CHAPTER 11

Tertiary Treatment/Advanced Wastewater Treatment

TERTIARY TREATMENT/ADVANCED WASTEWATER TREATMENT

11.1 Filtration

11.1.1 General

Supplementary solids separation, following secondary clarification of wastewater, may be needed either as a final treatment step or prior to discharging to an ion exchange bed, carbon bed, reverse osmosis or other system. Filtration should be accomplished through a filter consisting of sand; sand and anthracite; anthracite; or anthracite, sand and garnet (or ilmenite).

11.1.2 High Rate Gravity Filters

11.1.2.1 Design

A minimum wastewater depth of 3 feet, measured from the normal operating wastewater surface to the surface of the filter medium, shall be provided. Even distribution of the wastewater over the filter area shall be provided. The top filter material shall not be displaced by the influent wastewater. The bottom washwater trough elevation shall be above the maximum level of expanded medium during backwashing. A top washwater trough elevation shall be no more than 30 inches above the filter surface. Spacing of the troughs shall be such that horizontal partical travel distance is not greater than 3 feet, and equal spacing between troughs is provided so that the same number of square feet of filter area is served by each trough.

For High Rate Filtration, dual or multi-media only shall be used. The maximum filter rate shall be 4 gpm/ft^2 immediately after backwash with a nominal rate of less than 4 gpm/ft^2 at the peak daily flow. A minimum of two filters shall be provided. Filtration shall be designed so that, with one filter out of service, each of the remaining filter(s) shall filter no greater than 4 gpm/ft^2 at the design peak daily flow. Equipment for the application of filter aids to the filter influent should be provided.

11.1.2.2 Medium

a. Sand - The medium shall be clean silica sand having

1. a depth of 30 inches;
2. an effective size of from 0.35 mm to 0.55 mm, depending upon the loading of the wastewater, and;
3. a uniformity coefficient not greater than 1.70.

b. Anthracite - a combination of sand and clean crushed anthracite may be used. The anthracite shall have:

1. an effective size of 0.8 mm - 1.2 mm, and;
2. a uniformity coefficient not greater than 1.85;
3. anthracite layer shall not exceed 20 inches in a 30-inch bed.

c. A 3-inch layer of torpedo sand may be used as a supporting medium for the filter sand; such torpedo sand shall have:

1. an effective size of 0.8 mm to 2.0 mm, and,
2. a uniformity coefficient not greater than 1.70.

d. Gravel - Gravel, when used as the supporting medium, shall consist of hard, rounded silicious particles.

1. The minimum gravel size of the bottom layer should be 3/4 inch or larger.
2. For proper grading of intermediate layers:

   (i) the minimum particle size of any layer should be as large as the maximum particle size in the layer next above and;

   (ii) within any layer the maximum particle size should not be more than twice the minimum particle size.

3. The depth of any gravel layer should not be less than 2 inches or less than twice the largest gravel size for that layer, whichever is greater. The bottom layer should be thick enough to cover underdrain laterals, strainers, or other irregularities in the filter bottom.
4. The total depth of gravel above the underdrains should not be less than 10 inches.

(Reduction of gravel depths may be considered upon justification when proprietary filter bottoms are installed.)

e. Multi-media - To be approved on a case-by-case basis.

The medium should consist of anthracite, silica sand, and/or other suitable sand. Since filters presently utilizing dual media and mixed media are proprietary in nature, no attempt will be made to set standards for minimum filter media depth, effective size and uniformity coefficient of filter media, or the specific gravity of that medium.

11.1.2.3 Underdrains.

Porous-plate bottoms shall not be used. Perforated pipe underdrains should be used, consisting of a manifold and laterals. Underdrain systems allowable in water plants such as Leopold or Wheeler bottoms are acceptable. The orifice loss in backwashing must exceed the sum of the minor hydraulic losses in the underdrain system to secure good distribution of flow over the entire area of the filter bottom. In order to insure adequate design of perforated pipe underdrain systems the following ratios must fall within the ranges shown:

$$\frac{\textbf{orifice area}}{\textbf{bed area}} = \frac{0.0015}{1} \text{ to } \frac{0.005}{1}$$

$$\frac{\textbf{lateral area}}{\textbf{area of orifices served}} = \frac{2}{1} \text{ to } \frac{4}{1}$$

$$\frac{\textbf{manifold area}}{\textbf{area of laterals served}} = \frac{1.5}{1} \text{ to } \frac{3}{1}$$

Orifices should have 3 to 12 inch spacing, and laterals the same. Underdrains should be made of corrosion and scale resistant materials, or properly protected against corrosion.

Orifices through false filter bottoms or underdrain design are preferred. The glazed tile filter block used in some filter bottoms and the stainless steel modulars used in other filter bottom designs are recommended to provide even and uniform distribution of backwash water. Hydraulic distribution data on each standard filter size should be submitted.

11.1.2.4 Backwash

Provisions shall be made for washing filters as follows:

a. a rate to provide for a 50 percent expansion of the medium is recommended, consistent with water temperatures and specific gravity of the filter medium; a minimum rate of 15 gpm/ft^2 is recommended, however 20 gpm/ft^2 may be required for adequate expansion of the filter medium.

b. filtered wastewater provided at the required backwash rate by washwater tanks, a washwater pump(s) or a combination of these is required,

c. washwater pumps in duplicate unless an alternate means of obtaining washwater is available; air release must be provided;

d. washwater supply to backwash two filters for at least 5 minutes at the design rate of wash; plus surface wash requirements;

e. A washwater regulator or valve on the main washwater line to obtain the desired rate of filter wash with the washwater valves on the individual filters completely open is required.

f. Air scouring at 3-5 cu ft/min/ft^2 of filter area for at least 3 minutes preceding water backwash is acceptable.

g. Rate of flow indicators on the main washwater line shall be provided and should be located so that it can be easily read by the operator during backwash.

h. Backwash wastewater treatment and disposal must be accomplished within the rated design capacities of the treatment system. Backwash wastewater cannot be discharged to a stream without first receiving adequate treatment. If it is desired to recycle the backwash wastewater through a secondary system, then the hydraulic design of the entire system (including the clarifier and filter) must be based on the anticipated rate of raw influent flow plus the flow rate at which the backwash water enters the system. In most systems a backwash water holding tank and controlled discharge system will be required. This holding system must be capable of storing the wastes from two backwashes and discharging the wastes to the treatment system within 24 hours at a rate which, in combination with the raw influent, does not exceed the hydraulic design of any system component when the loading period for the plant is 24 hours. For plants with loading periods less than 24 hours, additional backwash holding capacity may be required. For example, a school's sewage treatment plant with an 8-hour loading period and a backwash holding system which pumps from its holding tank to the head of the treatment process only during low loading periods may require a holding tank with a capacity for three or more backwash volumes.

i. Backwash may be initiated either automatically or manually; the length of the backwash period must be automatically controlled by a timing device adjustable in one minute increments up to a possible 15 minute backwash duration.

11.1.2.5 Surface Wash

Surface wash facilities are required. Disinfected filtered wastewater effluent should be used for surface wash. Revolving-type surface washers should be provided; however, other types may be considered. All rotary surface wash devices should be designed with:

a. Provisions for minimum washwater pressures of 40 psi and;

b. Provisions for adequate surface washwater to provide 0.5 to 1 gallon per minute per square foot of filter area.

11.1.3 Pressure and Vacuum High Rate Filters

11.1.3.1 General

Pressure sand filters are those operating under pressure in a closed container. Generally, a pump discharge line delivers the influent to the pressure filter. Vacuum sand filters are those operating under partial vacuum within the underdrain system; they can have open beds. Generally, a pump suction line is connected to the underdrain of a vacuum sand filter.

11.1.3.2 Design

Design requirements for pressure or vacuum filters include all of those listed for High Rate Gravity Filters in paragraphs 11.1.2.1 through 11.1.2.5, plus the following; Pressure filter containers must meet all applicable safety codes and requirements. Containers must be large enough to permit a man to work inside for medium removal and underdrain maintenance. A minimum diameter of 3 feet is suggested. An access port must be provided for inspection and maintenance purposes.

11.1.4 Standard Rate Gravity Filters

11.1.4.1 General

A minimum of two complete units is required. Each unit must be designed to treat 100 percent of plant flow except where design flow is 100,000 gpd or greater (see Design Section 11.1.4.2). The sand surface must be submerged at all times. Generally, standard rate filters are monomedium sand filters (see Media Section 11.1.4.3).

11.1.4.2 Design

The hydraulic design loading for each filter must be within the range of 1.0 to 2.0 gpm/ft^2. For installation less than 100,000 gpd the nominal filter rate shall be 1.0 gpm/ft^2 with one cell loaded no more than 2.0 gpm/ft^2 during backwash of the other cell. For installations greater than 100,000 gpd it is expected that each filter cell will be loaded at 2 gpm/ft^2 and during periods of backwash; no other cell may be loaded higher than 4 gpm/ft^2. Even distribution of the wastewater over the filter shall be provided. The filter sand shall not be displaced by the influent wastewater. The bottom washwater trough elevation shall be above the maximum level of expanded medium during backwash. A top washwater trough elevation shall be no more than 30 inches above the filter surface. Spacing of the troughs shall be such that horizontal partical travel distance is not greater than 3 feet, and equal spacing between troughs is provided so that the same number of square feet of filter area is served by each trough.

11.1.4.3 Medium

The filter medium should have the following properties:

a. Sand

A sieve analysis should be provided by the design engineer. The medium should be clean silica sand having (1) a depth of not less than 27 inches and generally not more than 30 inches after cleaning and scraping and (2) an effective size of 0.35 mm to 0.5 mm, depending upon the quality of the applied wastewater, and a uniformity coefficient not greater than 1.6.

Clean crushed anthracite or a combination of sand and anthracite may be used. Such media should have (1) an effective size from 0.45 mm to 0.8 mm and (2) a uniformity coefficient not greater than 1.7.

b. Supporting medium for the filter sand

A sieve analysis should be provided by the design engineer. A 3-inch layer of torpedo sand should be used as the supporting medium for the filter sand. Such torpedo sand should have (1) an effective size of 0.8 mm to 2.0 mm and (2) a uniformity coefficient not greater than 1.7.

c. Gravel

Gravel when used as a supporting medium should consist of hard, rounded particles and should not include flat or elongated particles. The coarsest gravel should be 2 1/2 inches in diameter when the gravel rests directly on the strainer system and should extend above the top of the perforated laterals or strainer nozzles. Not less than four layers of gravel should be used.

11.1.4.4 Underdrains

All requirements of Section 11.1.2.3 apply.

11.1.4.5 Backwash

All requirements of Section 11.1.2.4 apply with the additional consideration:

There shall be the capability to backwash at a rate of 20 gpm/ft^2 for adequate expansion of the filter medium.

11.1.4.6 Surface Wash

All requirements of Section 11.1.2.5 apply.

11.1.5 Shallow Bed Filters (Slow Sand Filters)

These filters are normally used at small treatment facilities and will be reviewed on a case-by-case basis.

11.1.6 Operability

11.1.6.1 The clear well must be protected to keep unfiltered effluent from entering the clear well in the event that some accident or malfunction causes a filter to overflow.

11.1.6.2 It is suggested that a supplementary clean water source, such as a high volume hydrant (protected by a back-flow prevention device) be available for filling the clear well.

11.1.6.3 Any wastewater treatment facility that has a flow peaking factor equal to or greater than 1.5 shall have an equalization/surge tank to control filtration rate. The size of the equalization/surge tank must be determined on the basis of rate and duration of peak flows including the recirculated backwash water. For systems with a flow peaking factor less than 1.5, the rate of filtration may be accomplished by valves in such a way that will not cause water to surge through the filter at rates higher than design. Position indicators must be provided for automatic valves. Pressure or head loss gages must be provided on the influent and effluent side of each filter. Micro switches will also be acceptable. On larger installations (75,000 gpd or greater) a rate of flow indicator will be required. Rapid variations of filtration rate are undesirable as they may cause dislodging of deposited matter and subsequent deterioration of effluent quality.

11.1.6.4 A by-pass around the filters must be provided and controlled by an easily accessible valve with markings for open or closed positions.

11.1.6.5 The capability to disinfect both prior to and after the filters shall be provided.

11.1.6.6 Vertical walls within the filter are required unless otherwise approved.

11.1.6.7 There shall be no protrusion of the filter walls into the filter medium.

11.1.6.8 Sufficient head room shall be provided when filters are indoors to permit normal inspection and operation.

11.1.6.9 The minimum depth of filter shall be 8 feet.

11.1.6.10 Trapped effluent to prevent backflow of air to the bottom of the filters is required.

11.1.6.11 Washwater drain capacity shall be designed to carry maximum flow.

11.1.6.12 Walkways around filters, not less than 24 inches wide, shall be provided where the installation is above ground level.

11.1.6.13 When backwash is automatically controlled, the backwash rate shall increase gradually or "step up" in a manner so to not displace the media or "blow" the filter bottom with a sudden surge.

11.2 Post Aeration

11.2.1 General

Post aeration is used to maintain a required minimum dissolved oxygen residual in treated wastewater effluent. Post aeration is often needed following a dechlorination process where an oxygen depleting chemical such as sulfur dioxide is used.

11.2.2 Aeration Tank Systems

Design consists of determining the oxygen requirements and providing sufficient oxygen transfer capability to satisfy these requirements. The design should consider the quantity of oxygen to satisfy the oxygen deficit required to meet the receiving water standards plus the oxygen-utilization rate of the effluent wastewater. Design of the oxygen transfer equipment in an aeration tank stage should be based on the final dissolved oxygen leaving that aeration tank stage. Design of aeration tanks and equipment should conform to the pertinent requirements of Chapter 7, "Activated Sludge."

Calculations shall be submitted to justify the basis of design.

Aeration equipment may be any of the following:

1. Fine-bubble diffused air
2. High or Low speed surface aerators
3. Submerged turbine
4. High-purity oxygen

Other types will be considered based on performance and design data submitted with the request.

11.2.3 Cascade Systems

Cascade aeration consists of a series of steps or weirs over which the wastewater is passed in thin layers to maximize turbulence and promote transfer of atmospheric oxygen.

The engineer shall demonstrate that the design will meet the receiving water standards either by use of data from the literature or pilot testing. Calculations shall be submitted to justify the basis of design.

11.2.4 Operability

11.2.4.1 The design should incorporate provisions for the control of foam.

11.2.4.2 A series of basins may improve transfer efficiency and also reduce total horsepower required as opposed to one large basin.

11.2.4.3 Baffles should be used with mechanical aerators to prevent vortexing.

11.3 Nutrient Removal

Nutrient removal, either supplementary or incorporated within standard secondary treatment facilities may be required in areas where receiving waters are greatly used and re-used or where highly restrictive use classifications have been established. For organization purposes, a very broad definition of "nutrients" shall be adopted herein to include refractory organics, nitrogen, phosphorus and inorganic salts. Sufficient operating data and information are not available to permit the establishment of detailed criteria outlining the proper application of the various available processes and operations to a specific treatment situation. Until sufficient operating data are obtained, the development and design of nutrient removal processes must be based upon the best obtainable pilot plant data (developed by the application of standard processes and operations to the specific waste treatment problem on a small scale basis). In order for approval of any type of supplementary nutrient removal system, sufficient pilot plant operating data must be made available to allow an evaluation of the adequacy and efficacy of the proposed process. No process will be approved unless adequate provisions are made for the ultimate disposal of concentrated pollutants "created" by the process (such as spent ion exchange regenerants, concentrated brines from reverse osmosis and electrodialysis systems, contaminated sorption media, chemical sludges and so forth).