, other provisions may be necessary to dispose of floating materials which may adversely affect sludge handling and disposal. The unusual characteristics of scum which may adversely affect pumping, piping, sludge handling and disposal, should be recognized in the design. Scum piping should be glass lined or equivalent. Precautions should be taken to minimize water content in the scum.

5.4.2 Sludge Removal

Sludge collection and withdrawal facilities shall be designed to assure rapid removal of the sludge. Provisions shall be made to permit continuous sludge removal from settling tanks. Final clarifiers in activated sludge plants shall be provided with positive scraping devices. Suction withdrawal should be provided for activated sludge plants designed for the reduction of nitrogenous oxygen demand.

5.4.3 Sludge Removal Piping

Each sludge hopper shall have an individually valved sludge withdrawal line at least six (6) inches in diameter if pumped and at least eight (8) inches in diameter if gravity flow is used. This does not apply to air lift methods of sludge removal, as this should be determined by the sludge removal rate. Static head available for sludge withdrawal shall be at least thirty (30) inches, as necessary, to maintain a three (3) feet per second velocity in the withdrawal pipe. Clearance between the end of the withdrawal line and the

hopper walls shall be sufficient to prevent "bridging" of the sludge. Adequate provisions shall be made for rodding or back-flushing individual pipe runs.

***Air lift type sludge removal will not be approved for removal of primary sludges.

5.4.4 Sludge Removal Control

Sludge wells equipped with telescoping valves or other appropriate equipment shall be provided for viewing, sampling and controlling the rate of sludge withdrawal. A means for measuring the sludge removal rate and sludge return rate shall be provided. Sludge pump motor control systems shall include time clocks and valve activators for regulating the duration and sequencing of sludge removal. Gravity flow systems should have back-up pumping capabilities.

5.4.5 Sludge Hopper

The minimum slope of the side walls shall be 1.75 vertical to 1 horizontal. Hopper wall surfaces should be made smooth with rounded corners to aid in sludge removal. Hopper bottoms shall have a maximum dimension of two (2) feet. Extra-depth sludge hoppers for sludge thickening are not acceptable.

5.5 Protective and Service Facilities

5.5.1 Operator Protection

All clarifiers shall be equipped to enhance safety for operators. Such features shall appropriately include machinery cover lift lines, stairways, walkways, handrails and slip-resistant surfaces.

5.5.2 Mechanical Maintenance Access

The design shall 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.

5.5.3 Electrical Fixtures and Controls

Electrical fixtures and controls in enclosed settling basins shall meet the requirement of the National Electrical Code. The fixtures and controls shall be located so as to provide convenient and safe access for operation and maintenance. Adequate area lighting shall be provided.

5.6 Operability, Flexibility, and Reliability

5.6.1 Scum Removal

5.6.1.1 A method of conveying scum across the water surface to a point of removal should be considered, such as water or air spray. Baffles should be designed to ensure capture of scum at minimum and maximum flow rates.

5.6.1.2 Facilities designed for flows of 0.1 MGD and greater should have mechanical scum removal equipment.

5.6.1.3. Scum holding tanks may be provided, with a method of removing excess water.

5.6.1.4 Large scum sumps should have a mixing device (pneumatic, hydraulic, or mechanical) to keep the scum mixed while being pumped.

5.6.1.5 Manual scum pump start-stop switches should be located adjacent to scum holding tanks.

5.6.2 Overflow Weirs

5.6.2.1 Since closely spaced multiple overflow weirs tend to increase hydraulic velocities, their spacing should be conservative.

5.6.2.2 Center-feed, peripheral draw-off clarifiers shall not have the overflow weir against the clarifier sidewall. Weir placement shall be 1/10 diameter or greater toward the center.

5.6.2.3 The up-flow rate shall not be greater than the surface overflow rate at any location within the solids separation zone of a clarifier.

5.6.2.4 Overflow weirs should be of the notched type; straight edged weirs will not be approved.

5.6.2.5 Overflow weirs shall be adjustable for leveling.

5.6.3 Unit Dewatering

5.6.3.1 The capacity of dewatering pumps should be such that the basin can be dewatered in 24 hours; eight hours is preferable.

5.6.3.2 The contents of the basin should be discharged to the closest process upstream from the unit being dewatered that can accept the flow.

5.6.3.3 Consideration shall be given to the need for hydrostatic pressure relief devices to prevent flotation of structures.

5.6.4 Hydraulics

5.6.4.1 Lift/pump stations located immediately upstream of secondary clarifiers shall have flow-paced controls to reduce shock loadings.

5.6.4.2 Square clarifiers with circular sludge withdrawal mechanisms shall be designed such that corner hydraulic velocities do not cause sludge carry-over.

5.6.5 Sludge Removal

5.6.5.1 When two or more clarifiers are used, provisions shall be made to control and measure the rate of sludge withdrawal from each clarifier.

5.6.5.2 Consideration should be given to removing activated sludge from the effluent end of rectangular clarifiers.

5.6.5.3 Consideration shall be given to chlorination of return activated sludge and digester supernate. Sufficient mixing and contact time should be provided.

5.6.6 Other Design Considerations

5.6.6.1 Designs should consider the possible need for future modifications to add chemicals such as flocculants.

5.6.6.2 A method of foam control should be considered for all inlet channels and feed wells in activated sludge systems.

CHAPTER 6

Fixed Film Reactors

FIXED FILM REACTORS

6.1 Trickling Filters

6.1.1 General

Trickling filters may be used for treatment of wastewater amenable to treatment by aerobic biological processes. This process is less complex and has a lower power requirement than some of the other processes.

6.1.2 Pretreatment

Trickling filters shall be preceded by effective clarifiers equipped with scum removal devices or other suitable pretreatment facilities. (See Chapters 4 & 5)

6.1.3 Types of Processes

Trickling filters are classified according to the applied hydraulic and organic loadings. The hydraulic loading is the total volume of liquid applied, including recirculation, per unit time per square unit of filter surface area. Organic loading is the total mass of BOD applied, including recirculation, per unit time per cubic unit of filter volume.

6.1.3.1 Low or Standard Rate

These are loaded at 1 to 4 million gallons per acre per day (mgad) and 5 to 25 pounds BOD per 1,000 cubic feet per day (lb BOD/1000 cu ft/day. Nitrification of the effluent often occurs.

6.1.3.2 Intermediate Rate

These are loaded at 4 to 10 mgad and 10 to 40 lb BOD/1000 cu ft/day. Nitrification is less likely to occur.

6.1.3.3 High Rate

These are loaded at 10 to 40 mgad and 25 to 300 lb BOD/1000 cu ft/day. Nitrification is not likely to occur.

6.1.3.4 Super Rate

These are loaded at 15 to 90 mgad (not including recirculation) and up to 300 lb BOD/1000 cu ft/day. Filters designed as super rate require a manufactured media. Nitrification is not likely to occur.

6.1.3.5 Roughing

These are loaded at 60 to 180 mgd (not including recirculation) and 100 lb BOD/1000 cu ft/day. Nitrification will not occur. Roughing filters shall be followed by additional treatment, and will be equipped with manufactured media.

6.1.4 Considerations for Design

The following factors should be considered when selecting the design hydraulic and organic loadings:

Characteristics of raw wastewater
Pretreatment
Type of media
Recirculation
Temperature of applied wastewater
Treatment efficiency required

The following table presents allowable ranges for the design of trickling filters. Modifications of these criteria will be considered on a case-by-case basis.

Design Loading Table

Operating Characteristics	Low or Standard Rate	Intermediate Rate	High Rate	Super High Rate Manufactured Media	Roughing
Hydraulic Loading:					
mgd/acre	1-4	4-10	10-40	15-90	60-180*
gpd/sq ft	25-90	90-230	230-900	350-2000*	1400-4200*
Organic Loading:					
lb BOD/acre-ft/day	200-1000	700-1400	1000-12000		
lb BOD/1000 cu ft/day	5-25	10-40	25-300	up to 300	100+
Depth (ft)	5-10	4-8	3-6	3-8	15-40
BOD Removal (%)	80-85	50-70	65-80	65-85	40-65

*Does not include recirculation

6.1.5. Estimation of Performance

A number of equations are available for use in estimating trickling filter performance. Any design should evaluate several different formulas to compare the various parameters in different combinations with one another. Winter operating conditions must be analyzed since winter operations normally result in lower efficiency than summer operations. The trickling filter design must evaluate the impacts of recirculation, air draft temperatures and medium.

6.1.5.1 Recirculation

Recirculation capability is required for all variations of the trickling filter process except roughing filters provided that minimum hydraulic loading rates are maintained at all times. The recirculation ratio should be in the range of 0.5 to 4.0. Recirculation should be provided for manufactured media to maintain 0.5 to 1.0 gallon per minute per square foot (gpm/sq ft) or the manufacturer's recommended minimum wetting rate at all times. Recirculation ratios greater than 4.0 should not be used to calculate effluent quality.

6.1.5.2 Staging

Staging of filters can be considered for high-strength wastes or for nitrification.

6.1.6 Special Details

6.1.6.1 Media

a. Rock, Slag, or Similar Media

Rock, slag, and similar media should not contain more than 5 percent by weight of pieces whose longest dimension is three times the least dimension. They should be free from thin, elongated and flat pieces, dust, clay, sand, or fine material and should conform to the following size and grading when mechanically graded over a vibrating screen with square openings:

Passing 4-1/2 inch screen: 100 percent by weight

Retained on 3-inch screen: 90-100 percent by weight

Passing 2-inch screen: 0-2 percent by weight

Passing 1-inch screen: 0 percent by weight

Hand-picked field stone should be as follows:

Maximum dimension of stone: 5 inches

Minimum dimension of stone: 3 inches

Material delivered to the filter site should be stored on wood-planked or other approved clean hard-surfaced areas. All material should be rehandled at the filter site, and no material should be dumped directly into the filter. Crushed rock, slag, and similar media should be rescreened or forked at the
filter site to remove all fines. Such material should be placed by hand to a depth of 12 inches above the tile underdrains, and all materials should be carefully placed so as not to damage the underdrains. The remainder of the material may be placed by means of belt conveyors or equally effective methods approved by the engineer. Trucks, tractors, or other heavy equipment should not be driven over the filter during or after construction.

b. Manufactured Media

Application of manufactured media should be evaluated on a case-by-case basis. Suitability should be evaluated on the basis of experience with installations handling similar wastes and loadings.

Media manufactured from plastic, wood, or other materials are available in many different designs. They should be durable, resistant to spalling or flaking, and relatively insoluble in wastewater. They are generally applied to super high rate and roughing filter designs.

6.1.6.2 Underdrainage System

a. Arrangement

Underdrains with semicircular inverts or equivalent should be provided and the underdrainage system should cover the entire floor of the filter. Inlet openings into the underdrains should have an unsubmerged gross combined area equal to at least 15 percent of the surface area of the filter.

b. Slope

The underdrains should have a minimum slope of 1 percent. Effluent channels should be designed to produce a minimum velocity of 2 feet per second at average daily rate of application to the filter.

c. Flushing

Provision should be made for flushing the underdrains and effluent channel. In small filters, use of a peripheral head channel with vertical vents is acceptable for flushing purposes. Inspection facilities should be provided.

d. Ventilation

The underdrainage system, effluent channels, and effluent pipe shall be designed to permit free passage of air. The size of drains, channels, and pipe should be such that not more than 50 percent of their cross-sectional area will be submerged under the design hydraulic loading. Provision should be made in the design of the effluent channels to allow for the possibility of increased hydraulic loading.

6.1.6.3 Dosing Equipment

a. Distribution

The sewage shall be distributed over the filter by rotary distributors or other suitable devices which will permit reasonably uniform distribution to the surface area. At design average flow, the deviation from a calculated uniformly distributed volume per square foot of the filter surface should not exceed plus or minus 10 percent at any point. Provisions must be made to spray the side walls to avoid growth of filter flies.

b. Application

Sewage may be applied to the filters by siphons, pumps, or by gravity discharge from preceding treatment units when suitable flow characteristics have been developed. Application of sewage should be practically continuous. Intermittent dosing shall only be considered for low or standard rate filters. In the case of intermittent dosing, the dosing cycles should normally vary between 5 and 15 minutes, with distribution taking place approximately 50

percent of the time. The maximum rest should not exceed 5 minutes, based on the design average flow.

c. Hydraulics

All hydraulic factors involving proper distribution of sewage on the filters should be carefully calculated. For reaction-type distributors, a minimum head of 24 inches between the low-water level in the siphon chamber and center of the arms should be required. Surge relief to prevent damage to distributor seals, should be provided where sewage is pumped directly to the distributors.

d. Clearance

A minimum clearance of 6 inches between medium and distributor arms should be provided. Greater clearance is essential where icing occurs.

e. Seals

The use of mercury seals is prohibited in the distributors of newly constructed trickling filters. If an existing treatment facility is to be modified, any mercury seals in the trickling filters shall be replaced with oil or mechanical seals.

6.1.6.4 Recirculation Pumping

Low-head, high-capacity pumps are generally used. Submersible pumps are commonly used. A means to adjust the flow is recommended in order to maintain constant hydraulic operation.

6.1.6.5 Waste Sludge Equipment

Pumps for trickling filter sludge should be capable of pumping material up to 6-percent solids (or more if needed) when pumping directly to the digester. Time clock controlled on-off control is desirable. When secondary sludge is pumped to the primary clarifier, the sludge pumps should be designed to pump material with low solid concentrations and high flow rates.

6.1.6.6 Miscellaneous Features

a. Flooding

Consideration should be given to the design of filter structures so that they may be flooded.

b. Maintenance

All distribution devices, underdrains, channels, and pipes should be installed so that they may be properly maintained, flushed, or drained.

c. Flow Measurement

A means shall be provided to measure recirculated flow to the filter.

6.2 Rotating Biological Contactors

6.2.1 General

6.2.1.1 Description

This section presents the requirements for fixed-film reactors using either partially submerged vertical media rotated on a horizontal shaft or other designs with similar concepts.

6.2.1.2 Applicability

Rotating biological contactors (RBC) may be used for treatment of wastewater amenable to treatment by aerobic biological processes. The process is especially applicable to small communities. These requirements shall be considered when proposing this type of treatment.

6.2.1.3 Pretreatment

Primary clarifiers or fine screens should be placed ahead of the RBC process to minimize solids settling in the RBC tanks. (See Chapters 4 & 5)

6.2.2 Media

6.2.2.1 Description

Typical media consists of plastic sheets of various designs with appropriate spacings to maximize the surface area, allow for entrance of air and wastewater, the sloughing of excess biological solids and prevention of plugging. The medium is mounted on a horizontal steel shaft. Other similar systems will be considered on a case-by-case basis.

6.2.2.2 Types

Two types of medium are currently available.

a. Standard Density

Standard-density medium is available in sizes up to 100,000 square feet (sq ft) per shaft. It should be used for all secondary treatment applications.

b. High Density

High-density medium is available in sizes up to 150,000 sq ft per shaft. It should be used only for nitrification or effluent polishing where the influent BOD is sufficiently low to ensure that plugging of the medium will not occur.

6.2.3 Design Loadings

6.2.3.1 RBC Media

Design loadings should be in terms of total organic loading expressed as pounds BOD_5 per day per 1000 square feet of media surface area (lb BOD_5/day/1000 sq. ft.). The development of design

loadings should consider influent BOD, soluble BOD, effluent BOD, flows, temperature, and the number of treatment stages. The design loading should generally range between 2.5 and 3.5 lb BOD_5/day/1000 sq. ft.

6.2.3.2 Final Clarifiers

The following requirements are in addition to those set forth in Chapter 5, "Clarifiers."

The overflow rate should be less than or equal to 600 gpd/sq ft at the average daily design flow.

6.2.4 Special Details

6.2.4.1 Enclosures

Enclosures should be provided for the RBC medium to prevent algae growth on the medium and minimize the effect of cold weather. Enclosures may be either fabricated individual enclosures or buildings enclosing several shafts. Buildings may be considered for installations with several shafts or, where severe weather conditions are encountered, to promote better maintenance.

a. Fabricated Individual Enclosures

Enclosures should be made of fiberglass or other material resistant to damage from humidity or corrosion. The exterior of the enclosures should be resistant to deterioration from direct sunlight and ultraviolet radiation. Access points should be provided at each end of the enclosure to permit inspection of shafts and to perform operation and maintenance. Enclosures shall be removable to allow removal of the shaft assemblies. Access around enclosures shall be sufficient to permit suitable lifting equipment access to lift covers and shafts.

b. Buildings

Adequate space should be provided to allow access to and removal of shafts from enclosures. Buildings should be designed with provisions to remove shafts without damage to the structure. Buildings should be designed with adequate ventilation and humidity control to ensure adequate atmospheric oxygen is available for the RBC shafts, provide a safe environment for the operating staff to perform normal operation and maintenance, and minimize the damage to the structure and equipment from excess moisture.

6.2.4.2 Hydraulic Design

The RBC design should incorporate sufficient hydraulic controls, such as weirs, to ensure that the flow is distributed evenly to parallel process units. RBC tank design should provide a means for distributing the influent flow evenly across each RBC shaft. Intermediate baffles placed between treatment stages in the RBC system should be designed to minimize solids deposition. The RBC units should be designed with flexibility to permit series or parallel operation.

6.2.4.3 Dewatering

The design should provide for dewatering of RBC tanks.

6.2.4.4 Shaft Drives

The electric motor and gear reducer should be located to prevent contact with the wastewater at peak flow rates.

6.2.4.5 Recycle

Effluent recycle should be provided for small installations where minimum diurnal flows may be very small. Recycle should be considered in any size plant where minimum flows are less than 30% of the average design flow.

6.2.4.6 Access

Access shall be allowed for lifting equipment to provide maintenance in the event of a failure.

6.3 Activated Biofilter

6.3.1 General

6.3.1.1 Description

The activated biofilter (ABF) process is a combination of the trickling filter process using artificial media and the activated sludge process.

6.3.1.2 Applicability

The activated biofilter process may be used where wastewater is amendable to biological treatment. This process requires close attention and competent operating supervision, including routine laboratory control. These requirements should be considered when proposing this type of treatment. The process is more adaptable to handling large seasonal loading variations, such as those resulting from seasonal industries or changes in population, than are some of the other biological processes. Where significant quantities of industrial
wastes are anticipated, pilot plant testing should be considered.

6.3.2 ABF Media

Artificial media are used in the trickling filter portion of the process to allow high BOD and hydraulic loadings and permit recycle of activated sludge through the trickling filter without plugging. Either wood or plastic artificial medium may be used. Medium depth typically ranges from 7 to 25 feet.

6.3.3 Design

6.3.3.1 General

Calculations shall be submitted to justify the basis of design of the ABF tower pump station, ABF tower, aeration basin, aeration equipment, secondary clarifiers, activated sludge return equipment, and waste sludge equipment.

6.3.3.2 ABF Tower Pump Station

The ABF tower pump station shall be designed to pump the peak influent flow plus the maximum design ABF tower recirculation and return activated sludge flows. Application of wastewater to the ABF tower should be continuous.

6.3.3.3 ABF Tower

The ABF tower shall be designed based on organic loading expressed as pounds of influent BOD per 1,000 cubic feet per day (lb BOD/1,000 cu ft/day). The organic loading should be established using data from similar installations or pilot plant testing. A minimum hydraulic wetting rate should be maintained and be expressed as gallons per minute per square foot (gpm/sq ft). Typical values for organic loading range from 100 to 350 lb BOD/1,000 cu ft/day (4,300 to 15,000 pounds BOD per acre-foot per day), and hydraulic wetting rates range from 1.5 to 5.5 gpm/sq ft, including recirculations and return flows.

6.3.3.4 Aeration Basin

The aeration basin should be designed in accordance with Chapter 7, "Activated Sludge," based on the food-to-microorganism (F/M) ratio expressed as pounds of influent BOD per day per pound of mixed liquor volatile suspended solids (MLVSS). The F/M ratio should be based on the influent total BOD to the ABF tower or the estimated soluble BOD leaving the ABF tower. Designs using total BOD to the ABF tower should be based on data from similar installations or pilot plant testing. Designs using the estimated soluble BOD leaving the ABF tower should use typical F/M ratios (presented in Chapter 7, "Activated Sludge"). Estimate of BOD removal in the ABF tower should be based on similar installations or pilot plant testing. Calculations of mixed-liquor suspended solids should include the influent suspended solids and solids sloughing from the ABF tower in addition to growth of activated sludge due to removal of soluble BOD. Determination of aeration basin volume should include consideration of aeration basin power levels (using aeration equipment horsepower) expressed as horsepower per 1,000 cubic feet of basin volume. Aeration basin power levels should be limited to prevent excessive turbulence, which may cause shearing of the activated sludge floc.

Aeration prior to the ABF tower may also be considered.

6.3.3.5 Aeration Equipment

Oxygen requirements should be estimated as outlined in Chapter 7, "Activated Sludge," for the ABF tower effluent plus the oxygen requirements of the sloughed solids from the ABF tower.

6.3.3.6 Secondary Clarifiers

Secondary clarifiers should be equipped with rapid sludge withdrawal mechanisms and be designed in accordance with Chapter 5, "Clarifiers," and Chapter 7, "Activated Sludge."

6.3.3.7 Return Sludge Equipment

Return sludge equipment should be designed in accordance with Chapter 5, "Clarifiers."

6.3.3.8 Waste Sludge Equipment

Waste sludge equipment should be designed in accordance with Chapter 12, "Sludge Processing and Disposal."

6.3.3.9 ABF Tower Recirculation

ABF tower recirculation should normally be provided. At a minimum, recirculation capacity should meet the requirements for the minimum hydraulic wetting rate.

6.3.4 Special Details

6.3.4.1 ABF Tower

The ABF tower dosing equipment and underdrainage system should be designed in accordance with Section 6.1.6.3 "Dosing Equipment." Fixed or rotating distributors may be used. In addition, the design of the ABF tower should incorporate a skirt around the top to prevent spray from falling to the ground around the tower.

6.3.4.2 Maintenance Provisions

All distribution devices, underdrains, channels, and pipes should be installed so that they may be properly maintained, flushed, and drained.

6.3.4.3 Flow Measurement

Devices should be provided to permit measurement of flow to the ABF towers, ABF tower recirculation, return activated sludge, and waste activated sludge flows.