Introduction to Domestic Wastewater Treatment

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CONTENTS

1. GENERAL

1.1 Purpose. This introduction provides general information, illustrative guidance, and criteria for the design of domestic wastewater treatment.

1.2 Scope. Criteria presented here are applicable to new and upgraded domestic wastewater treatment facilities. This course provides information on how to determine the sizes of wastewater treatment unit operations.

1.3 Objectives. A wastewater treatment plant should be designed to achieve Federal, State and local effluent quality standards stipulated in applicable discharge permits. Specifically, the plant must be easy to operate and maintain, require few operating personnel, and need a minimum energy to provide treatment. Plants should be capable of treating normal laundry wastes together with sanitary wastewater. Pretreatment of laundry wastes will not be considered except where such wastes might exceed 25 percent of the average daily wastewater flow, or as a resources conservation measure when feasible. In a design for the expansion of existing plants, criteria contained herein regarding flows and wastewater characteristics may be modified to conform to existing plant performance data, if the plant has been in operation long enough to have established accurate data.

1.4 Special design considerations. In the design for the expansion of existing treatment works or construction of new facilities, the designer may offer criteria on new treatment processes for consideration. Pollution control facilities will incorporate the latest proven technology in the field. Technology is considered proven when demonstrated successfully by a prototype plant treating similar wastewater under expected climatic conditions. If treatment level is obtained, operational performance and maintenance records would have been adequately documented to verify the capability of the process.

2. SITE SELECTION

2.1 Location. The major factors in the selection of suitable sites for treatment facilities include the following: topography; availability of a suitable discharge point; and maintaining a reasonable distance from living quarters, working areas and public use areas of the proposed facilities, as reflected by the master plans. The siting criteria for the water pollution control facility should consider State wellhead protection requirements for drinking water sources. In the absence of a state requirement, a minimum distance of 1,000 feet should be maintained between a drinking water source and any proposed water pollution control facility. For on-site treatment systems, rainfall and soil characteristics are major criteria. For plants of 50,000 gallons per day or less, treatment capacity will be more than 500 feet from the facilities when this minimum distance will not result in unacceptable noise or odor levels. Larger plants, and wastewater treatment ponds regardless of size, will be more than one-quarter mile from such facilities. Greater distance may be required when such facilities are located on the leeward side of the treatment plant; in areas subject to prolonged or frequent air stagnation or fog/mist cover; and at a lower elevation than the treatment works, with surface and ground water flowing from the treatment plant toward the occupied area.

2.1.1 Cold climate. Exceptions to the 500-foot restriction can be made for cold climate module complexes where the treatment system is part of the module complex. However, sewage treatment works will not be located within the same module as living quarters.

2.1.2 Septic tank systems. Standard septic tank systems with subsurface drain fields do not fall under the 500-foot restriction. Distance reductions must not result in creation of unacceptable noise levels when plant equipment is in operation.

2.2 Space requirements. Sufficient space must be allocated not only for suitable arrangement of the initial units and associated plant piping but also to accommodate future expansion. Future expansion includes the provision of increased capacity for existing processes and the addition of new types of units known to be required for upgrading predesigned systems to the future requirements of more stringent stream and effluent standards.

2.3 Access. The site will be selected so that an all-weather road is available or can be provided for access to the plant. Available rail sidings will also be utilized when practical. Consideration should be given, during layout of buildings, roads, fencing and appurtenances, to winter conditions such as snow drifting and removal. Considerable energy savings may result from partially earth protected north walls, from solar passive collectors, and from proper insulation. Evergreen shrubs planted in the correct location may dampen cold prevailing winter winds, but if planted in an incorrect position, can cause drifts or interfere with snow removal.

3. TREATMENT REQUIREMENTS

3.1 General considerations. Before treatment plant design is begun, treatment requirements will be determined on the basis of meeting stream and effluent requirements set by either U.S. or State governments or foreign governmental agencies.

3.1.1 Standards. The U.S. Environmental Protection Agency (EPA) issues effluent standards covering the discharge of toxic and hazardous pollutants. Strict limitations on discharges of these pollutants should be imposed.

3.1.2 Pretreatment. Public Law 92-500, with subsequent amendments, requires pretreatment of pollutants which may interfere with the operation of a sewage treatment plant or pass through such a plant untreated. Additionally, in many cases, pretreatment of industrial wastewater will be necessary to prevent adverse effects on the sewage treatment plant processes. Some types of industrial waste may be admitted to wastewater treatment plants, e.g., cooling tower discharges, boiler blowdown, vehicle washrack wastewater, swimming pool filter discharges, and aircraft wash wastes using biodegradable detergents. Flow of industrial wastewater may be reduced through process modification or wastewater recirculation. Adverse impacts on the treatment plant can be mitigated by reducing the concentration of those compounds causing the problem. Table 3-1 is a listing of compounds which inhibit biological treatment processes. In some cases, the adverse impact may be caused by short-lived occurrences of either wastewater containing high concentrations of compounds or a wastewater flow rate much higher than the average daily flow. This situation, which is commonly called “slugs,” may in some cases be managed by including an equalization basin upstream of the treatment plant.

Table 3-1
Information on materials which inhibit biological treatment processes

Pollutant	**Inhibiting or toxic concentration (1), mg/L**		
	Aerobic processes	**Anaerobic processes**	**Nitrification**
Copper	1.0	1.0	0.5
Zinc	5.0	5.0	0.5
Chromium (hexavalent)	2.0	5.0	2.0
Chromium (trivalent)	2.0	2,000 (2)	*
Total chromium	5.0	5.0	-
Nickel	1.0	2.0	0.5
Lead	0.1	*	0.5
Boron	1.0	*	*
Cadmium	*	0.02 (2)	*
Silver	0.03	*	*
Vanadium	10	*	*
Sulfides	*	100 (2)	*
Sulfates	*	500	*
Ammonia	*	1,500 (2)	*
Sodium	*	3,500	*
Potassium	*	2,500	*
Calcium	*	2,500	*
Magnesium	*	1,000	*
Acrylonitrite	*	5.0 (2)	*
Benzene	*	50	*
Carbon tetrachloride	*	10 (2)	*
Chloroform	18.0	0.1 (2)	*
Methylene chloride	*	1.0	*
Pentachlorophenol	*	0.4	*
1,1,1 Trichloroethane	*	1.0 (2)	*
Trichlorofluoromethane	*	0.7	*
Trichlorofluoroethane	*	5.0 (2)	*
Cyanide	*	1.0	2.0
Total oil (petroleum origin)	50	50	50

(*) Insufficient data available to determine effect.
(1) Raw wastewater concentration unless otherwise indicated.
(2) Digester influent concentration only; lower values may be required for protection of other treatment processes.
(3) Petroleum-based oil concentration measured by API Method 733-58.

3.1.3 State regulations. Most states require a minimum of secondary treatment for all domestic wastewaters. In critical areas, various types of advanced wastewater treatment processes for the removal of phosphorus and nitrogen will be imposed by the State regulatory agencies to protect their water resources. The designer must review the applicable State water quality standards before setting the treatment level or selecting the treatment processes.

3.1.4 Local regulations. In general, local governments do not specify requirements for wastewater treatment facilities. Construction of wastewater facilities must conform to applicable zoning and Occupational and Health Administration (OSHA) requirements.

3.2 Preliminary treatment. Preliminary treatment is defined as any physical or chemical process at the wastewater treatment plant that precedes primary treatment. Its function is mainly to protect subsequent treatment units and to minimize operational problems. Pretreatment at the source to render the wastewater acceptable at the domestic wastewater treatment facility is not included.

3.3 Primary treatment. Primary treatment is defined as physical or, at times, chemical treatment for the removal of settleable and floatable materials.

3.4 Secondary treatment. Secondary wastewater treatment is defined as processes which use biological and, at times, chemical treatment to accomplish substantial removal of dissolved organics and colloidal materials. Land treatment can be classified as secondary treatment only for isolated locations with restricted access, and when limited to crops which are not for direct human consumption.

3.5 Advanced treatment.

3.5.1 Definition. Advanced wastewater treatment is defined as that required to achieve pollutant reductions by methods other than those used in a conventional treatment (sedimentation, activated sludge, trickling filter, etc.). Advanced treatment employs a number of different unit operations, including ponds, post-aeration, microstraining, filtration, carbon adsorption, membrane solids separation, and specific treatment processes such as phosphorus and nitrogen removal.

3.5.2 Efficiency. Advanced wastewater treatment is capable of very high effectiveness and is used when necessary to meet strict effluent standards. Organics and suspended solids removal of over 90 percent is obtainable using various combinations of conventional and advanced wastewater treatment processes. Phosphorus levels of less than 1 milligram per liter and total nitrogen levels of 5.0 milligrams per liter or less can also be achieved through advanced treatment.

3.6 Evaluation of wastewater treatment processes. Table 3-2 provides a summarized evaluation of wastewater treatment processes. Tables 3-3 and 3-4 illustrate the applicable processes and their possible performance. All of the above will be used for guidance in selecting a process chain of treatment units, which applies directly to the selection of treatment processes.

Table 3-2
Evaluation of wastewater treatment processes

Treatment process	Application	Advantages and capabilities	Disadvantages and limitations
1. Preliminary			
a. Equalization	Waste streams with high variability	1. Dampens waste variations 2. Reduce chemical requirements 3. Dampens peak flows, reduces treatment plant size	1. Need large land areas 2. Possible septicity, requiring mixing and/or aeration
b. Neutralization	Waste streams with extreme pH values	1. Provides the proper conditions for biological, physical, chemical treatment 2. Reduces corrosion and scaling	1. May generate solids 2. Sophisticated equipment, instrumentation
c. Temperature adjustment	Waste streams with extreme temperatures	Provides proper conditions for biological treatment	High initial equipment costs
d. Nutrient addition	Nutrient deficient wastes	Optimizes biological treatment	
e. Screening	Waste streams containing large solids (wood, rags, etc.	1. Prevents pump and pipe clogging 2. Reduces subsequent solids handling	Maintenance required to prevent screen plugging. Ineffective for sticky solids.
f. Grit removal	Waste streams containing significant amounts of large, heavy, inorganic solids	Lower maintenance costs, erosion	Solids to be disposed of are sometimes offensive
2. Primary Treatment			
a. Sedimentation	Waste streams containing settleable suspended solids	1. Reduces inorganic and organic solids loadings in subsequent biological units 2. By far the least expensive and most common method of solid/liquid separation 3. Suitable for treatment of wide variety of wastes 4. Requires simpler equipment and operation 5. Demonstrated reliability as a treatment process	1. Possible septicity and odors 2. Adversely affected by variations in the nature of the waste 3. Moderately large area requirement
b. Dissolved air flotation	Waste streams containing oils, fats, suspended solids and other floatable matter. Can be used for both clarification and thickening.	1. Removes oils, greases and suspended solids 2. Less tank area than a sedimentation tank 3. Higher content of solids than sedimentation 4. Satisfies immediate oxygen demand. Maintains aerobic conditions.	High power and maintenance cost

Table 3-2 (continued)
Evaluation of wastewater treatment processes

Treatment process	Application	Advantages and capabilities	Disadvantages and limitations
3. Secondary Treatment			
a. Activated sludge (aeration and secondary sedimentation)	Biologically treatable organic wastes	1. Flexible --- can adapt to minor pH, organic, temperature changes 2. Produces high quality effluent---90%% BOD and suspended solids removal 3. Small area required 4. Available in package units 5. The degree of nitrification is controllable 6. Relatively minor odor problems	1. High operating costs (skilled labor, electricity) 2. Generates solids requiring sludge disposal 3. Some process alternatives are sensitive to shock loads, and metallic or other poisons 4. Requires continuous air supply
b. Aerated pond (with secondary sedimentation)	Biologically treatable organic wastes	1. Flexible --- can adapt to minor pH, organic and temperature waste changes 2. Inexpensive construction 3. Minimum attention 4. Moderate effluent (80-95% BOD removal	1. Dispersed solids in effluent 2. Affected by seasonal temperature variations 3. Operating problems (ice, solids settlement, etc.) 4. Moderate power costs 5. Large area required 6. No color reduction
c. Aerobic-anaerobic ponds	Biologically treatable organic wastes	1. Low construction costs 2. Non-skilled operation 3. Moderate quality effluent (80-95% BOD removal) 4. Removes some nutrients from wastewaters	1. Large land area required 2. Algae in effluent 3. Possible septicity and odors 4. Weed growth, mosquito and insect problems
d. Trickling filter	Biologically treatable organic wastes	1. Moderate quality effluent (80-95% BOD removal) 2. Moderate operating costs (lower than activated sludge and higher than oxidation pond) 3. Good resistance to shock loads	1. Clogging of distributors or beds 2. Small, mosquito and insect problems
e. Chemical oxidation [2]	Low flow, high concentration wastes of known and consistent waste composition, or removal of refractory compounds	1. Disinfects effluent 2. Aids grease removal 3. Removes taste and odor 4. Removes organics without producing a residual waste concentrate	1. Chemical cost 2. High initial equipment costs 3. Skilled operation 4. Requires handling of hazardous chemicals

Table 3-2 (continued)
Evaluation of wastewater treatment processes

Treatment Process	Application	Advantages and Capabilities	Disadvantages and Limitations
f. Chemical mixing flocculation and clarification	Waste stream high in dissolved solids, colloids, metals, or precipitable inorganics and waste containing emulsified oils	1. Removes metallic ions, nutrients, colloids, dissolved salts 2. Recovery of valuable materials 3. Provides proper conditions for biological treatment	1. Sophisticated equipment and instrumentation 2. Residual salts in effluent 3. Produces considerable sludge
g. Gravity filtration	Waste streams with organic or inorganic suspended solids, emulsions, colloids	1. Breaks emulsions 2. Removes suspended solids	1. Clogging 2. Frequent backwashing
h. Pressure filtration	Waste streams high in suspended solids (i.e. sludges, organic solids)	1. High solids removal (80-95%)	1. High pressure costs 2. Clogging 3. High pressure drop (power costs)
i. Dissolved-air flotation with chemicals	Waste streams containing oils, fats, colloids, and chemically coalesced materials	1. Produces high degree of treatment 2. Removes oils, greases	1. High initial equipment costs 2. High operations cost 3. Sophisticated instrumentation
j. Anaerobic contact	Waste streams with high BOD and/or high temperature	1. Methane recovery 2. Small area required 3. Volatile solids destruction	1. Heat required 2. Effluent in reduced chemical form requires further treatment 3. Sludge disposal 4. Requires skilled operation
4. Advanced Treatment			
a. Activated carbon adsorption	Waste streams containing trace amounts of organics and color-, taste- and odor-producing compounds	1. Removes nonbiodegradable organics from wastewaters 2. Removes taste and odor producing compounds 3. Reduces color	1. High equipment costs 2. Carbon costs – a. pH adjustment b. Initial carbon c. Make-up carbon 3. No inorganic removal 4. Wastes must be solid-free to prevent clogging 5. Air pollution potential when regenerating activated carbon
b. Micro straining filtration	Tertiary treatment	1. Up to 89% of suspended solids removed 2. Can produce final effluent of solids less than 10 mg/l	1. Very sensitive to solids overloading 2. Requires automatic controls, absorbent techniques

Table 3-2 (continued)
Evaluation of wastewater treatment processes

Treatment Process	Application	Advantages and Capabilities	Disadvantages and Limitations
c. Land treatment	“T” Biologically treatable wastes with low to moderate amounts of toxic substances	1. Inexpensive 2. Minimum operator attention, minimum sludge 3. Water conservation 4. Crop production 5. Very high quality effluent and/or in discharge	1. Large land area required 2. Possible contamination of potable aquifers 3. Freezing in winter 4. Odors in summer under some conditions; usually minor concern
d. Subsurface disposal (e.g. deep well injection)	Solids-free, concentrated waste streams	1. Disposal of inorganics and organics 2. Ultimate disposal of toxic or odorous materials	1. Subsurface clogging 2. Groundwater pollution 3. High maintenance and operation costs 4. Limited aquifer life 5. High initial costs
e. Groundwater recharge	Treated waste streams	1. Reduces bacterial concentration 2. Conserves water resources 3. Prevents salt water intrusion into potable aquifers	1. Possible groundwater contamination 2. Limited to porous formations
5. Sludge			
a. Anaerobic digestion	Biodegradable solids	1. Methane production 2. Solids stabilization and conditioning 3. Liquefaction of solids 4. Minimum land required 4. Use of digested sludge as fertilizer or soil conditioner	1. Heat required 2. Process upsets when excess volatile acids generated 3. Odors 4. Skilled labor 5. Explosion hazard
b. Aerobic digestion	Biological solids	1. Relatively little odor 2. Solids stabilization and conditioning 3. Unsophisticated operation	1. Moderate land area required 2. High energy usage 3. Reduced dewatering ability
c. Autoclaving	Biological solids	1. Compact operation 2. Solids conditioning 3. Kills microorganisms	1. High initial equipment costs 2. Power costs 3. Skilled labor
d. Elutriation	Sludges with high mineral content or high alkalinity	1. Enhances solids conditioning 2. Chemical savings	1. Large volumes of water of low alkalinity required

Table 3-2 (continued)
Evaluation of wastewater treatment processes

6. Sludge

Treatment Process	Application	Advantages and Capabilities	Disadvantages and Limitations
a. Vacuum filtration	Organic or inorganic sludges	1. Solids concentration 2. Compact equipment	1. High equipment, energy and maintenance costs 2. Skilled labor 3. Necessity for pretreatment (thickening and chemical addition) 4. Limited throughput
b. Centrifugation	Non-abrasive, non-corrosive sludges	1. Solids concentration 2. Compact equipment 3. Low chemical conditioning 4. High throughput	1. Equipment costs 2. Skilled labor 3. Energy costs
c. Sand beds (including wedge wire and vacuum assisted)	Organic or inorganic sludges	1. Solids concentration 2. Low chemical costs; polymer sometimes used	1. Land area required 2. Weather problems; a. Winter – freezing b. Summer – odor
d. Presses	Organic or inorganic sludges	1. Solids concentration 2. Compact equipment	1. High capital and operating costs 2. Precoat and chemical conditioning necessary 3. Not applicable for small quantities
7. Sludge Disposal			
a. Incineration (regular and fluidized)	Combustible organic sludges (25 – 33% solids)	1. Excellent sludge volume reduction 2. Kills biological organisms 3. Possible by-product recovery a. Heat b. Valuable metals	1. High equipment costs 2. Fuel and power costs 3. Air pollution potential 4. Ash disposal required 5. Sophisticated equipment
b. Wet oxidation	Combustible organic sludges (3 - 10% solids)	1. Produces easily handled product 2. Kills biological organisms 3. Possible by-product recovery 4. Conditioning prior to other disposal techniques	1. High initial costs 2. Fuel and power costs 3. High organic concentration in effluent stream
c. Land disposal	Stable biological sludge	1. Low investment 2. Postpones ultimate sludge disposal process installation, or 3. Provides ultimate disposal if land is available	1. Large land area required

Table 3-2 (continued)
Evaluation of wastewater treatment processes

Treatment Process	Application	Advantages and Capabilities	Disadvantages and Limitations
d. Sanitary landfill	Dewatered biological sludges (30 – 35% solids)	1. Low investment 2. Suitable for undigested sludges, odorous or toxic materials 3. Land reclamation	1. Groundwater contamination 2. Requires cover material and compaction 3. Hauling costs

(1) Effluent quality cited cannot consistently be obtainable during some seasonal periods of the year.
(2) This process is also applicable for advanced waste treatment.
Note: The individual processes listed and standing alone do not constitute secondary treatment or advanced treatment.

Table 3-3
Approximate performance data for various wastewater processes (1)

Process	Constituent, effluent from process, mg/L						Waste for ultimate disposal
	ss (4) (200)	**BOD (4) (200)**	**COD (4) (450)**	**N (4) (30)**	**NH_3 (4) (15)**	**P (4) (10)**	
Imhoff tank	80	120	350	25	15	9	Sludge
Rotating biological disks	25	13	100	20	5	7	Sludge
Trickling filter processes:							
Conventional (low rate)	25	18	100	20	1	7	Sludge
Conventional (high rate)	30	20	100	25	15	7	Sludge
Tower filter	30	20	100	25	15	7	Sludge
Activated sludge process:							
Complete mix	20	15	90	20	12	7	Sludge
Contact stabilization	20	15	90	20	12	7	Sludge
Extended aeration	20	15	90	15	2	7	Sludge
Aerated lagoon (with settling)	20	15	90	25	2	7	Sludge
Oxidation ditch (with settling)	20	15	90	25	2	7	Sludge
Stabilization pond processes:							
Aerobic (aerated)	170	60	200	25	1	9	Sludge (3)
Aerobic-anaerobic (natural aeration)	120	40	150	15	1	4	Sludge (3)
Aerobic-anaerobic (partial mechanical aeration)	90	25	140	15	1	4	Sludge (3)
Anaerobic (2)	100	40	140	15	1	4	Sludge (3)
Land treatment processes:							
Slow rate	2	4	80	5	1	0.5	
Overland flow	4	6	90	10	4	4	
Rapid infiltration	2	4	50	10	1	0.5	

(1) Under ideal conditions
(2) Usually followed by aerobic or facultative ponds
(3) Following pretreatment
(4) Concentration in incoming wastewater, mg/L

Table 3-4
Operational characteristics of various treatment processes

Process Characteristics	Rotating Disk	Trickling Filters	Activated Sludge	Wastewater Treatment Ponds	Land Treatment
Reliability with respect to:					
Basic process	Good	Good	Good	Good	Excellent
Influent flow variations	Fair	Fair	Fair	Good	Good
Influent load variations	Fair	Fair	Fair	Good	Good
Presence of industrial waste	Good	Good	Good	Good	Good
Industrial shock loadings	Fair	Fair	Fair	Fair	Good
Low temperature (20 deg C)	Sensitive	Sensitive	Good	Very sensitive	Good (to 0 deg C)
Expandability to meet:					
Increased plant loadings	Good; must add additional disk module	Limited (stone may be replaced by synthetic media)	Fair to good, if designed conservatively	Fair; additional ponds required	Good
More stringent discharge requirements with respect to:					
Suspended solids	Good; add filtration or polishing ponds	Good; add filtration or polishing ponds	Good; add filtration or polishing ponds	Add additional solids removal unit	Excellent
BOD	Improved by filtration	Improved by filtration	Improved by filtration	Improved by solids removal	Excellent
Nitrogen	Good; denitrification must be added	Good; denitrification must be added	Good; denitrification must be added	Fair	Excellent
Operational complexity	Average	Average	Above average	Below average	Below average
Ease of operation and maintenance	Very good	Very good	Fair	Good	Excellent
Power requirements	Moderate	Low	High	Low to high	Moderate
Waste products	Sludges	Sludges	Sludges	Sludges	---
Potential environmental impacts	Odors	Odors	---	Odors	---
Site Considerations					
Land area requirements	Moderate, plus buffer zone	Moderate, plus buffer zone	Moderate, plus buffer zone	Large, plus buffer zone	Large, plus buffer zone
Topography	Level	Level to moderately sloped	Level	Level	Level to moderately sloped

4. BASIC DESIGN CONSIDERATIONS

4.1 General. The required treatment is determined by the influent characteristics, the effluent requirements, and the treatment processes that produce an acceptable effluent. Influent characteristics are determined by laboratory testing of samples from the waste stream or from a similar waste stream, or are predicted on the basis of standard waste streams. Effluent quality requirements are set by Federal, interstate, State, and local regulatory agencies. Treatment processes are selected according to influent-effluent constraints and technical and economic considerations.

4.2 Design population. Treatment capacity is based on the design population, which is the projected population obtained by analysis. The design population is determined by adding the total resident and one-third the non-resident populations and multiplying by the appropriate capacity factor (taken from Table 4-1 for smaller communities), which allows for variations in the using population. The resident population is determined by adding the following:

Table 4-1
Capacity Factors

Effective Population	Capacity Factor
Under 5,000	1.50
5,000	1.50
10,000	1.25
20,000	1.15
30,000	1.10
40,000	1.05
50,000	1.00

4.3 Estimating future service demand.

4.3.1 Nature of activities. The nature of the activities in a community is a very important factor in determining per capita waste loads because different activities have different water uses. Table 4-2 illustrates this fact in terms of gallons per capita per day (gpcd); Table 4-3 shows how waste loadings vary between resident and non-resident personnel. The values shown in Table 4-3, for that portion of the contributing population served by garbage grinders, will be increased by 30 percent for biochemical oxygen demand values, 40 percent for oil and grease, and 100 percent for suspended solids. Contributing compatible industrial or commercial flows must be evaluated for waste loading on a case-by-case basis.

Table 4-2
Example of per capita sewage flows

Type of facility	**Residents (gpcd)**	
	Permanent	**Non-residents**
Hospitals	300-600	100
All other residential	100	35

Note: Add 30 gallons per 8-hour work shift for non-residents

Table 4-3
Example of sewage characteristics

Item	**Residents (lb/capita for 24 hours)**	**Non-residents (lb/capita for 24 hours)**
Suspended solids	0.20	0.10
Biochemical oxygen demand	0.20	0.10
Oil and grease	0.09	0.05

4.4 Volume of wastewater.

4.4.1 Variations in wastewater flow. The rates of sewage flow at military installations vary widely throughout the day. The design of process elements in a sewage treatment plant is based on the average daily flow. Transmission elements, such as conduits, siphons and distributor mechanisms, will be designed on the basis of an expected peak flow rate of three times the average rate. Clarifiers will be designed for a peak hourly flow rate (i.e., 1.75 times the average daily rate). Consideration of the minimum rate of flow is necessary in the design of certain elements, such as grit chambers, measuring devices and dosing equipment. For this purpose, 40 percent of the average flow rate will be used.

4.4.2 Average daily wastewater flow. The average daily wastewater flow to be used in the design of new treatment plants will be computed by multiplying the design population by the per capita rates of flow determined from Table 4-2, and then adjusting for such factors as industrial wastewater flow, stormwater inflow and infiltration. Where shift personnel are engaged, the flow will be computed for the shift when most of the people are working. A useful check on sewage volumes is to compare water consumption to the sewage estimate (neglecting infiltration which will be considered subsequently). About 60 to 80 percent of the consumed water will reappear as sewage, the other 20-40 percent will be lost to irrigation, fire-fighting, washdown, and points of use not connected to the sewer.

4.4.2.1 Good practice requires exclusion of stormwater from the sanitary sewer system to the maximum practical extent. Infiltration must also be kept to a minimum. Both must be carefully analyzed and the most realistic practical quantity that can be used in design must be assigned to these flows. Leakage of stormwater into sewer lines often occurs through manhole covers or collars, but this is usually no more than 20 to 70 gallons per minute if manholes have been constructed and maintained properly. However, leakage into the sewer mains and laterals through pipe joints and older brick manholes, with increase in groundwater levels, can result in large infiltration. The amount of water that actually percolates into the groundwater table may be negligible if an area is occupied by properly guttered buildings and paved areas, or if the subsoil is rich in impervious clay. In other sandy areas, up to 30 percent of rainfall may quickly percolate and subsequently lift groundwater levels. Infiltration rates have been measured in submerged sewer pipes. Relatively new pipes with tight joints still displayed infiltrations at around 1,000 gallons per day per mile, while older pipes leaked to over 40,000 gallons per day per mile. Sewers built first usually followed the contour of water courses and are often submerged while more recent sewers are not only tighter, but are usually built at higher elevations as the system has been expanded. In designing new treatment facilities, allow for infiltration. Utilize existing flow records, sewer flow surveys, and examine the correlation between recorded flows and rainfall data to improve the infiltration estimates. The economic feasibility of improving the collection system to reduce the rate of infiltration should be considered.

4.4.2.2 Another method for calculating the infiltration component of total flow is to multiply the miles of a given pipe size and condition by the diameter in inches and to sum the inch-miles. The sum of inch-miles of the pipe estimated according to conditions is then multiplied by factors between 250 and 500 to obtain gallon/day. If infiltration is known to be negligible at manholes, then an infiltration allowance may be calculated based upon the area served and Figure 4-1. Curve A should be used for worst conditions when pipes are old and joints are composed of jute or cement. Curve B applies to old pipes with hot or cold asphaltic joints or for new pipes known to have poor joints. Curve C is used for new sewers where groundwater does not cover inverts and when joints and manholes are modern and quite tight. Of course, field tests may be conducted to closely estimate infiltration.

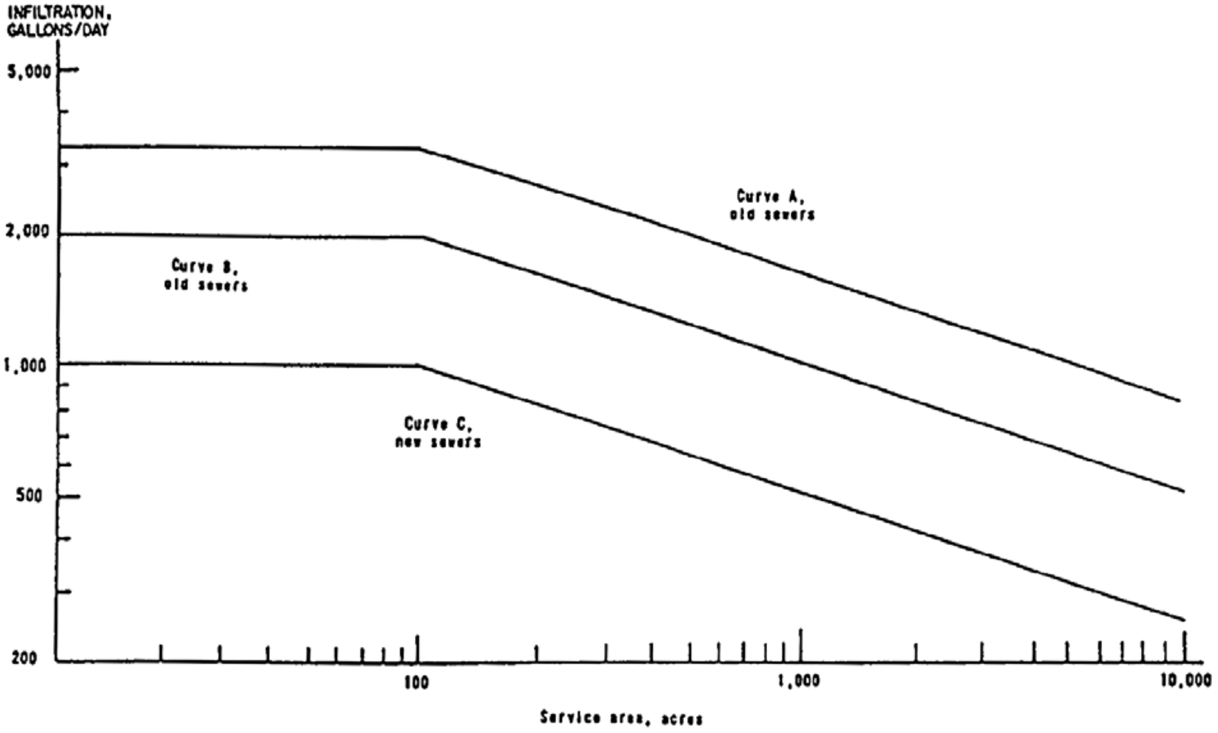

Figure 4-1
Infiltration allowances

4.4.2.3 Average wastewater flow is usually expressed in million gallons per day, but will be calculated in the appropriate units for the design of the unit process under consideration.

4.4.3 Contributing populations. In calculating contributing populations, use 3.6 persons per family residential unit. In hospitals, count the number of beds, plus the number of hospital staff eating three meals at the hospital, plus the number of shift employees having one meal there. This total is the number of residents to be used in the design calculations. Individuals will be counted only once, either at home or at work. The capacity factor still applies in calculating design populations.

4.4.4 Industrial flow. Industrial wastewater flows will be minimal at most military installations. When industrial flows are present, however, actual measurement is the best way to ascertain flow rates. Modes of occurrence (continuous or intermittent) and period of discharge must also be known. Typical industrial discharges include wastewaters from the following:

— wastewater treatment plant itself
— maintenance facilities
— vehicle wash areas
— weapons cleaning buildings
— boiler blowdowns
— swimming pool backwash water
— water treatment plant backwash
— cooling tower blowdown
— fire fighting facility
— photographic laboratory
— medical or dental laboratories

4.4.5 Stormwater flow. Including stormwater flows in treatment plant design is important either when combined sewer systems are served or when significant inflow enters the sewer system. Separate sewers are required in new systems and only sanitary flows are to be routed through treatment plants. For existing plants that are served by combined sewer systems, capacities will be determined by peak wet-weather flow obtained from plant flow records. In the absence of adequate records, hydraulic capacities of four times the dry-weather flow will be used in the design.

4.5 Population equivalents. Suspended solids and organic loading can be interpreted as population equivalents when population data constitute the main basis of design. Typical population equivalents are given in Table 4-3. These equivalent values can also be used to convert non-domestic waste loads into population design values. The effects of garbage grinding will be incorporated into population-equivalent values when applicable. The waste stream to be treated at existing military installations should, when feasible, be characterized. This actual data should be used in the design.

4.6 Capacity factor. A capacity factor (CF) taken from Table 4-1 is used to make allowances for population variation, changes in sewage characteristics, and unusual peak flows. The design population is derived by multiplying the actual population (called the effective population) by the appropriate capacity factor. Where additions are proposed, the adequacy of each element of the plant will be checked without applying the capacity factor. When treatment units are determined to be deficient, then capacity factors should be used to calculate the plant capacity required after expansion. However, the use of an unnecessarily high CF may dilute waste sufficiently enough to adversely affect some biological processes. If the area served by a plant will not, according to the best current information, be expanded in the future, the capacity factor should not be used in designing treatment components in facilities serving that area. The following equation (Eq 4-1) may be used to estimate total flow to the sewage plant where domestic, industrial and stormwater flows are anticipated.

$$x = a + b \qquad \text{(Eq 4-1)}$$

Where:

x = Total flow to sewage plant

a = Flow from population (effective population × 100 gpcd × capacity factor)

b = Infiltration + industrial wastewater + stormwater (4 × dry-weather flow)

4.7 Wastewater characteristics.

4.7.1 Normal sewage. The wastewater at existing facilities will be analyzed to determine its characteristics and constituents as required. Analytical methods will be as given in the current edition of the American Public Health Association (APHA) publication, *Standard Methods for the Examination of Water and Wastewater* and as approved by the Environmental Protection Agency (EPA). For treatment facilities at new installations, which will not generate any unusual waste, the treatment will be for normal domestic waste with the following analysis:

- pH 7.0 std units
- Total solids 720 mg/L
- Total volatile solids 420 mg/L
- Suspended solids 200 mg/L
- Settleable solids 4 ml/L
- BOD 200 mg/L
- Total nitrogen 30 mg/L
- Ammonia nitrogen 15 mg/L
- Oils and grease 100 mg/L
- Phosphorus 10 mg/L
- Chloride 50 mg/L

Concentrations presented above are in milligrams per liter which is equivalent to parts per million (ppm). These values represent an average waste; and therefore, should only be used where detailed analysis is not available. When the water supply analysis for the installation is known, the above analysis will be modified to reflect the normal changes to the constituents in water, as they arrive at the wastewater treatment plant. Changes will be as follows:

- P in water supply + 12 mg/L = P in plant influent;

- Cl in water supply + 8 mg/L = Cl in plant influent;
- Total nitrogen in water supply + 12 mg/L = Total nitrogen in plant influent.

4.7.2 Non-domestic loading. Non-domestic wastes are stormwater, infiltration, and industrial contributions to sewage flow. Stormwater and infiltration waste loadings can be determined by analyses of the constituents of normal sewage, as presented in the previous section. For these types of flows, the major loading factors are suspended solids, biochemical oxygen demand, and coliform bacteria.

4.7.3 Industrial loading. Industrial waste loadings can also be characterized to a large extent by normal sewage parameters. However, industrial waste contains contaminants not generally found in domestic sewage and is much more variable than domestic sewage. This is evident in terms of pH, biochemical oxygen demand, chemical oxygen demand, oil and grease, and suspended solids. Other analyses (e.g., heavy metals, thermal loading, and dissolved chemicals) may also be necessary to fully characterize an industrial waste. Each industrial wastewater must be characterized individually to determine any and all effects of the treatment processes.