CHAPTER 8

SYSTEM ALTERNATIVES AND PERFORMANCE

8-1. Introduction

This chapter will discuss system alternatives and performance data for wastewater treatment and solids handling systems commonly used for military installations. Information and descriptive data on available unit operations and processes have been included and are presented herein to enable the establishment of sound engineering and economic relationships among alternatives. This chapter principally addresses domestic treatment methods with notations concerning the impact of industrial or military wastes. Theoretical and design factors are not covered and reference should be made to textbooks and the U.S. EPA design manuals listed in the bibliography for more detailed description of wastewater treatment methods and limitations. Appendices C and D present design and cost factors also.

8-2. Wastewater treatment systems

a Treatment system alternatives.

(1) Treatment evaluations. For some installations, certain alternatives may readily be excluded from consideration due to climate, land requirements, flow quantity and other factors. Most installations, however, will require evaluation of several treatment alternatives to either upgrade existing systems or provide new facilities. The treatment alternatives presented herein are proven methods which are most practical for wastes from military installations. Many other processes have been tried or are in use at other than military installations and some are currently in the technical development stage. Authority to deviate from using the proven methods in this section must be obtained from HQDA (DAEN-ECE-G) WASH DC 20314.

(2) Treatment alternatives. Wastewater treatment methods which shall be considered for military wastes are categorized in figure 8-1. System alternatives are arranged by increasing degree of treatment:

–Preliminary.
–Primary.
–Secondary.
–Advanced.

Within each of the broad treatment classifications, there is a listing of principal unit processes. These represent those alternatives most generally applicable to military facilities. Combinations of processes can be arranged to effect the desired degree of treatment.

(3) Size of installations requiring treatment. Specific data are not presented in this manual on the sizes and types of unit processes or operations employed at Army installations, but statistical data indicate over one-half of the Army installations are receiving less than 1.0 mgd of wastewater flow. Table 8-1 shows that less than 2 percent exceed 10.0 mgd. These data are based on all reported Army installations including both domestic and industrial wastewater sources, government-owned, government-operated (GOGO), at U.S. as well as overseas facilities. The intent of this information is to classify the size range of existing facilities and thus determine which unit processes or operations must receive emphasis on the basis of size alone. It is apparent that processes applicable to small installations will predominate (97).

Table 8-1. Classification of Army facilities by wastewater flow

Average Wastewater Flow Category mgd	Number of Facilities In Category	As Percent of Total
0.1	14	10.8
0.1-1.0	61	47.3
1.0-10.1	52	40.3
10.0	2	1.6
	129	100.0

(4) Type of installations requiring treatment. These are five basic types of military installations, all of which require different considerations for wastewater treatment.

(a) Large camps-equivalent to a Division plus families and day workers; usually have year-round domestic flows in the *2* to 5 mgd range.

(b) Summer training camps-Division size load during the summer; very small flows in winter.

(c) Reserve training centers–about one week per month may have up to 600 personnel; other times, only 5 to 10.

(d) Army depots–essentially warehouse operations; up to about 1000 personnel, including families; relatively steady year-round flows.

(e) Industrial installations-small domestic flows.

(5) Degree of treatment required. Under Executive Order 12088, Federal agencies must en-

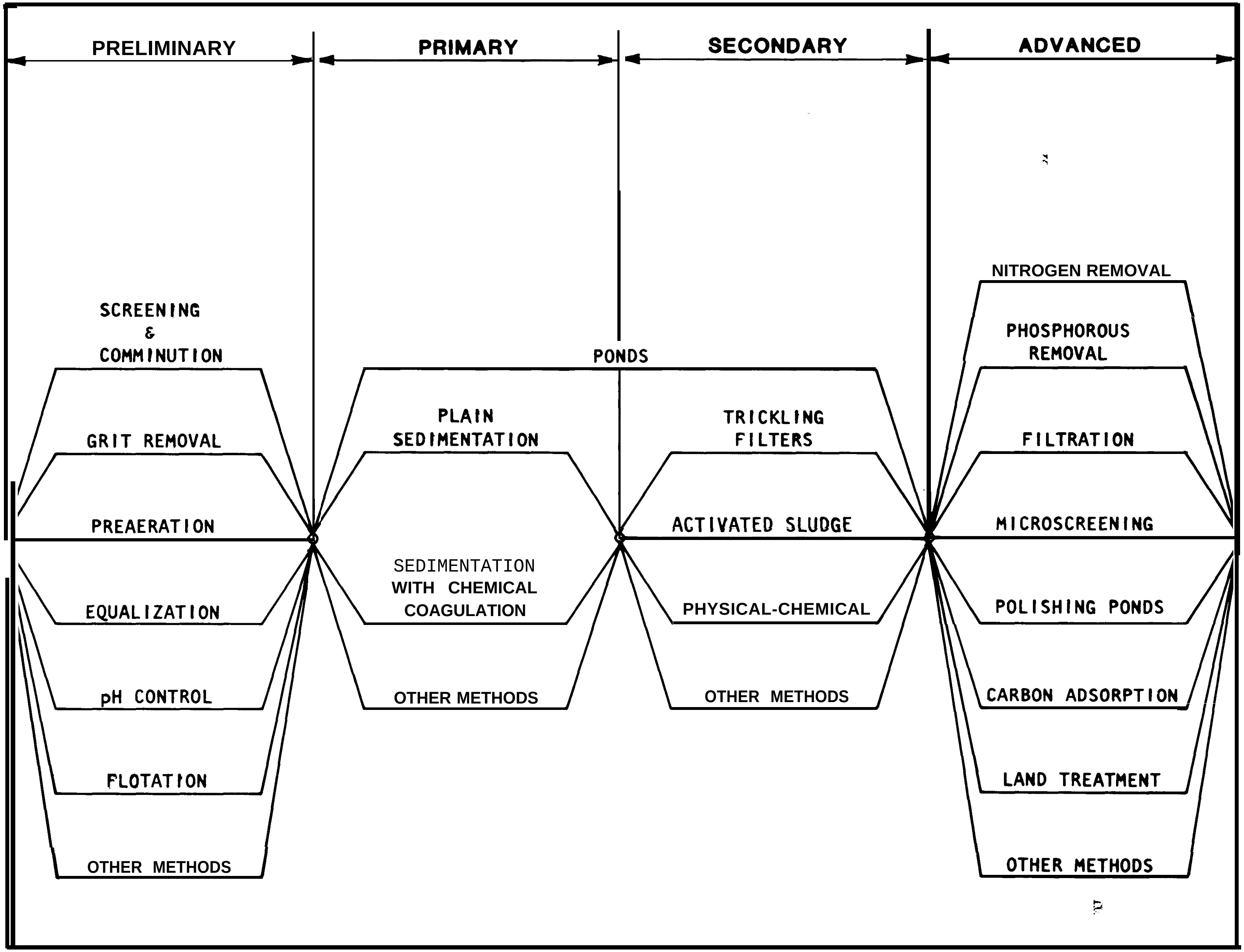


Figure 8-1. Alternative wastewater treatment processes for military installations.

sure that their facilities are designed, constructed, managed, operated and maintained to conform with Federal, State, interstate and local water quality standards and effluent limitations. These standards are or will be established in accordance with the Federal Water Pollution Control Act, as amended. All the U.S. EPA wastewater treatment requirements in furtherance of the Act have not yet been established. Treatment requirements for some industrial categories have been delayed due to lack of developed technology; however, pertinent U.S. EPA regulations should be investigated for specific details at a particular location. The U.S. EPA has set effluent limitations for publicly-owned and industrial wastewater treatment facilities. Interpretation of these requirements as they apply to military installations is as follows:

(a) Military installations which provide wastewater treatment for principally domestic sources will be required to meet criteria as set forth for publicly-owned facilities.

(b) Military installations which generate industrial or process wastewaters will be required to meet either limitations set forth by that specific industrial classification or limitations formulated by the U.S. EPA for that class of Federal facility.

b. System performance.

(1) Introduction. For the flow schemes presented in table 8-2, typical concentrations of important wastewater constituents are given following various stages of treatment. These concentrations shall serve only as a general guide for preliminary planning purposes. It is emphasized that wastewater concentrations, both raw and treated at various stages, may vary widely from those shown for a specific military installation. In many cases, bench or pilot studies will be necessary to predict the unit process loadings and removal efficiencies that would be used in final design. The wastewater treatment alternatives shown in table 8-2 include treatment processes designed to convert or remove various forms of the following constituents:

–Carbonaceous BOD.
–Suspended solids.
–Nitrogen.
–Phosphorus.

(2) Preliminary and primary treatment. Primary sedimentation will remove a significant fraction of the suspended solids in the raw wastewater. It also removes the insoluble BOD, nitrogen (primarily organic nitrogen), and phosphorus associated with the removed suspended solids.

(3) Secondary treatment. Secondary biological treatment will convert most of the soluble and nonsettleable organic material into biological cell mass. In the process, much of the organic nitrogen will be converted to ammonia. A small fraction of the nitrogen, as well as a portion of the phosphorus, will be tied up in the biological cell mass. The degree of bio-flocculation of the cell mass will determine the efficiency of suspended solids removal in the final sedimentation step. The activated sludge system achieves better bio-flocculation than the trickling filter process; therefore, suspended solids in the final effluent from an activated sludge system are generally lower than a trickling filter system.

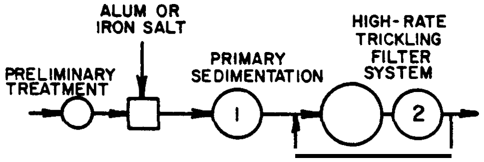
(4) Advanced treatment.

(a) Filtration. Filtration of a secondary effluent will reduce suspended solids considerably. The BOD is also lowered by the amount due to the suspended solids in the secondary effluent. Usually the soluble BOD in a secondary effluent is below 10 mg/L, so the majority of the BOD is exerted by the suspended organic material. Again, trickling filter system effluents are not as well flocculated as activated sludge system effluents; therefore, multi-media filtered effluents from trickling filters will contain higher suspended solids than filtered effluents from an activated sludge system.

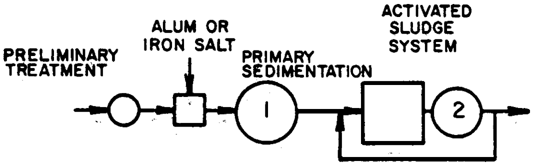
(b) Vitrification. Little vitrification takes place in either the high rate trickling filter or activated sludge process at normal design loadings. To assure good vitrification, a second stage trickling filter system or suspended growth nitrification system should be employed. These systems can reduce ammonia to about 2 to 4 mg/l, and will also result in a reduction in the carbonaceous BOD.

(c) Phosphorus removal. Phosphorus removal may be accomplished by mineral or lime addition to the primary sedimentation tank, lime clarification of the secondary effluent, or addition of lime or minerals to the final clarifier of trickling filter systems. Side benefits of these processes are suspended solids removal along with removal of nitrogen and carbonaceous BOD associated with the suspended solids. Mineral addition to the primary sedimentation tank is the least expensive process where phosphorus removals of less than 90 percent are required. Bench or pilot studies are necessary to determine the best chemicals to use as well as the required chemical dosage. Lime clarification of the secondary effluent is the process to use if high degrees of phosphorus removal are required. With low alkalinity wastewaters, a two-stage lime clarification

Table 8-2. Performance of typical wastewater treatment system alternatives

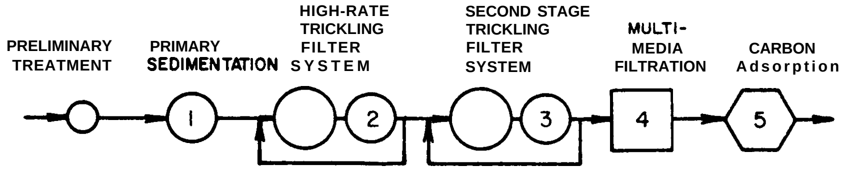


Constituent	Influent Concentration (mg/L)	Concentrations Following Treatment Units (mg/L)	
		1	2
BOD	300	150	40
Suspended Solids	300	90	40
Phosphate (as P)	20	4	2
Ammonia (as N)	25	25	22
Organic Nitrogen (as N)	25	10	4
Nitrate (as N)	0	0	5

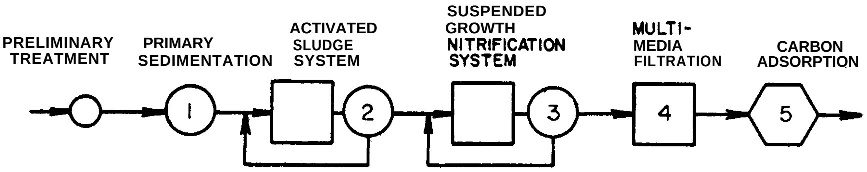


		1	2
BOD	300	150	25
Suspended Solids	300	90	25
Phosphate (as P)	20	4	2
Ammonia (as N)	25	25	26
Organic Nitrogen (as N)	25	10	3
Nitrate (as N)	0	0	2

Table 8-2 (Cent'd). Performance of typical wastewater treatment system alternatives

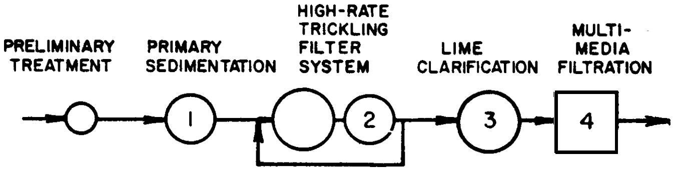


Constituent	Influent Concentration (mg/L)	Concentrations Following Treatment Units (mg/L) 1	2	3	4	5
BOD	300	195	45	25	10	2
Suspended Solids	300	120	50	30	10	10
Phosphate (as P)	20	18	14	12	11	11
Ammonia (as N)	25	25	26	4	4	4
Organ i c Nitrogen (as N)	25	15	5	3	1	1
Nitrate (as N)	0	0	4	27	27	27

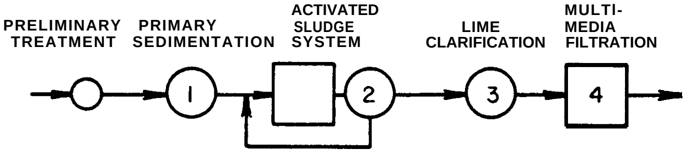


		1	2	3	4	5
BOD	300	195	30	15	5	1
Suspended Solids	300	120	30	20	3	3
Phosphate (as P)	20	18	14	13	11	11
Ammonia (as N)	25	25	30	3	3	3
Organ i c Nitrogen (as N)	25	15	4	2	1	1
Nitrate (as N)	0	0	1	29	29	29

Table 8-2 (Cent'd). Performance of typical wastewater treatment system alternatives

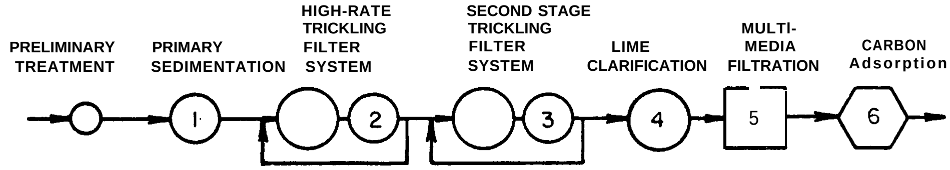


Constituent	Influent Concentration (mg/L)	Concentrations Following Treatment Units (mg/L)			
		1	2	3	4
BOD	300	195	45	20	10
Suspended Solids	300	120	50	20	2
Phosphate (as P)	20	18	14	2	1
Ammonia (as N)	25	25	26	24	24
Organic Nitrogen (as N)	25	15	5	2	1
Nitrate (as N)	0	0	4	4	4

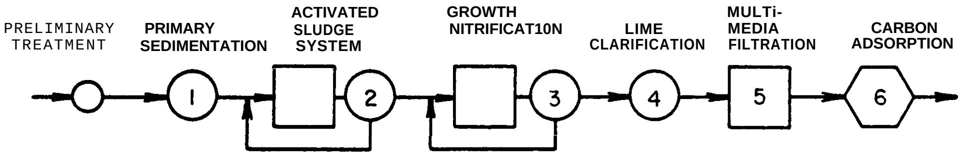


		1	2	3	4
BOD	300	195	30	10	5
Suspended Solids	300	120	30	15	2
Phosphate (as P)	20	18	14	2	1
Ammonia (as N)	25	25	30	28	28
Organic Nitrogen (as N)	25	15	4	2	1
Nitrate (as N)	0	0	1	1	1

Table 8-2 (Cent'd). Performance of typical wastewater treatment system alternatives

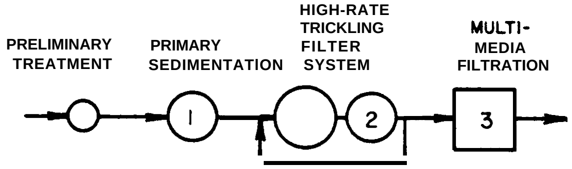


Constituent	Influent Concentration (mg/L)	Concentrations Following Treatment Units 1	2	3 (mg/L)	4	5	6
BOO	300	195	45	25	10	7	2
Suspended Solids	300	120	50	30	15	1	1
phosphate (As P)	30	18	14	12	2	1	1
Ammonia (as N)	25	25	26	4	4	4	4
Organic Nitrogen (as N)	25	15	5	3	2	1	1
Nitrate (as N)	0	0	4	27	27	27	27

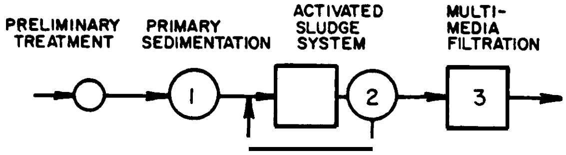


		1	2	3	4	5	6
BOD	300	195	30	15	5	4	1
Suspended Solids	300	120	30	20	10	1	1
Phosphate (as P)	30	18	14	13	2	1	1
Ammonia (as N)	25	25	30	3	3	3	3
Organic Nitrogen (as N)	25	15	4	2	2	1	1
Nitrate (as N)	0	0	1	29	29	29	29

Table 8-2 (Cont'd). Performance of typical wastewater treatment system alternatives



Constituent	Influent Concentration (mg/L)	Concentrations Following Treatment Units 1	2	3(mg/L)
BOO	300	195	45	15
Suspended Solids	300	120	50	15
Phosphate (as P)	20	18	14	12
Ammonia (as N)	25	25	26	26
Organic Nitrogen (as N)	25	15	5	1
Nitrate (as N)	0	0	4	4



		1	2	3
BOD	300	195	30	10
Suspended Solids	300	120	30	6
Phosphate (as P)	20	18	14	12
Ammonia (as N)	25	25	30	30
Organic Nitrogen (as N)	25	15	4	1
Nitrate (as N)	0	0	1	1

process may be necessary. The need for a single-stage or two-stage process along with required lime dosages can only be determined from bench or pilot studies. Filtration of a lime clarified secondary effluent will generally result in effluent phosphorus concentrations less than 1 mg/L because of the removal of phosphorus tied up with the suspended solids in the effluent from lime clarification (142).

(d) Additional suspended solids and organic removal. Various combinations of lime clarification and/or filtration can reduce wastewater BOD to the 5 to 10 mg/L range, and suspended solids to 1 mg/L or less. In order to get the BOD below 5 mg/L, it is almost always necessary to use a granular carbon adsorption step. Carbon will adsorb most of the soluble organic compounds that cause the remaining BOD. A properly designed and operated carbon adsorption step can reduce the final wastewater BOD to as low as 1 to 2 mg/L.

(e) Land treatment. An alternative to the several mechanical treatment processes following secondary treatment in table 8-2 is land application. Many military installations which have considerable land of the proper soil characteristics may find that land treatment is a cost-effective alternative. With proper site location and operation, disposal of a secondary-treated effluent to the land will provide treatment equivalent to or better than that from a carbon adsorption system or other mechanical facilities.

8-3. Effluent discharge alternatives

a. Surface water. Analysis of the impact of wastewater discharge on the receiving surface water (stream, lake, ocean, estuary) requires information on a number of parameters for proper formulation. For example, the impact of a discharge on the oxygen resources requires knowledge of the deoxygenation rate of the wastewater; reaeration rate of the stream; physical characteristics of the stream including flows, geometry and velocities; stream and waste temperatures; quality of the stream prior to discharge; and characteristics of other waste discharges along the stream. Methods for analyzing the impact of effluents discharged to surface waters are well documented (43)(147)(149). The impact of constituents other than those which affect oxygen can be evaluated using some of the same analytical techniques as indicated for oxygen. Normally in the U. S., State and Federal pollution control regulatory agencies will provide performance criteria for treatment which negates the need for extensive stream surveys. In foreign locations, however, more analyses of the impact of an effluent on the stream may be necessary.

b. Land application. Land treatment can be an effective means of providing advanced treatment for secondary effluents and shall be considered for military installations requiring a high degree of treatment. Approaches for spreading treated effluent on the land can be classified as either rapid infiltration-percolation, overland flow, or spray irrigation. Evaluation, design and costing methods for land application are available (53)(71)(72)(126). Regulatory agencies should be consulted for specific project applications.

(1) Rapid infiltration-percolation. This method consists of dosing spreading basins on an intermittent basis to maintain high infiltration rates. The main portion of the wastewater enters the groundwater after filtering and treatment by the soil, although there is some loss to evaporation. Soils are usually deep, permeable types such as coarse textured sands, silty sands or sandy silts.

(2) Overland flow. This technique is the controlled discharge, by spraying or other means, of effluent onto the land with a large portion of the wastewater appearing as run-off. Soils suited to overland flow are clays and clay silts with limited drainability. The land for an overland flow treatment site should have a moderate slope. In the U. S., overland flow has been developed mainly for treatment for high-strength wastewater, such as that from canneries. This process has not been extensively used for the treatment of domestic wastewater in the U. S., although Australia has used it for this purpose for a number of years, with BOD and suspended solids removals of about 95 percent.

(3) Spray irrigation. This process is the controlled discharge of secondary treated effluent, by spraying on land to support plant growth. Maximum amounts of wastewater consistent with crop yields may be applied. Although overland flow and infiltration-percolation may have merit under special circumstances, irrigation is probably the best method for application to different soil types and cultural practices. In addition, irrigation maximizes nutrient benefits of the wastes. However, precautions and safeguards against contamination by aerosol dispersion of pathogenic organisms or viruses by spray application is necessary (7).

(4) Design considerations. Some factors to be considered when evaluating the applicability of an irrigation system are the amount of available land, the need for reclaimed water, wastewater characteristics and flow rates, and type of soil at

available sites. Other factors which are important in site selection include climate, soil characteristics and depth, topography, and hydrologic and geologic considerations. For land treatment applications, the equivalent of secondary treatent should be provided. Normally, the chlorinated effluent from existing ponds or trickling filters at military installations can be applied to the land without further treatment.

(a) Hydraulic capacity. Whenever possible, the site should be selected so the pollutant removal capacity of the soils is the limiting factor rather than the hydraulic capability. This will minimize the land area needed. The hydraulic capacity will vary with each site since it is dependent upon the type of soil, local precipitation and whether or not underdrains are provided. Where agricultural crops are the means by which the wastewater effluent is reused, an application rate of about two inches per week seems to be a controlling factor. The local precipitation, winter climate, type of crops and soils all dictate the proper schedule and the area of land needed for land application.

(b) Nitrogen capacity. One of the aspects of wastewater irrigation that is not well defined is the allowable nitrogen loading. Some nitrogen is evaporated during application, the soil can eliminate some, the crops can utilize a portion, but nitrates can still be transported to the groundwater. The acceptable nitrogen loading rate depends upon the type of soil and crop. It is often necessary to limit the nitrogen loading to the amount that crops can assimilate in certain types of soil. This may require a reduction in the liquid loading rate in some areas and at certain times of the year.

(c) Phosphorus capacity. Some limitations on long term use of sites for land treatment may develop from the phosphorus balance. The soil can accumulate a certain amount, but after a period of time phosphorus will leach with the renovated water. Special soil surveys are needed to assess the life of a site when the phosphorus loading is considered.

(d) Organic capacity. The biodegradable organics measured by the BOD test can be almost totally removed by the soil matrix. This overall removal generally occurs in the upper 5 to 6 inches of soil, and the major filtration often occurs in the top few centimeters.

(e) Beneficial use. In climatic zones where irrigation is required, land application of effluents from military installations handling primarily domestic wastes is quite feasible. In areas where irrigation is of less benefit, the need for an economic and feasible alternative to surface water disposal is an important factor for considering land applications.

c. *Other.* Several other methods of effluent discharge are available depending on the circumstances at particular military installations. At facilities needing large quantities of cooling water, reuse of a well-treated (secondary) wastewater for such purposes is often practical. Similarly, water reuse occurs indirectly when discharge is to a stream rather than to the land. Reuse is also practiced quite often when treated effluents are used to spray golf courses, park facilities, and other such areas which may exist at military installations. In arid areas, effluent discharge may approach zero with proper use of evaporation ponds. Some wastewater treatment facilities now utilize this technique of evaporation for final effluent disposal. Both water reuse evaporation methods should be considered in planning pollution control programs at military installations.

8-4. Solids handling systems

a. System alternatives. A line diagram of the sludge handling and disposal systems which should receive consideration at military installations is presented as figure 8-2. The sludge handling steps are arranged in sequential order from left to right with various alternatives under each major step. These systems are discussed in this section and figure 8-1 shows the system which is applicable to most military installations considering the size and existing facilities. Available references (55) and (125) can provide a comprehensive summary on detailed design criteria and extensive bibliographies on sludge handling. Some design criteria are summarized in appendix B for sludge handling processes that can be utilized to make preliminary cost-effective comparisons with cost curves presented in appendix A.

b. Existing systems. Military facilities commonly have existing sludge handling facilities consisting of anaerobic digestion plus dewatering and landfill or land spreading disposal. These handle settled solids from primary units or the combined solids from both primary and secondary units. Evaluations of facility upgrading must consider the interrelationship of the existing liquid and solids handling operations. For example, where sufficient digester capacity exists, it may be cost-effective to utilize a liquid treatment process which produces more solids than another alternative. When the sludge system is near capacity, the choice of a particular liquid treat-

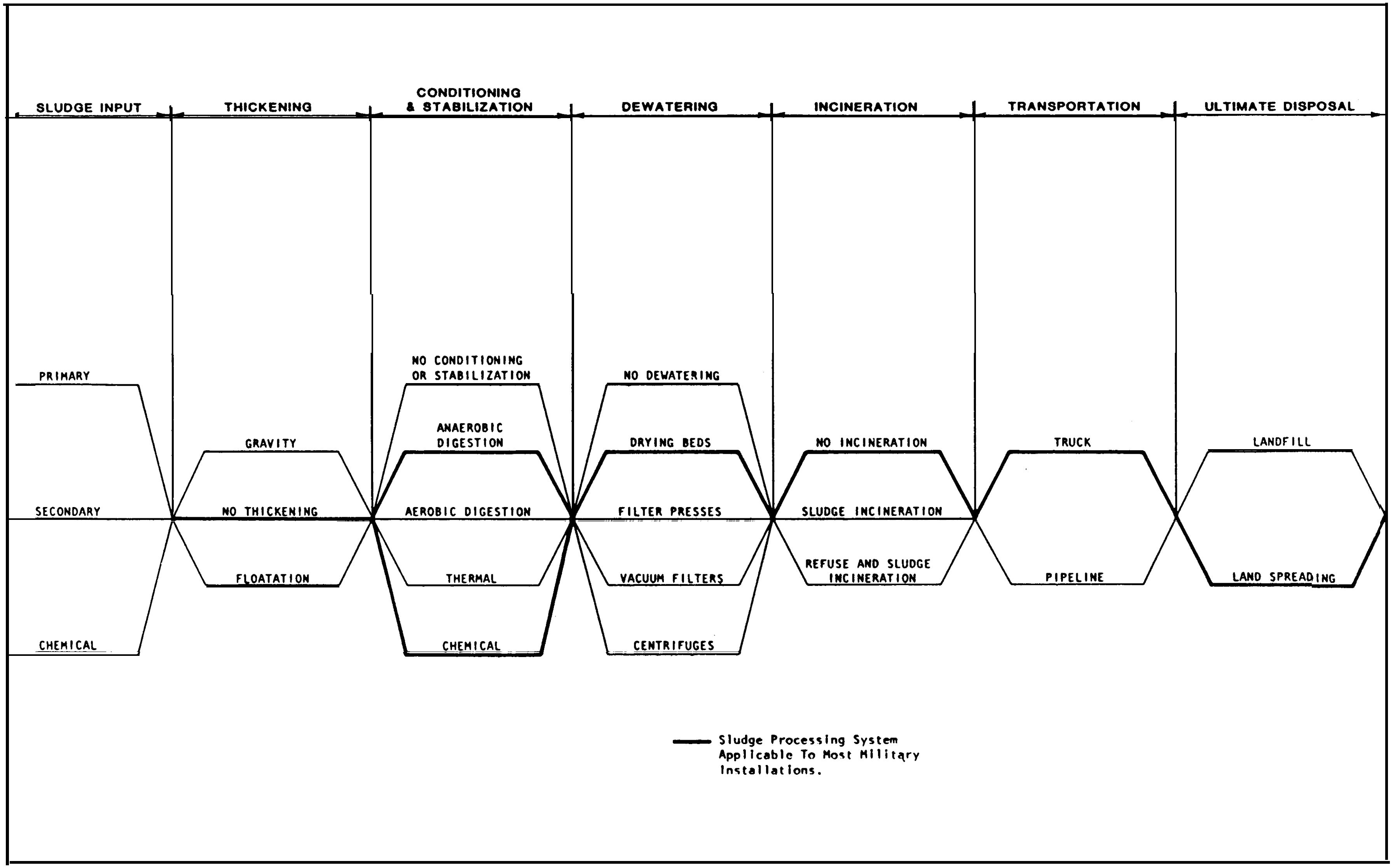


Figure 8-2. Alternative sludge processing systems for military installations.

ment plan may be dictated by the need to expand the solids processing facilities.

c. *Solids disposal alternatives.* The two most feasible methods for disposing of sewage solids from military installations include sanitary landfill and land spreading.

(1) Landfill. Disposing of dewatered sewage sludge with refuse in a sanitary landfill is normally an economical operation. Sewage solids tend to sift among the voids in compacted refuse, and nominal land savings are achieved. Combining the two waste materials at one facility is also desirable from a management standpoint.

(2) Landfarm. Land spreading dewatered sewage sludge is currently used by several military operations and is a cost-effective alternative to sanitary landfill. The land spreading technique can be utilized for either liquid or dewatered sludge, but the sludge must be stabilized; raw sludge application is unacceptable. This disposal method effectively utilizes the soil conditioning characteristics of the sewage solids. Proper monitoring and close attention to procedures employed during spreading are required to avoid potential environmental difficulties. Land requirements for spreading are greater than landfill; consequently, this method is feasible only where sufficient land area is available.

d. System performance.

(1) Introduction. The performance of solids handling systems is dependent upon many variables including: solids loading, operation, chemical addition, equipment maintenance and waste characteristics. These variables will greatly affect the output of the unit and should be considered when designing the system and when comparing performance data from similar type units. The performance and general design criteria discussed below are recorded average values and should be used as guidelines in preparation of design documents or in reviewing the performance of an existing facility. Bench scale testing or jar tests are recommended to determine the optimum operating point or quantity of chemical required. For additional information, refer to the U.S. EPA Process Design Manual, “Sludge Treatment and Disposal”. For additional description of the types of solids handling systems available, refer to chapter 7.

(2) Conditioning and stabilization. Sludge conditioning is generally described as a pretreatment of sludge to improve water removal by a method of thickening or dewatering. Common conditioning methods include:

—Polymer addition.
—Inorganic chemical addition.
—Heat treatment.
–Ash addition.

(a) Chemical conditioning requirements. Table 8-3 lists the common types of chemicals used for conditioning sludge and enumerates a range of dosages common for various types of sludge.

Table 8-3. Chemical conditioning requirements for various sludge types (167)

Sludge Type	$FeCl_3$ lb/ton dry solids	$Ca(OH)_2$ lb/ton dry solids	Polymers lb/ton dry solids
Raw Primary	20-60	0-100	3-5
Primary & Activated Sludge	80-160	0-300	6-15
Activated Sludge	120-200	100-300	8-25
Digested Primary	40-60	60-160	3-8
Digested Primary & Activated Sludge	120-200	100-300	6-20

(b) Heat treatment. Heat treatment of sludge uses a combination of temperature, time and pressure to condition a sludge without the use of chemicals. The process significantly changes the characteristics of the sludge by breaking down the cellular matter and releasing a major portion of the water in the cell mass. The dewaterability is improved by reducing the specific resistance to the sludge for filtering. Temperatures in the range of 350 to 450 degrees F and pressures in the range of 200 to 500 psig are generally required. Additional information concerning the design of a heat treatment system can be found in the literature (10)(11) (167).

(c) Ash addition. Ash is primarily used as a filler to reduce chemical addition requirements and improve the dewatering characteristics of the sludge. Generally, ash is used to improve the cake release from belt or filter presses and improve the dewatering of sludge in a vacuum filter. Depending on the type of ash available, a hydrolysis between free water in the sludge and ash will result in a dryer cake. Bench scale tests are recommended to determine the optimum dosage of ash because excess quantities may only result in an increased volume of sludge without any additional improvement in the dewaterability.

(3) Thickening. Sludge thickening can be accomplished by a variety of methods. These methods have been discussed in Chapter 7 and include: gravity, air flotation and centrification. Table 8-4 summarizes typical performance data for these processes for different types of sludges.

Table 8-4. Thickening characteristics of various sludge types (percent solids) (167)

Sludge Type	Gravity Thickener	Air Flotation	Centrification (solid bowl type)
Raw Primary	8-12	5-7	28-35
Activated Sludge	2-3	3-6	12-15
Trickling Filter	4-7	3-7	15-20
Primary & WAS	4-6	6-8	18-24

(4) Dewatering. Dewatering is the removal of water from wastewater treatment plant solids to achieve a volume reduction greater than that achieved by thickening. Dewatering is done primarily to decrease the capital and operating costs of the subsequent direct sludge disposal or conversion and disposal process. Dewatering sludge from a 5 to a 20 percent solids concentration reduces volume by three-fourths and results in a non-fluid material. Dewatering is only one component of the wastewater solids treatment process and must be integrated into the overall wastewater treatment system so that performance of both the liquid and solids treatment schemes is optimized and total costs are minimized. The dewatering processes discussed in chapter 7 include: drying beds, vacuum filters, belt presses and plate presses.

(a) Drying beds. Drying beds are the most common type of dewatering equipment in use at military installations today. Drying beds are used throughout the United States in small and large treatment systems; however, their use has declined over recent years. Their most common use is in drying of domestic wastewater sludge but some industries also use this method. Table 8-5 lists the advantages and disadvantages of sludge dry beds.

Table 8-5. Advantages and disadvantages of using sludge drying beds

Advantages	Disadvantages
a. When land is readily available, this is normally the lowest capital cost.	a. Requires more land than fully mechanical methods.
b. Small amount of operator attention and skill is required.	b. Removal usually labor intensive.
c. Low energy consumption.	c. Lack of a rational engineering design approach allowing sound engineering economic analysis.
d. Less sensitive to sludge variability.	d. Must be designed with careful concern for climatic effects.
e. Low to no chemical consumption.	e. Requires a stabilized sludge.
f. Higher dry cake solids contents than fully mechanical methods.	f. May be more visible to the general public.

(b) Vacuum filters. Vacuum filters consume more energy per unit of sludge dewatered than drying beds and are labor intensive. Performance data for vacuum filters is presented in table 8-6.

Table 8-6. Typical sludge concentrations produced by vacuum filtration

Sludge Type	Cake Solids (percent)	Rate (lb/hr/cu ft)
Raw Primary	25-30	5-10
Primary & Activated Sludge	20-25	3-6
Activated Sludge	12-18	2-5
Digested Primary	28-32	4-6
Digested Primary & Activated Sludge	20-24	3-5

(c) Belt presses. Belt press performance is highly dependent upon chemical addition, pressure, cloth type, etc. and it is difficult to generalize their operating efficiency. Table 8-7 has been prepared as a summary of the reported minimum and maximum cake solids for various types of sludges.

Table 8-7. Typical dewatering performance of belt filter presses

Sludge Type	Cake Solids percent	Feed Solids percent	Polymer lb/ton of dry solids
Raw Primary	28-24	3-10	2-9
Activated Sludge	16-32	1-3	2-4
Primary & Activated Sludge	12-28	0.5-1.5	4-12
Anaerobically Digested Activated Sludge	18-22	3-4	4-8
Metal Hydroxide Sludge	35-50	3-5	2-6

(d) Filter presses. Recessed plate pressure filters have been proven to yield the highest cake solids concentration of all the dewatering methods discussed. A disadvantage of the units is a high capital and labor cost and its requirement that it be operated in a batch mode. Table 8-8 provides ranges of performance of filter presses on various sludges. Additionally, cycle times may be as long as 6 to 8 hours per batch before optimum cake solids is achieved.

Table 8-8. Typical dewatering performance of filter presses (167)

Sludge type	Cake Solids (percent dry solids by weight)
Raw Primary	40-50
Activated Sludge	25-40
Primary & Activated Sludge	35-45
Alum Sludge	25-40
Metal Hydroxide Sludge	45-60

(5) Incineration. The two most common types of incinerators in use, both in civil and military installations, are multiple hearth and fluidized sand bed furnaces. The multiple hearth furnace is not designed for intermittent operation primarily because a significant amount of fuel is required for start-up of the unit. For fluidized sand bed furnaces, the sand retains enough heat that the furnace can be shut down for 8 to 10 hours and then be restarted without the use of start-up fuel. Fuel requirements for normal operation of the units are 20 to 25 percent higher for fluidized bed furnaces. The selection of the type of furnace used should be made on a case by case basis.