CHAPTER 5

WASTEWATER MANAGEMENT PROGRAM FORMULATION

5-1. Introduction

a. General requirements. Developing a wastewater management program requires the evaluation of the quantity, quality, and location of wastes produced; the sizing and configuration of collection systems; and a determination of the degree of treatment required to comply with discharge or stream standards. This chapter describes the approach and principles used to define and meet specific system requirements. The major portion of wastes will be domestic, although most military systems contain at least some industrial wastes. Specific information on industrial wastes which may require special consideration is presented in chapter 6. Wastewater characteristics are discussed in chapter 3. There are some differences in approach used in assessing the need for modifying or upgrading an existing system compared with that used for establishing the requirements of new facilities. At most military installations, a wastewater management program will require upgrading treatment as opposed to construction of completely new facilities.

b. Planning cycle. As discussed in chapter 4, numerous regulations are imposed on the discharge of both domestic and industrial wastewaters and the safe disposal of solids generated in waste treatment. Since all such discharges are regulated by law, program formulation and solution development can be seen as problem-solving cycle beginning and ending with specific regulatory requirements. The planning cycle is presented schematically in figure 5-1 and discussed briefly below.

(1) Regulatory requirements. At both the beginning and end of the planning cycle, regulatory requirements in themselves define the ultimate objectives of any wastewater management program. The cycle may be triggered for one or a combination of the following reasons:

—Permit violations with existing systems requiring upgrading and/or new construction.

—New limitations requiring increased levels of treatment.

—The imposition of discharge limitations on non-conventional pollutants such as ammonia or chemical oxygen demand requiring the extension of existing or construction of new facilities.

—The imposition of discharge limitations on toxic pollutants not previously regulated and requiring a re-evaluation of existing processes and/or treatment methods.

—Limitations on the handling and disposal of hazardous wastes not previously identified but requiring immediate attention.

Once the program is in motion, it must be coordinated as applicable with local, State, interstate, and Federal agencies. The Federal Facilities Coordinator of the Regional U.S. EPA office having jurisdiction should be utilized as the point of contact for obtaining all applicable effluent requirements, for approval of treatment processes selected, and for securing of the required discharge or disposal permits.

(2) Problem identification/definition. The initial steps in identifying and defining a problem involve setting specific objectives, reviewing available data, and developing a program outline.

(a) Objectives. Program objectives, based on the previous step, are developed to establish general constraints on work to be performed. Such objectives should include, but may not be limited to identifying the following:

—Area or facilities to be served.

–Source, configuration, and location of waste sources in question.

—System components to be included such as lateral sewers, trunk sewers, and existing treatment facilities.

—Provision for future facilities.

–Process waste to be handled.

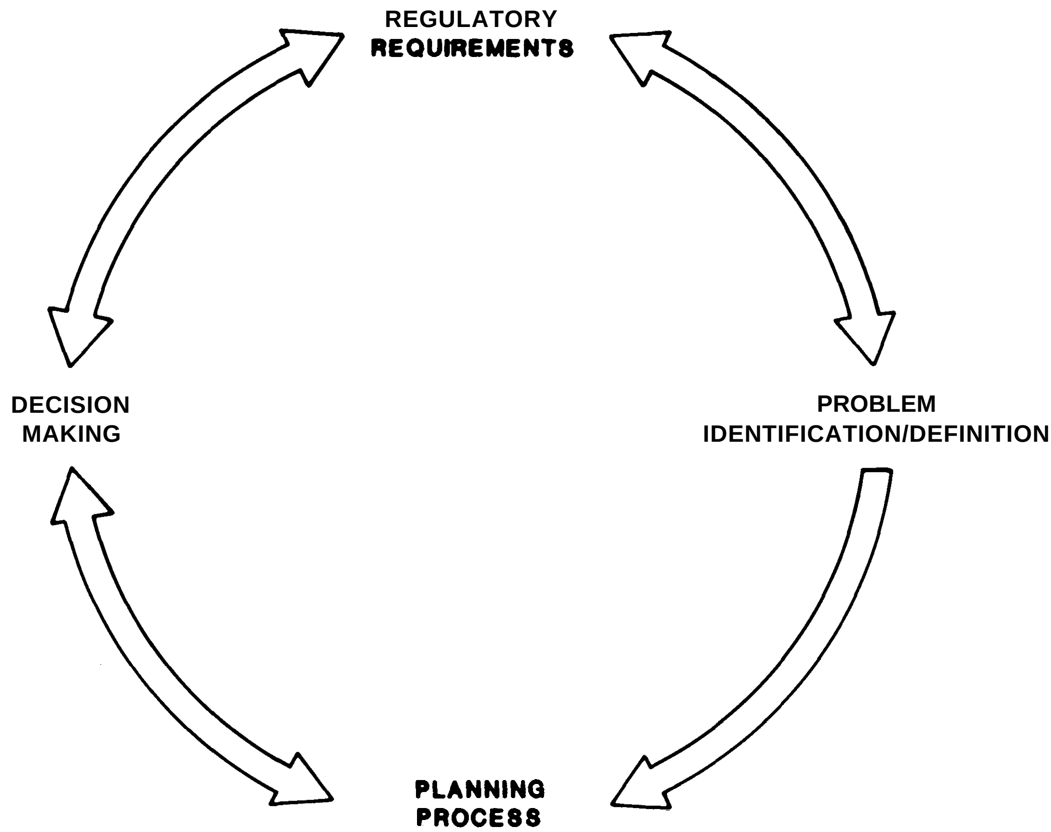
—Location of treated wastewater disposal.

–Location of treatment process residuals disposal.

–Specific modifications that may be required for existing systems.

—Any special considerations resulting from regulations and/or safety in handling specific process wastes (e.g., explosives, etc.).

(b) Data review. All available data should be reviewed. Specific information for new facilities may be limited to reports and preliminary plans of proposed construction plus quantitative data on the function and staffing of the installation. For modification, expansion, or upgrading of



DOUBLE HEADED ARROWS INDICATE FEED" BACK

REGULATORY REQUIREMENTS

PERMIT VISITATIONS
INCREASED LEVELS OF TREATMENT
LIMITS ON NONCONVENTIONAL POLLUTANTS
LIMITS ON TOXIC POLLUTANTS
LIMITS ON HAZARDOUS WASTE DISPOSAL
SPECIFIC TREATMENT NEEDS

PLANNING PROCESS

SOLUTION DEVELOPMENT
ALTERNATIVES DEVELOPMENT
COSTS DEVELOPMENT

PROBLEM iDENTIFICATION/DEFINITION

DEFINITION OF OBJECTIVES
DATA REVIEW
PROGRAM OUTLINE

DECISION MAKING

ALTERNATIVE REVIEW
NEGOTIATIONS
PROCESS SELECTION
FINANCIAL DECISIONS PROCUREMENT
IMPLEMENTATION

Figure 5-1. Program formulation problem solving cycle

existing facilities, additional data such as detailed system plans, design criteria, and operating records are generally required. Reference should be made to applicable planning guides and technical manuals (TM 5-803-1, TM 5-803–3, and TM 5-814-3), which stipulate requirements for sewerage and wastewater treatment at military installations. Military installations of a similar nature should be contacted to determine how similar problems have been addressed. The review should be conducted with a secondary purpose of defining and obtaining missing data or information.

(c) Program outline. After objectives have been developed and a review of available data and definition of missing information has been completed, a preliminary plan for implementing the wastewater management program should be formulated. The program outline prepared can be expected to vary depending on the types of facilities required. Typical types of facilities include the following:

- Upgrading existing wastewater management systems to correct deficiencies and/or modification to achieve a higher level of treatment.
- Wastewater management programs for completely new installations including facilities to meet mission requirements, personnel housing, and supporting service and recreational facilities.
- Treatment facilities to serve an addition of personnel housing with support facilities.
- Treatment and disposal facilities to serve an addition of a functional facility such as a major equipment maintenance center at a storage depot.
- Modification of an existing wastewater system for an installation where a change in mission of the facility changes the waste quality or quantity.

The above is not a complete list of facilities; however, it does illustrate the need for differences in the approach to program development.

(3) Planning process. Having clearly defined the program objectives and set general constraints on the work required, the planning process may begin. The typical course of the planning process is presented schematically in figure 5-2 with work elements proceeding in order from left to right. The specific work elements are aimed at problem solution, alternatives, and cost development.

(4) Decision making. As the project progresses, information is generally fed forward to decision makers controlling financial decisions, procurement, and project implementation. Feedback from decision makers based on initial reviews of alternatives and additional negotiations with regulatory agencies serves to direct the work in progress and ensure that ultimate objectives are met. The decision making process feeds forward to the original objectives and with implementation and procurement represents the final step in the process.

5-2. Water and wastewater inventory

a. Introduction. The water and wastewater inventory is an important part of any environmental control program. It provides a data base from which solutions to wastewater management problems can be developed. In any type of inventory, various waste streams are characterized for flow rate, concentration of pollutants and source. This information is essential in developing a treatment or abatement strategy and is required by Federal 'Law for inclusion in an NPDES permit application. Military installations desiring to discharge into municipal sewage systems often must present the municipality with a complete wastewater characterization before connection will be considered.

(1) Inventory objectives. Due to the importance of such inventories, accurate, complete, and reliable survey information is essential. For this reason, the planner and the survey team should always keep in mind the major objectives of an industrial waste survey. These objectives are:

(a) To locate and inventory the waste sources.

(b) To quantify the waste sources in terms of pollutant concentrations, flows, and mass loadings.

(c) To classify the waste stream as: low strength, i.e., suitable for reuse or untreated discharge; incompatible or hazardous; valuable for recovery; amenable to or requiring treatment; or complex and/or high strength.

(d) To identify problem areas.

(e) To develop preliminary control philosophies and alternatives.

(2) Loadings and variability. The inventory of waste streams is necessary as a matter of record and to ensure that all waste streams have been considered. Quantifying each of the waste streams provides the basic waste load information required for selection of alternatives and design of treatment systems. Particular attention should be given to the variability of the waste stream quantities.

(3) Reviewing alternatives. In developing the survey data, the characteristics of each waste stream should be closely examined to determine potential alternatives for handling the stream. The first step in this process is to classify the waste stream. Low strength wastewaters "may be suitable for reuse elsewhere or for discharge without treatment. Incompatible waste streams may be hazardous, extremely difficult to treat when mixed with water or other wastes, or very easy to treat when not mixed with other wastes.

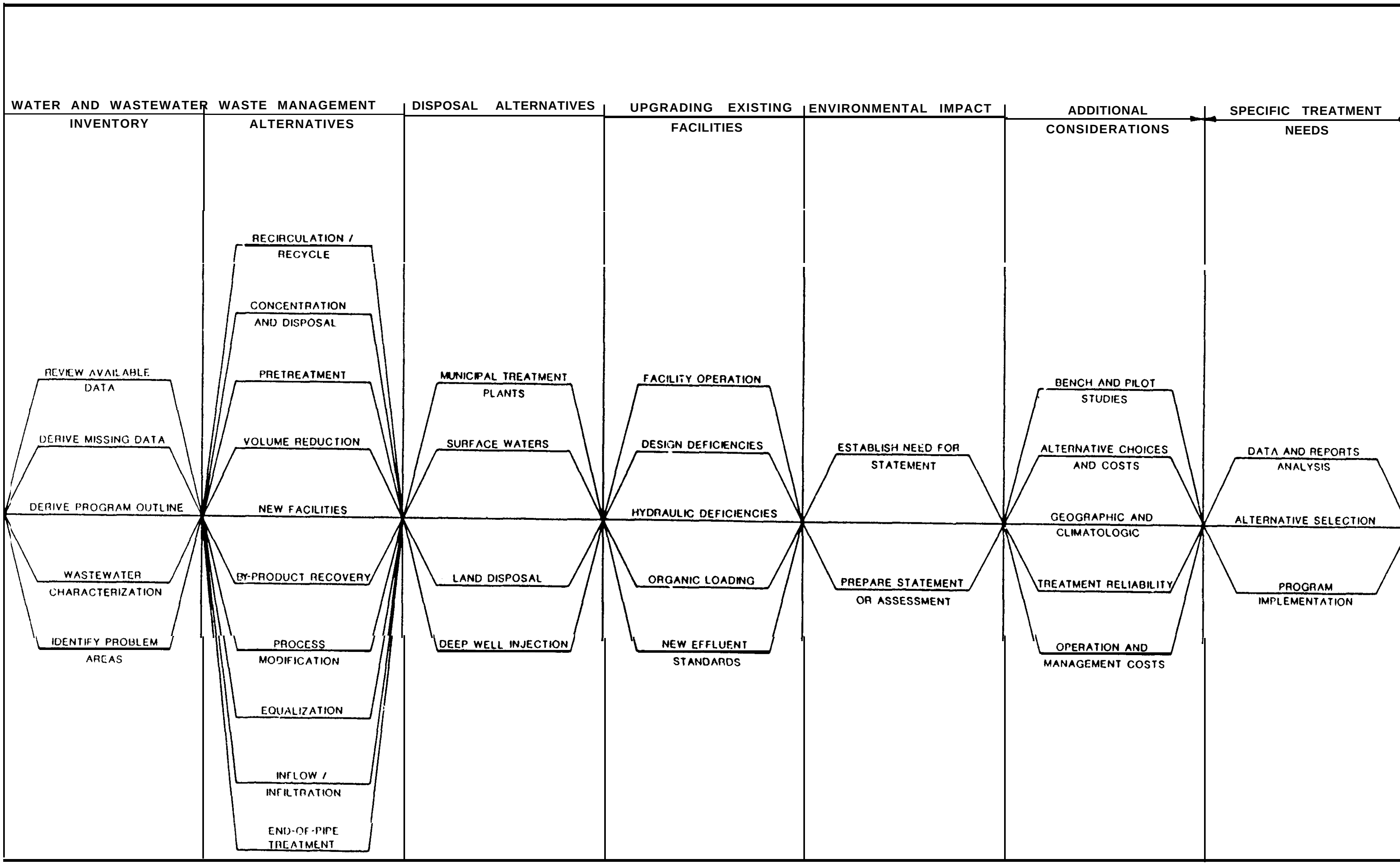


Figure 5-2. Factors to be considered in a wastewater management program.

Some wastewaters may contain valuable metals, oil, or other materials suitable for recovery. Waste streams amenable to or requiring treatment are moderate in strength and probably require no special consideration. High strength wastewaters may be a very complex mixture of substances or a highly concentrated source of a few constituents. In either case, the wastewater requires special consideration when it is included in a collection system where it will be diluted and probably more difficult to treat. Once problem areas have been identified, alternative control schemes should be assembled on a preliminary basis. This provides the starting point for an evaluation of the alternatives which will result in developing a solution to the problems.

b. Domestic waste. Domestic or sanitary wastewaters at military installations are derived from barracks, households, schools, hospitals, administrative buildings, and any other sources related to the general population served. Typical parameters required to define the size of domestic waste collection and treatment facilities include flow, BOD, suspended solids, phosphorus, and nitrogen content. Average daily per capita contributions are defined in TM 5-814-1 and TM 5-814-3. Data for BOD and suspended solids are tabulated in TM 5-814-3. Similarly, flow data are shown in TM 5–814-1. Combining per capita use, population and the capacity factor, sewage treatment facilities can be sized. Hydraulic characteristics of all facilities must be based on peak flows. The relationship between peaking factor and population is shown in TM 5-814-1. Most domestic water sources can discharge directly to the sewer system without pretreatment. However, some sources of domestic waste, such as food preparation facilities, may require preliminary treatment units such as grease removal or coarse screens to minimize problems in the sewers or at the treatment plant.

c. *Industrial waste.* Industrial or process wastes at military installations are produced by metal finishing operations, vehicle repair depots, photographic processing, munitions plants, laundries, and other similar facilities. Industrial chemicals and the by-products from these facilities contribute to the process wastewater. Reference should be made to chapter 3 in this manual for characteristics of wastes from these sources. In some instances, process wastes can be routed directly to sewers handling sanitary wastes without pretreatment. If the process waste contains a toxic compound, a hazardous compound, or excessive quantities of such materials as oil and grease, separate pretreatment is required. Wastes which cause sewer plugging, interfere with the treatment system, or pass through the system and cause contamination of the receiving stream should be kept out of the sanitary sewer until the interfering effect is eliminated. Flow and quality characteristics of process wastes which combine with sanitary waste must be included to yield total system capacity requirements. In some cases, process wastes are collected and treated in a separate system which discharges directly to the receiving stream.

d. Wastewater characterization. The use of published standard data for determining the magnitude of parameters for flow and waste constituents is normal practice; often no other data are available at new facilities. An adequate allowance is included in published standards to provide a factor of safety in system sizing. However, it is prudent to supplement this approach by also considering characterization of wastes from any similar existing facilities or installations. This latter approach can be implemented by examining laboratory records, data logs, and reports. Waste flows can also be determined by correlation with water use after adjustment for lawn watering, cooling losses, and other uses wherein water is not returned to the sewer. Wastewater characterization can also be accomplished by examining the industrial chemicals used in the processes contributing to the waste stream. To determine the constituents of the industrial chemicals, the appropriate Military Specification (MIL SPEC) should be examined and the quantity of each constituent verified.

5-3. Solution methodology

a. Alternative approaches. In order to solve a wastewater management problem, it is first necessary to define an approach to the problem. The approaches commonly employed are end-of-pipe control and in-plant control. End-of-pipe control usually involves collecting all the waste sources into one waste stream and designing treatment processes to remove the undesirable constituents. In-plant control involves handling wastes at their source either by modifying the source or by removing undesirable constituents while they are still concentrated. Often, the most attractive solution to a waste problem will be a combination of both abatement philosophies.

b. In-plant/source control. Control techniques for in-plant pollution abatement are usually oriented toward a single source. In developing such controls it is necessary to consider the means by which the waste is generated. In general, in-plant control consists of one or more of the following:

—Segregation.
—Recirculation and recycling.
—Disposal of concentrated residuals.
—Pretreatment.
—Reduction in volume or waste load.
—Process modification.

(1) Segregation. Segregation means isolating the waste streams originating from various sources or types of sources from others. Segregation usually involves controlling the manner in which wastes are collected. Often, segregation of waste streams is the key to implementing in-plant control because each source may require individual consideration. Segregation may be necessary before any of the other in-plant controls can be exercised. For example, in order to reclaim waste oils, it is necessary to collect used oil before it enters the sewer. Thus, segregation is the key to oil reclamation. Potential undesirable effects of segregation should also be considered. These arise whenever two streams which are complimentary in some respect are segregated. When an acidic stream is segregated from a basic stream pH adjustment problems may intensify. Similarly, warm and cold streams are sometimes better treated when combined due to temperature effects on treatment efficiency. A nutrient containing waste stream is desirable in a mixture of predominantly carbonaceous waste and should, therefore, not be segregated. All these and similar factors should be considered whenever segregation is contemplated.

(2) Water recirculation and recycling. In-plant control by recirculation and recycling refers to the reuse of wastewaters from some operation either within that operation or within another operation. Recirculation and recycling may require some form of local treatment in order to render the wastewater recyclable. An example of a case where treatment is not necessary would be heat recovery from laundry wastewater to preheat boiler water. An example of a waste that requires treatment before reuse would be the filtering of water in a wet spray booth scrubber before recycling. These operations will result primarily in reduced hydraulic loading of the treatment plant.

(3) Disposal of concentrated residuals. In some instances, wastes can be collected in a semi-dry or otherwise concentrated state and recovered for reuse or separate disposal. Potential benefits of special disposal are enhancement of end-of-pipe treatment due to a reduction in pollutional load or by elimination of toxic or otherwise hazardous material which may be detrimental to end-of-pipe treatment. Income can also be generated by the marketing of reclaimable substances such as oils or solvents.

(4) Pretreatment. Isolated waste streams may be treated locally for removal of specific constituents before discharge to the main collection system. Such pretreatment is possible in a vehicle maintenance area by installation of an oil/water separator on the sewer which collects floor washings. A number of treatment processes may be used for pretreatment as illustrated in table 5-1.

(5) Reduction in volume or waste load by better housekeeping. A close examination of most processes will reveal a number of operations which result in unnecessary dumping to the sewer. Needless flushing of spilled materials, emptying of old or used containers, running of unused hoses, and leaking of worn equipment are all examples where reduction can be effective. In many cases, good housekeeping practices, proper management, adequate supervision and everyday common sense can be applied to reduce waste discharges.

(6) Process modification. In considering the in-plant controls, a frequently overlooked method is modification of the operation which generates the waste. Modification can occur by either changing or replacing the equipment or materials employed in the operation. Equipment modification could involve repair, renovation or replacement of existing process machinery. An example of this would be to replace a wet scrubber with a cyclone or fabric filter to remove cinders from a waste paper incinerator. The replacement of chemicals and materials used with ones having less pollutional impact can also have a significant in-plant control.

(7) Combined sewers. Many sewer systems have served as combined sewers handling both sanitary and storm flows. In some instances, this was purposely planned to eliminate the need for two separate systems. However, this practice was implemented prior to the time when any significant waste treatment was required. Today, combined sewers do not exist to a significant extent on military installations and are prohibited in new construction. If a combined sewer is encountered during modification of an existing facility, the stormwater flow should be separated from the process flow.

(8) Cooling water. Water used for indirect cooling purposes (such as shell and tube heat exchangers) normally contains essentially no BOD or suspended solids. Once-through cooling waters can be diverted from the sanitary sewer system. For recirculating evaporative cooling systems,

Table 5-1. Example of waste load reductions by in-plant control

In-plant Control Method	Description of Modification	Flow Reduction MGD	Flow Reduction Percent	BOD Load Reduction lb/day	BOD Load Reduction Percent
Segregation and special disposal	Incineration of high strength organic streams	0.04	0.4	6,510	11.7
	Wet scrubber replaced with afterburner	0.30	2.7	560	1.0
Process modification	Repair and replacement of process equipment	1.60	14.4	4,650	8.3
	Unit shutdowns due to the age of the process or product*	0.25	2.2	1,860	3.3
Substitution	Use of raw materials with less pollutant load	0	0	560	1.0
Recycling	Reprocessing of specific wastestreams to recover more product and concentrate waste	0.01	0.1	560	1.0
Reduction	A number of small, varied projects	0.60	5.4	3,900	7.0
	Totals	2.8	25.2	18,600	33.3

*These were not caused by environmental considerations but they were a factor.

dissolved solids may be high and diversion may not be possible.

(9) Infiltration/inflow. Entry of storm flow and groundwater into the sewer system through faulty sewer lines or illicit connections can be a major contribution to sewer flows. Infiltration is particularly serious for the several days following a major storm event or other periods when groundwater levels are high. Inflow impacts the sewer flow during and immediately following the storm event when roof drain or storm sewer connections contribute. Infiltration/inflow can create undesirable environmental conditions and health hazards by sewer overflows and by requiring bypassing of treatment facilities when hydraulic capacity is exceeded. To produce needed environmental protection with minimum costs, infiltration/inflow must be effectively controlled either by corrective action to the sewer system, provision of equalization/surge basins or by provision of increased treatment capacity.

(10) By-product recovery. By-product recovery, applied to process waste, is another means of waste reduction wherein materials from a waste stream are recovered for further use. It is quite often not economically feasible, but it should be considered and evaluated.

(11) Equalization. An indirect means of waste reduction before treatment can be accomplished by equalization of wastes. This involves various methods for smoothing out the wastewater loads reaching a treatment facility, and is especially applicable to the treatment of wastes from industrial or process operations.

(12) Examples. The use of centralized vehicle wash facilities (CVWF) provides an excellent example of exercising in-plant control techniques. The centralized wash facility is designed to be used for exterior washing after tactical operations and employs water conservation by treatment and recycle of wash water. Segregation is accomplished by isolating the wash water for exterior washing from the wastewater generated by vehicle maintenance activities and any other wastewater source. Recycling ,and treatment are accomplished by collecting wash water, removing settleable solids and floating oils, passing it through an intermittent sand filter and storing it for reuse. The volume of wash water can be minimized by using baths for soaking and loosening the dirt from vehicles and by using automatic shut-off nozzles on all wash hoses. Detergents, solvents or other cleaning aids are not allowed because they are not necessary for exterior washing, and they complicate the waste strem. Another example of using an in-plant control approach to pollution abatement is presented in table 5-1. In this case, a chemical plant was faced with implementing a comprehensive control program employing both in-plant and end-of-pipe technologies. The total reduction in BOD waste load was 33 percent and the flow reduction was 25 percent due to in-plant control. Table 5-1 illustrates how this reduction was achieved. Process modification and segregation for special disposal played key roles in attaining the reduction. The in-plant controls resulted in a corresponding decrease in the size of end-of-pipe treatment facility required.

c. End-of-pipe control. Pollution control using and end-of-pipe abatement philosophy means treating the waste discharges from a number of operations after these wastes have been combined in a common sewer. End-of-pipe control usually addresses removal of a large variety of wastewater constituents. There are many treatment processes which can be employed in a treatment sequence to obtain an acceptable discharge quality. This approach is generally more attractive than in-plant control because all wastewater treatment operations are carried out in a single, central location. Technologically, the end-of-pipe alternative may pose severe treatment problems due to the variety of pollutants in the wastewater and the variability of wastewater characteristics to be handled by a single facility.

5-4. Disposal alternatives

A major factor in developing a solution for wastewater management is the method of ultimate disposal of the treated wastewater. Very often there is more than one disposal alternative and it is the planner's task to select the one which is most suitable for the specific waste. There are four general wastewater disposal alternatives:

–Discharge to a domestic wastewater treatment plant.
—Dilution in surface waters.
–Land disposal.
—Deep well injection.

The following is a brief discussion of each of these disposal alternatives as related to wastewaters from military installations.

a. Discharge to a domestic waste water treatment plant. Military installations may be located within or near a civilian community which owns a treatment plant, or they may have a treatment system for their own domestic wastes. In both cases the industrial and new domestic wastewater may be discharged to the existing plant for treatment in combination with the existing wastewaters. Before proceeding with combined treatment of industrial and domestic wastes, several factors should be considered.

(1.) Verification of waste compatibility. Non-compatible industrial discharges can be identified based upon physical and chemical wastewater parameters which could damage or make inoperative the sewage treatment facilities. Industrial discharges can reduce the biochemical reaction rates or decrease the sludge settling velocity for biological treatment systems. Sludge handling problems commonly result from poor settleability and dewaterability of combined industrial/ municipal sludges. Additionally, toxic compounds, such as heavy metals, may render the municipal plant's sludge unacceptable for common disposal methods.

(2) Loading variations. The contaminant concentrations of industrial wastes are usually much more variable than that of domestic wastes. Variations in the amount or type of the waste generated can significantly impact the municipal plant operation and performance. Batch processes or changes in production methods result in organic, hydraulic, and toxic loading variations which domestic systems have difficulty anticipating and responding to.

(3) Pretreatment technologies. The applicable pretreatment technologies can only be defined after a comprehensive assessment of the waste characteristics, discharge limitations and consideration of alternative generation and treatment techniques. Occasionally, non-compatible waste components can be eliminated by process changes. Frequently, production or maintenance schedules can be adjusted to minimize discharges or reduce the impact on municipal plants during switching to new products or operations. Examples of in-plant and end-of-pipe techniques are presented in table 5-2 for removal of potentially non-compatible materials in industrial discharges.

(a) Selection of the pretreatment technology should also include consideration of reducing the amount and concentration of compatible pollutants. Such consideration can frequently result in a substantial reduction in the sewer use for industrial discharges. Installation of aerated lagoons or anaerobic pretreatment systems can also result in significant savings. Biological systems can be used to reduce waste loads discharged to a physical-chemical treatment system.

(b) The most commonly used physical/ chemical pretreatment methods are screening, emulsion breaking, oil/water separation, sedimentation, equalization, and neutralization. Biological pretreatment methods which are most commonly used are aerated lagoons, rough trickling filters, and rotating biological contactors. Examples of pretreatment methods employed at military installations before discharge to municipal sewers are:

—Screens used for lint collection in laundries.
—Removal of oil and grease from wash rack wastes.
—Sedimentation of solids from wash rack wastes.
—Gravity separation of oils and wastes from motor pool maintenance facilities.

b. Dilution in surface waterways. Discharge of wastewaters to surface waterways is the most common ultimate disposal method. Both the location of discharge point and the type of dispersion mechanism are important for protecting water quality. A properly designed subsurface dispersion system will allow maximum utilization of the receiving water assimilative capacity.

(1) Federal, State and local governments have placed restrictions on wastewater discharge quality in order to control the detrimental effects of contaminants as described in chapter 2. These restrictions may require a certain type of treatment system be used, or they may specify concentration limits on certain parameters regardless of the treatment system used to obtain these. Typically, the quality of the receiving stream or body of water is taken into consideration along with the intended use of the water following the wastewater discharge. Each state has classified its major streams and bodies of water according to their own set of use classifications. Table 5-3 lists some typical classifications and the associated quality criteria and required treatment methods for each one. The regulations involved in water quality control are discussed in chapter 4.

(2) Of the various pollutants discharged to surface waterways, oxygen-depleting compounds have received the most attention. These compounds are primarily soluble organics, the discharge of which may be extremely damaging to the health of the receiving stream. Soluble organics are used as food by microorganisms. Microorganisms exist almost everywhere in our world and most microorganisms utilize oxygen for respiration. Discharge of large quantities of organic material results in increased microorganism growth and oxygen consumption. Thus, the increased organism activity resulting from discharge of soluble organics exerts a "biochemical oxygen demand (BOD) on the receiving strewn. This natural phenomenon may deplete dissolved

Table 5-2. Potential non-compliance materials and example control measures*

Component	In-plant Control	End-of-Pipe Control
Physical Constituents		
1. Suspended Solids	Clarifier	Primary clarifier
2. Floating Material	Separators	Separators
3. Fiber	Screen	Screens, primary clarifier
4. Temperature	Cooling tower	Combine w/other wastes
5. Oily material	Separator, segregation	Separator
Chemical Constituents		
1. Organics		
a. Complex	Activated carbon, ozone	Activated carbon
b. Toxic	Activated carbon, special disposal	Activated carbon
c. Surfactants	Activated carbon, special disposal, process substitution	--
d. Colored waste	Activated carbon	--
e. pH	Neutralization	Neutralization
2. Inorganic		
a. Total dissolved fixed solids	Special disposal	Ion exchange
b. Heavy metals	Precipitation	Precipitation

*The waste generation rate must also be considered in terms of the diurnal discharge of domestic wastewater into the POTW.

Table 5-3. Stream classification for water quality criteria[a]

Class		Quality Criteria	Required Treatment
A[b]	Water supply, recreation	Coliform bacteria, color, turbidity, pH, dissolved oxygen, toxic materials, taste- and odor-producing chemicals, temperature	Secondary (tertiary in some cases to meet criteria) plus disinfection
B[b]	Bathing, fish life, recreation	Coliform bacteria, pH dissolved oxygen, toxic materials, color and turbidity (at high levels), temperature	Secondary plus disinfection
C	Industrial, agricultural navigation, fish life	Dissolved oxygen, pH, floating and settleable solids, temperature	Primary and, in some cases, secondary
D	Navigation, cooling water	Nuisance-free conditions, floating material, pH	Primary

[a]Based upon data from (3) and (4)
[b]May require nutrient (nitrogen and phosphorus) removal

oxygen in a stream to a point where other aquatic life cannot, exist.

(3) Toxic materials and heavy metals such as cadmium, lead, mercury and zinc may severely inhibit or kill organisms in the receiving waters. Many of these substances may concentrate in aquatic organisms. Small concentrations in the stream can be stored up in aquatic animals (bioaccumulation) to extremely high levels which may eventually be passed to man through the food chain. Occurrence of this type of toxic migration has been documented for several toxic compounds such as polychlorinated biphenyls (PCB's).

(4) The major problem associated with additions of color and turbidity to natural waters is that these parameters reduce light penetration into the water. This, in turn, decreases the rate of photosynthesis and causes a decrease in the stream population of algae and aquatic plants. The food supply for animals feeding on algae and aquatic plants is then reduced, possibly resulting in growth inhibition or death of the higher forms of life.

(5) Nutrients, although necessary to aquatic life, may, when present at too high a concentration, cause algal blooms (where algae reproduce extremely quickly, covering water surfaces in large floating colonies). Although algae produce oxygen in sunlight by photosynthesis, at night they utilize oxygen in much the same manner as other microorganisms do. When they reach a harmful level, the lake or reservoir is considered eutrophic. This is offensive in recreational facilities and may inhibit future uses of impounded waters unless treatment is provided.

(6) Refractory materials, such as some synthetic detergents, may cause foaming which is aesthetically displeasing.

(7) Oil and floating materials are aesthetically undesirable, typically high in BOD, and may suffocate aquatic life by blanketing gills, leaves and other oxygen transfer surfaces. Floating substances may also have a capping effect on the stream decreasing or destroying the natural stream reaeration abilities.

(8) Acids and alkalis may shock (rapid or localized change in conditions which is detrimental to aquatic life) receiving streams if the pH of the waste is sufficiently different from the existing pH in the stream. Most localities require that discharges to natural waters be neutralized to within a pH range of 6.0 to 9.0. Some restrictions are even more stringent,

(9) Substances resulting in atmospheric odors, such as sulfides, are aesthetically unappealing and should be eliminated before discharge.

(10) Suspended solids produce a variety of detrimental effects. Turbidity and its associated problems are increased by suspended solids addition to a stream. The high organic content of some suspended solids exerts a high BOD on the water and creates oxygen depletion problems. Sedimentation of suspended solids results in an accumulation of solids on the bottom of the receiving body of water. This sludge bank may alter the habitat of the bottom dwelling (benthic) organisms sufficiently to decrease or eliminate some species populations. Additionally, biological activity within the sludge bank may produce gases which lift masses of decomposing sludge to the surface creating an unsightly and malodorous situation.

(11) Discharge of wastewaters having temperatures significantly higher than the receiving stream may elevate the temperature of the stream. This will subsequently decrease the dissolved oxygen content, since oxygen is less soluble in water at higher temperatures. Increased biological activity resulting from higher temperatures further accelerates oxygen depletion. Thermal pollution can therefore result in suffocation of aquatic life.

c. *Ocean disposal.* Within environmental constraints either barge transport or an outfall pipe can be used for ocean disposal of industrial wastes. The former is primarily used for the disposal of low volume concentrated wastewater whereas the latter is more suitable for large volumes of diluted wastewater.

(1) Developing an ocean outfall solution for a particular waste should include the following steps:

—Define the beneficial uses of the marine waters at the disposal site and its vicinity. Beneficial uses may include commercial fishing, marine recreation, navigation, fishery propagation and migration, and industrial use.

—Define the water quality criteria pertinent to the relevant beneficial uses. Areas of concern include public health, aesthetic nuisances, toxicity to marine biota, stimulation of planktonic blooms, and oxygen depletion.

—Define the oceanographic characteristics of the disposal site. This includes water circulation patterns, currents and dispersion, density and temperature profiles, and submarine topography.

–Design wastewater disposal system to meet required quality criteria.

(2) The main objective in the design of an ocean outfall is the enhancement of dilution of wastewater in marine waters. This is achieved by installing a multiple port diffuser through which wastewater is discharged. This dilution, referred to as "initial dilution", is primarily dependent on the depth of sea at the point of discharge.

(3) The wastewater plume which forms at the sea surface above the diffuser is subject to ocean currents, turbulent mixing, and wave and wind effects. This results in further dilution referred to as "turbulent dilution." The intensity of this dilution depends mainly on the natural turbulence in the ocean.

(4) Ocean dumping of industrial waste is closely regulated by the U.S. EPA. Before permits are issued several studies have to be conducted including biological and oceanographic investigations. Therefore, this approach should be taken only as a last resort when inland treatment and disposal are not feasible.

d. Land application. Land application of wastewater is a treatment approach in which the characteristics of the wastewater are altered by microbial stabilization, adsorption, immobilization and crop recovery. Industrial wastes are applied to the land at rates that are low enough not to exceed the assimilative capacity of the soil. Pretreatment processes are almost always necessary to reduce toxic or pollutant species which increase land requirements, and thus, improve the overall economics of the total system. Land application has not been widely used for industrial wastes due to the complexity of the wastewaters and the lack of proven design criteria. However, it is now believed that an environmentally acceptable rate of application can be determined for any and all domestic and industrial waste constituents with the exception of radioactive materials.

(1) Land application design. A rational approach to developing a land application solution should proceed in the following sequence:

—Determine the controlling parameter in the wastewater based on the assimilative capacity of the plant-soil system and the waste load on a constituent-by-constituent basis. The controlling parameter is that constituent which requires the greatest land area.

—Economically evaluate all components required for the land application system under various levels of the land-limiting constituents (LLC).

—Economically evaluate pretreatment or in-plant modifications for reducing the concentration of the land-limiting constituent.

—Select the most cost-effective combination of pretreatment and land application systems.

(2) Land application design has a highly site-specific character and requires careful development of the individual solution. Failures of existing systems have been most frequently attributed to not considering the site-specific nature of this disposal method.

(3) Determination of the land application rate for any industrial waste constituent is based on a calculation of the mass balance of this constituent in the soil system. The result of these calculations is the application rate, expressed in lb/acre-yr, that will not exceed the environmentally accepted levels of pollutant in any part of the system. There are no standard application rates for all types of soils and each case should be treated individually.

e. Deep well injection. Deep well injection is a disposal method in which industrial wastes are stored in subsurface strata of proper characteristics. The technology of deep well injection was described in detail by Warner (165).

(1) Deep well applications.

(a) Deep wells have been used extensively for many years in oil producing regions to return large quantities of saline water underground. However, due to the uncertainties involved and the regulatory constraints, they have not been used extensively for industrial waste disposal.

(b) The approval of a new injection well for industrial waste disposal requires investigation of alternative methods which concludes that an injection well is the most environmentally satisfactory option. Drilling of a preinjection test well, monitoring provisions, contingency plans and provisions for capping of wells after shutdown are also required. Even though this method may not be of widespread application, for a specific waste, it may be the most environmentally accepted practice available.

(2) Considerations for design.

(a) The most important consideration in developing deep well injection concerns the protection of underground water resources from being contaminated by the industrial wastes. This means that the wastes must remain confined in a specified zone and not diffuse into strata which were not designated for wastewater storage. The well area and its casing must be designed and constructed to avoid upward migration of fluid from the injection well. A comprehensive monitor-

ing program has to be established for the injection area.

(b) Compatibility of the wastewater with the water in the injection zone must be studied carefully. The reaction between wastewater constituents and salinity of the groundwater may result in precipitation of mineral salts or formation of gases both of which could render the strata impermeable. Organic material in the wastewater may result in extensive biological growth and rapid plugging of the aquifer pores.

5-5. Upgrading of existing facilities

Upgrading existing wastewater treatment systems refers to a variety of design and operational techniques intended to improve plant performance or increase plant capacity. Upgrading of existing plants may be desirable for one or several of the following reasons:

- To improve performance of facilities with operational deficiencies, i.e., those facilities which have poor performance due to difficulties in operation of the systems.
- To improve performance of facilities with design deficiencies, i.e., facilities displaying poor performance due to inadequacy of design.
- To increase hydraulic capacity to alleviate hydraulic overloads from infiltration and expansion of services.
- To increase organic capacity compensating for organic overload due to the number of connections or high strength contributions.
- To provide compliance with more stringent standards.

a. Plant performance. A national survey was conducted by the U.S. EPA in 103 wastewater treatment plants to identify and rank the major causes of poor plant performance. The survey excluded plants with hydraulic or organic overloading problems. Table 5-4 lists the top 10 ranked problem areas and provides a short explanation of each. The survey results indicate that operation and design are often the two most important areas to consider when upgrading an existing system.

b. Upgrading techniques. Methods or techniques used in upgrading are entirely dependent upon the problems to be solved by the upgrading. Often, several problems are involved; therefore, several techniques must be employed in a manner to provide the level of performance required. For simplicity of discussion, the various approaches will be addressed separately with the understanding that combined use is encouraged where necessary.

(1) Upgrading of poorly operated facilities. One of the most common reasons for poor plant performance is poor operation. The operating techniques applied in a plant should always be considered as the first step in upgrading a system. In order to verify performance, optimization of operations should be completed before any other upgrading technique is applied. Specific operating problems are listed and briefly discussed in the U.S. EPA survey quoted in paragraph 5-5a. These and other problems may be categorized into the three basic problem areas listed below:

- Improper application of process control methods.
- Inadequate training or guidance of plant operators.
- Improper testing and data analyses.

(2) Upgrading poorly designed facilities. Many plants have sizing or process design deficiencies relating to hydraulic or organic overloading problems. Many design problems also result in poor performance. These were listed in the U.S. EPA survey for five of the top 10 ranked plant problems. Major design deficiencies include:

- Insufficient flexibility in pumping rates, preventing proper control of plant processes in times of high or low flow.
- Inadequate by-passes for repair and maintenance of equipment, resulting in entire processes being taken out of service unnecessarily.
- Lack of standby equipment, causing possible loss of process operation while replacements are ordered.
- Poor hydraulic and solids distribution to parallel units resulting in over or underloading of different portions of the system.
- Lack of flexibility in process instrumentation and equipment resulting in poor low flow or low load operation.
- Poor accessibility of equipment for repair and maintenance often resulting in repair problems and negligent maintenance practices. The remedies for most of these problems are obvious. Correction of these deficiencies may result in sufficient improvement of plant performance to eliminate the need for further upgrading.

(3) Upgrading to provide increased hydraulic capacity. Although units based on flow rates are operable when hydraulically overloaded, the removal efficiencies are greatly reduced. Some of the units most adversely affected by hydraulic overload are equalization basins, primary clarifi-

Table 5-4. Ten top ranked causes of poor plant performance

The 10 major causes of poor plant performance are described as follows:

1. Operator Application of Concepts and Testing to Process Control -This factor was ranked as the most severe deficiency and leading cause of poor performance at 23 facilities and was a high-ranked factor at a total of 89 out of the 103 plants evaluated. It occurs when a trained operator in a satisfactorily designed plant permits less than optimum performance. This factor was ranked when incorrect control adjustment or incorrect control test interpretation occurred, or when the use of existing inadequate design features continued when seemingly obvious operations alternatives or minor plant modifications could have been implemented to improve performance. The lack of testing and control were not necessarily the result of inadequate training or comprehension in these areas, but simply the lack of or inability to apply learned techniques.

2. Process Control Testing Procedures - Inadequate process control testing involves the absence or wrong type of sampling or testing for process monitoring and operational control. This deficiency leads to making inappropriate decisions. Standard unit process tests such as mixed liquor suspended solids, mixed liquor dissolved oxygen, mixed liquor settleable solids, and return sludge suspended solids for activated sludge processes were seldom or never conducted. Also, important operating parameters such as sludge volume index, F/M ratio and mean cell retention time in suspended growth systems or recirculation rates in trickling filter plants were usually not determined. This factor adversely impacted performance at 67 of the 103 plants evaluated.

3. Infiltration/Inflow - The results of this widespread problem are manifested by severe fluctuations in flow rates, periods of severe hydraulic overloading, and dilution of the influent wastewater so that both suspended and fixed biological systems are loaded to less than optimal values. The extreme result is the “washout” of suspended growth systems as a result of the loss of solids from the final clarification stage during high flow periods. This factor was ranked first at 56 of the 103 plants evaluated.

Table 5-4 Cont'd)

4. Inadequate Understanding of Wastewater Treatment - This factor is distinguished from Factor #1 in that it is defined as a deficiency in the level of knowledge that individual staffs at various facilities exhibit concerning wastewater treatment fundamentals. On occasion, an operator's primary concern is simply to keep the equipment functional rather than to learn how the equipment relates to the processes and their control. This factor adversely affected performance at 50 plants and was the leading cause of poor performance at nine facilities.

5. Technical Guidance - Improper technical guidance includes misinformation from authoritative sources including design engineers, state and Federal regulatory agency personnel, equipment suppliers, operator training staff and other plant operators. At any one plant, improper technical guidance was observed to come from more than one source. This factor was ranked as the most severe deficiency at seven plants, and was an adverse factor at 47 facilities.

6. Sludge Wasting Capability- This factor was ranked as the leading cause of poor performance at nine facilities and was a factor at 43 plants studied. This factor includes inadequate sludge handling facilities and the inability to measure and control the volume of waste sludge. Either one or both of these conditions was noted as having a major impact on performance at several plants.

7. Process Controllability - The lack of controllability was evident in the inability to adequately measure and control flow streams such as return sludge flow and trickling filter recirculation rates. While measurement and control of return activated sludge flow were the most frequent reasons for rating this factor, process controllability was not a major cause of poor performance. It prevented an operator from "tuning" his treatment system to the varying demands which were placed on it by hydraulic and organic loading fluctuations. This factor occurred at 55 plants and was the leading factor at three facilities.

Table 5-4 Cent'd

8. Process Flexibility - Lack of flexibility refers to the unavailability of valves, piping and other appurtenances required to operate in various modes or to include or exclude existing processes as necessary to optimize performance. Poor flexibility precludes the ability to operate an activated sludge plant in the contact stabilization, step loading or conventional modes and the ability to bypass polishing ponds or other downstream processes to discharge high quality secondary clarifier effluent. Either the lack of or inadequate process flexibility was noted as the leading cause of poor performance at three plants and was a factor at 37 facilities.

9. Ineffective O&M Manual Instruction - This situation, existing at 40 plants, was judged serious although the adverse effect was moderate. The poor quality of most plants' O&M manuals undoubtedly has contributed to operators' general lack of understanding of the importance of process control and the inability to practice it, but a competent staff could use other available information sources.

10. Aerator Design - Deficiencies in aerator design were the major cause of poor performance at six facilities and were less significant factors at an additional 21 plants. Deficiencies were noted in the type, size, shape, capacity, and location of the unit and were of such a nature as to hinder adequate treatment of the waste flow and loading and stable operation.

ers, dissolved or induced air flotation system, filtration units, and oil/water separators.

(a) Reducing volumes. Hydraulic overloading may be caused by peak flows in excess of plant design or by average flows exceeding plant design capacity. Peak flows may be remedied by installing equalization basins which will dampen the peaks to acceptable average flow levels. Average loading in excess of hydraulic capacity may be remedied in many cases by elimination of infiltration and inflow. Decreased industrial water use or water recycle may also help to eliminate hydraulic overloading.

(b) Process modifications. Process modifications may be used to increase the hydraulic capacity of an existing system. The addition of chemical coagulant greatly enhances the efficiency of most hydraulic based units. Equipment has been developed to increase hydraulic capacity in some units, such as, tube settlers in clarifiers and corrugated plate interceptors in oil/water separators. If none of these methods provide sufficient increases, construction of parallel units may be necessary.

(4) Upgrading to provide increased organic loading capactiy. Biological units are most affected by organic overloading. Specifically, waste stabilization ponds, activated sludge systems, trickling filters, and rotary biological contractors are among the more easily affected systems. In these systems, organic overloading often results in poor sludge settleability, sludge bulking and odor problems. Increased secondary sludge production caused by overloading could result in problems with sludge thickeners, digesters, dewatering and disposal facilities. When overloaded, many biological systems not only exhibit decreased removal efficiencies, but in severe organic overloading situations they may fail completely. Aerobic systems may become anaerobic and/or the organisms may become completely unsettleable due to filamentous bulking. In activated sludge systems, organic overloading may sometimes result from inadequate mixing which leads to sludge settling in the aeration basin thus reducing the effective biomass in the system. This problem can be solved by increasing the

mixing level through the addition of mixing equipment, draft tubes or hydraulic modifications.

(a) Reducing organic loading. As with hydraulic overloading, organic overloads may be caused by either peak loads or excessive average loads. Peak loads may be dampened by equalization at the source or at the treatment plant. If the average load still represents an organic overload, other correctional methods must be used. In activated sludge systems with low dissolved oxygen concentrations, increasing aeration capacity may provide the oxygen required by the bacteria to assimilate excessive quantities of organic matter. Additionally, enrichment with pure oxygen may also provide the necessary oxygen. If the problem is not insufficient oxygen, increasing the aeration tank mixed liquor volatile suspended solids (MLVSS) level would provide a larger biological population which could subsequently oxidize more organic matter. This line of action is contingent upon the capability of the secondary clarifiers to accommodate higher solids loadings. A similar effect can be achieved by increasing the volume of the aeration basin.

(b) Temperature. One important factor in all biological treatment systems is operation at low temperatures. Since biological reactions slow down as temperature drops, many plants experience operational difficulties under winter conditions. Upgrading methods for winter operation and associated problems are directed toward better heat conservation within the treatment plant. Among the possible winter upgrading methods are reduced mixing in equalization basins, complete or partial bypass around equalization basins, covering equalization basins, and shift from surf ace to diffused aeration.

(c) Capital expansion. Finally, the addition of supplementary organic load reduction units such as roughing trickling filters before biological systems or polishing filters following biological systems, may be necessary to properly upgrade the treatment plant.

(5) Upgrading to meet more stringent standards. Many plants are facing the prospect of having to meet more stringent standards than those for which the plant was designed. Optimization of all operational and design aspects of the existing system may be insufficient to meet the new, more strict standards. Compliance may require construction of additional units depending on the parameters which must be met. Three parameter commonly subject to increasing strict standards are TSS, BOD, and NH_3. Suspended solids removal may be increased by addition of filters, clarifiers, or air flotation systems. BOD removal may be increased by aeration devices, increased aeration tank volumes, roughing units or polishing filters. Ammonia standards may require the addition of biological vitrification units, in-plant control, or the operation of existing biological systems to provide vitrification.

5-6. Environmental impact

The environmental impact statement (E IS) and the environmental assessment are documents which present the results of a study of all the potential effects of a proposed or existing facility or activity on its environment. A discussion of the requirements and preparation of the EIS is included in chapter 4 of this manual. Detailed instructions on the preparation of environmental impact statements are set forth in AR 200-2. Additional guidance is available in the DA Pamphlet 200-1.

5-7. Other considerations

In many instances, establishing a pollution control program involves consideration of factors different from those experienced at similar installations and can be evaluated only at the prospective site. Such factors may include the treatment needs of a new type of process waste; integration with an existing waste system; the effect of system performance under different climatic constraints; and peculiar needs such as architecture, landscaping, and materials of construction. A site visit should be conducted to establish the mission of the installation and to determine any unusual site conditions which may dictate certain pollution control plans.

a. Bench and pilot studies. A basic consideration during wastewater treatment investigations is evaluation of the need for bench (laboratory) and pilot scale studies. There are usually two objectives of such studies. The first is to determine whether the waste is amenable to treatment by the proposed unit operations or processes. The second is to obtain sufficient data to effectively design the full scale facility. Laboratory tests should be conducted before proceeding to pilot scale studies. For existing plants, full scale plant testing may be substituted for pilot studies under some circumstances.

(1) Factors considered. Generally, consideration of the need for bench (laboratory) and pilot scale studies is encountered with treatment of process or industrial wastes. Requirements may be to treat a waste stream or streams for which a suitable treatment method has not previously been established. These studies can also be used to determine if a particular process waste can be

combined and treated with normal sanitary waste. In these instances, laboratory studies are quite often conducted to determine treatability by the system. If it is treatable, then pilot scale studies may be initiated to yield data required for full scale design. Among commonly employed bench and/or pilot scale studies on industrial or combined domestic-industrial wastes are unit processes such as activated sludge, carbon adsorpotion, and dissolved air flotation.

(2) Application to domestic waste. In situations where wastewater requiring treatment originates from sanitary or domestic sources, the need for bench or pilot scale facilities is normally unnecessary. However, it may be desirable or even necessary to conduct such studies to assess the impact of severe climates on some processes; to confirm design criteria; or to determine the most cost-effective process selection.

b. Alternative treatment choices.

(1) Connection to municipal systems. When upgrading existing facilities to meet a higher level of treatment or selecting a wastewater treatment facility for a new installation, consideration shall be given to discharging either raw or partially treated wastewater to a municipal system if such a facility is within a practical and economical distance. When the municipality can provide the necessary increment of treatment capacity, such practice eliminates facility duplication and removes the operational and staffing problems from the military installation. It can also reduce costs. Combined or joint treatment is the preferred method outlined in the 1972 Amendments to the Federal Water Pollution Control Act.

(2) Expanding existing treatment facilities. When an existing facility is expanded to handle more waste or upgraded to provide a higher level of treatment, consideration must be given to integration of additional treatment facilities. Studies must be made to determine the types of processes to be added, timing to avoid service interruption, and provisions for any future facility expansion.

c. Geographic and climatologic. In the selection of a cost-effective treatment scheme, geographic and climatologic conditions must be carefully analyzed. In cold climates, the rate of biological degradation of waste materials decreases with decreasing temperature to a point where it may virtually cease during the winter months. Other treatment schemes, such as physical-chemical treatment, need to be explored in such situations. Extreme cold may cause operating problems due to freezing of mechanical components. Construction is more difficult in cold climates also. Extreme warm weather areas have few unusual treatment problems, because biological systems are aided by higher ambient temperatures.

(1) Cold region treatment systems. The U.S. Army Cold Regions Research and Engineering Laboratory, P. O. Box 282, Hanover, NH 03755, should always be contacted when exploring waste treatment alternatives for facilities located in regions where the ambient temperature is below 32 degrees F for significant periods of the year.

(2) Treatment processes for other areas. Installations located in arid and water-short areas often require the direct and indirect reuse of water due to limited supply. A high degree of treatment is often required for wastewaters prior to discharge due to the very low dilution provided by small stream flows in these areas. In wildlife refuges, fish spawning waters, and wetland areas, wastewater discharges must have low pollutant concentrations to preserve the delicate environmental balance. This is particularly true with regard to toxics, oxygen demanding material, nutrients, and temperature.

d. Treatment reliability. Components of the treatment process must be selected to ensure a high degree of reliability. Duplicate units shall always be provided for high maintenance units, treatment processes requiring frequent cleaning, and units which are essential for proper operational efficiency. Some examples of these are pumps, screens, filters, and chlorination equipment.

(1) Toxic waste. When treating toxic substances such as strong solutions of heavy metal salts and cyanides, sufficient testing after treatment is required to ensure acceptable quality before release. Redundant or duplicate processing steps may also be warranted. Automatic controls should be arranged for fail-safe operation.

(2) Domestic waste. For treatment plants primarily handling sanitary wastes, treatment system reliability is generally geared to established water quality standards.

(3) Establishing reliability requirements. In areas where effluent or stream standards are established, coordination with the Regional U.S. EPA Federal Facilities Coordinator should be employed to determine treatment requirements and reliability y necessary to meet all conditions. The U.S. EPA has set forth certain design guidelines to be used to ensure reliability of treatment processes dependent upon the type of receiving watercourse. Equipment and facilities to meet these requirements shall be incorporated

into the system during the planning and feasibility study analysis.

e. Operation and management. The selection of a wastewater treatment process shall include consideration of the operational expertise and management required. When the geographical location and installation size permit use of treatment ponds, operating needs will be much less than other treatment systems. For other treatment processes, operational capability becomes more of a factor in equipment selection. The increased emphasis on more stringent effluent quality standards and the resulting increase in the degree of treatment complexity, make it mandatory that operators have adequate training and experience. One major responsibility of the operating staff will be to perform all necessary tests to ensure that the effluent meets requirements. When process wastes are involved, more detailed surveillance and testing will be required. Operator capability and management needs are not usually the determining factor in process selection, but should be evaluated and properly weighted in life cycle cost consideration when making process selection.

5-8. Specific treatment needs

After all prior elements of the program are complete, selection of wastewater treatment system components can be made by evaluating all factors.

a. Data analysis. Analyses of all data will begin with the wastewater characteristics establishing the following:

–Average waste flow.

–Total system peak flow as well as peak flows in tributary sections of the system.

–Concentration of pollutants for which parameters (BOD, suspended solids, nutrients, etc.) have been established or can be estimated.

–Sources and type of process wastes.

–-Concentration of process chemicals and any potentially toxic materials.

(1) Waste reduction. The next step will be to factor into these data the effect of any waste reduction practices. The output from the procedure will establish system raw waste loads.

(2) Environmental consideration. The environmental impact statement or environmental assessment will document the required treated wastewater quality and establish the performance level required from treatment facilities. The required performance will serve as the basis for treatment process selection.

b. Selection of pollution control alternatives. If bench and/or pilot scale studies have been conducted on wastewaters to be treated, the results will provide guidance in the selection of process alternatives. With data obtained from the studies, design criteria can be established for feasible alternatives. Cost comparison and operational relationships can be established in selecting a cost-effective system. Pertinent economic considerations should be investigated. If bench or pilot scale studies have not been conducted, then process selection must involve preliminary and detailed screening of available unit processes to meet treatment requirements. Unit treatment processes and their ranges of applicability y, combined with economic criteria, all as discussed herein, will allow the selection of the most cost-effective solution.

c. *Program implementation.* After treatment methods have been established, discussions should be held with the Regional U.S. EPA Federal Facilities Coordinator to review environmental aspects, dates for implementation of the project, and such other information as may be necessary to satisfy regulatory agency requirements. One or more written reports are prepared during the course of the pollution control program investigations. The number and types of reports will depend on the complexity and time span of the project. The final report shall outline the investigations conducted, and summarize the findings and recommendations for implementation of the program. Often it is desirable to assign priority items for implementation of the program on a staged basis. These reports will form the basis for subsequent preliminary and/or final design reports and justification for the project.