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"Chapter 6 – Sewage Treatment and Disposal"

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Chapter 6

Sewage Treatment and Disposal

Topics

1.0.0 Sources of Raw Sewage

2.0.0 Characteristics of Sewage

3.0.0 Sewage Sampling

4.0.0 Sewage Testing

5.0.0 Disposing of and Monitoring Sewage Effluents

6.0.0 Septic Tanks, Cesspools, and Leaching Fields

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Overview

Sewage is the wastewater of community life. In composition it includes dissolved and suspended organic solids that are liable to become putrid and decay. Sewage contains countless numbers of living organisms, bacteria, and other microorganisms whose life activities cause the process of decomposition. When decay proceeds under anaerobic conditions (an absence of dissolved oxygen), offensive conditions result and odors and unsightly appearances are produced. When decay proceeds under aerobic conditions (a presence of dissolved oxygen), offensive conditions do not result and the process is accelerated.

It is important to remove sewage and other wastes to an area away from the center of activity. It is only by such practices that the environment can be maintained in an acceptable and safe condition. Among the waste products of life are the disease-producing (pathogenic) bacteria and viruses that can be readily transferred by sewage from sick individuals to well ones. Procedures for proper disposal of sewage are necessary to protect the health and comfort of the people and to maintain the cleanliness of the environment.

The degree of treatment used for sewage depends on two main considerations: (1) health protection for individuals in the command and community and (2) prevention of water pollution. State and local authorities with statutory authority in pollution control have established standards of purity that are necessary to prevent pollution of natural waters. Accordingly, when a Navy installation discharges liquid waste into controlled waters, the standards set by state and local authorities must be maintained. As a Utilitiesman you may be involved in the installation, operation, and maintenance of systems designed to meet the above requirements. This chapter discusses the major sources of sewage along with sampling and testing procedures and monitoring of sewage disposal ***influents***. In addition to these subjects, septic tanks, cesspools, and leaching fields are also discussed.

1.0.0 SOURCES of RAW SEWAGE

The major sources of raw sewage are domestic sewage, industrial sewage, and storm water.

1.1.0 Domestic Sewage

Domestic sewage consists of waste from toilets, lavatories, urinals, bathtubs, showers, home laundries, and kitchens. It also includes similar wastes from medical dispensaries and hospitals.

1.2.0 Industrial Sewage

Depending upon the source, industrial sewage has characteristics that are different from domestic sewage. Some of these wastes are dangerous to plant operators as well as to the treatment plant and collection system. Industrial waste sources include, but are not limited to, laundry and dry-cleaning plants, metal-cleaning and plating processes, paint spray booths, aircraft and vehicle cleaning racks, boiler plants, photographic processing systems, and fire-fighting activities. Industrial waste systems commonly require pretreatment or a completely separate facility.

Industrial wastes can also be very high or low in pH because of acids and/or bases used in their processes. You may expect intense colors in wastes from painting areas. Grit, salt, and dirt levels may be high from vehicle wash racks.

Radioactive wastes must never be dumped into regular collection systems. They must be handled separately and, in most cases, very carefully.

Explosive or flammable liquids can often enter the system from fuel storage areas. These liquids also create a dangerous fire hazard in a sewage treatment plant.

1.3.0 Storm Water

Storm water should be excluded from the sewage collection system as much as possible. Heavy input of storm water can disturb the operation of a treatment plant by sending it too much water, a problem called hydraulic overloading.

This situation may force diverting or bypassing effluent from the treatment plant. Bypassing is normally a violation of National Pollutant Discharge Elimination System (NPDES) permits. These permits are controlled by the Environmental Protection Agency (EPA). Bypassing can result in releasing bacteria, heavy metals, and other dangerous contaminants into receiving waters. It is to be avoided whenever possible.

Very large paved or roofed areas should not be drained into the sanitary collection system. Maintenance personnel should prevent storm water infiltration as much as possible by ensuring manholes are sealed, pipes are not cracked or broken, and all leaking joints are repaired.

1.4.0 Source Quantity Variables

Each military installation has different wastewater flows depending upon the types or sizes of industrial activities. Normally, 80 to 120 gallons per day per permanent resident and 30 to 50 gallons per day per transient and community labor personnel can be used as a rough volume estimate for flow.

1.5.0 Patterns of Flow

The amount of wastewater a treatment plant receives fluctuates from hour to hour. Changing seasons also affect the pattern flow. Peak flow of domestic wastes normally reaches a plant just after breakfast and for several hours in the early evening. Industrial wastes may reach the plant during the industry's period of operation. If the industry has two or three shifts, flow will be more constant.

The size and topography of the area served by a treatment plant also affects the flow pattern. Small plants may have large differences between peak and low flow periods. Larger plants normally have more uniform rates of flow. The period of lowest flow is usually between 2400 and 0500 hours. Unusual flow patterns help operating personnel identify and correct abnormal surges in flow in the wastewater system.

2.0.0 CHARACTERISTICS of SEWAGE

Sewage is composed of many materials that are broken down into three general areas. These areas are the physical, chemical, and biological characteristics of wastewater. This section will aid you in identifying these various characteristics.

2.1.0 Wastewater Composition

The concentrations of most materials in wastewater are expressed in milligrams per liter (mg/l) and denote the strength of the wastewater. The higher the concentration, or mg/l, the higher the strength. *Table 6-1* lists the most important materials that compose wastewater.

Table 6-1 — Characteristics of Typical Wastewater Generated at Military Facilities.

Parameter	Weak	Medium	Strong
Total solids	330	700	1,200
Total volatile solids	240	420	810
Suspended solids	100	200	400
Total dissolved solids	230	500	800
Volatile suspended solids	70	130	220
Settleable solids*	2	4	6
Biochemical oxygen demand (5 day)	100	200	400
Total nitrogen as N	10	20	40
Ammonia nitrogen as N	4	10	20
Total phosphorus as P	6	10	20
Grease	50	100	150
Chemical oxygen demand	300	450	600
*All the above are measured in milligrams per liter (mg/l) except settleable solids, which are measured in milliliters per liter (ml/l).			

2.2.0 Physical Characteristics

The physical characteristics of wastewater include those items that can be detected using the physical senses. They are temperature, color, odor, and solids.

2.2.1 Temperature

The temperature of wastewater varies greatly, depending upon the type of operations being conducted at your installation. Wide variation in the wastewater temperature indicates heated or cooled discharges, often of substantial volume. They have any one of a number of sources. For example, decreased temperatures after a snowmelt or rainfall may indicate serious infiltration. Changes in wastewater temperatures affect the settling rates, dissolved oxygen levels, and biological action. The temperature of wastewater becomes extremely important in certain wastewater unit operations such as sedimentation tanks and recirculating filters.

2.2.2 Color

The color of wastewater containing dissolved oxygen (DO) is normally gray. Black-colored wastewater usually accompanied by foul odors, containing little or no DO, is said to be *septic. Table 6-2* provides wastewater color information.

Table 6-2 — Significance of Color in Wastewater.

Unit Process	Color	Problem Indicated
Influent of Plant	Gray	None
	Red	Blood or other industrial wastes or TNT complex
	Green, Yellow, Other	Industrial wastes not pretreated (paints, etc.)
	Red or other soil color	Surface runoff into influent, also industrial flows
	Black	Septic conditions or industrial flows

2.2.3 Odor

Domestic sewage should have a musty odor. Bubbling gas and/or foul odor may indicate industrial wastes, anaerobic (septic) conditions, and operational problems. Refer to *Table 6-3* for typical wastewater odors, possible problems, and solutions.

Table 6-3 — Odors in Wastewater Treatment Plant.

Odor	Location	Problem	Possible Solutions
Earthy, musty	Primary and secondary units	No problem Normal	None required
Hydrogen sulfide (H_2S) rotten eggs	Influent	Septic	Aerate, chlorinate, oxonizate
	Primary clarifier	Septic sludge	Remove sludge
	Activated sludge Aeration tanks Trickling filters	Septic conditions (anaerobic)	More air or less BOD, recirculation rate HTH, flood
	Secondary clarifier		Remove sludge and/or grease
	Chlorine contact tank		Remove sludge
	General plant		Practice good housekeeping
Chlorine-like	Chlorine contact tank	Improper chlorine dosage	Adjust chlorine dosage controls
Industrial odors, general	Plant	Inadequate pretreatment	Enforce sewer use regulation

2.2.4 Solids

Wastewater is normally 99.9 percent water and 0.1 percent solids. If a wastewater sample is evaporated, the solids remaining are called total solids*.*

The amount of solids in the system has a significant effect on the total solids concentration in the raw sewage. Industrial and domestic discharges also add solids to the plant influent*.* There are many different ways to classify solids. The most common types are dissolved, suspended, settleable, floatable, colloidal, organic, and inorganic solids.

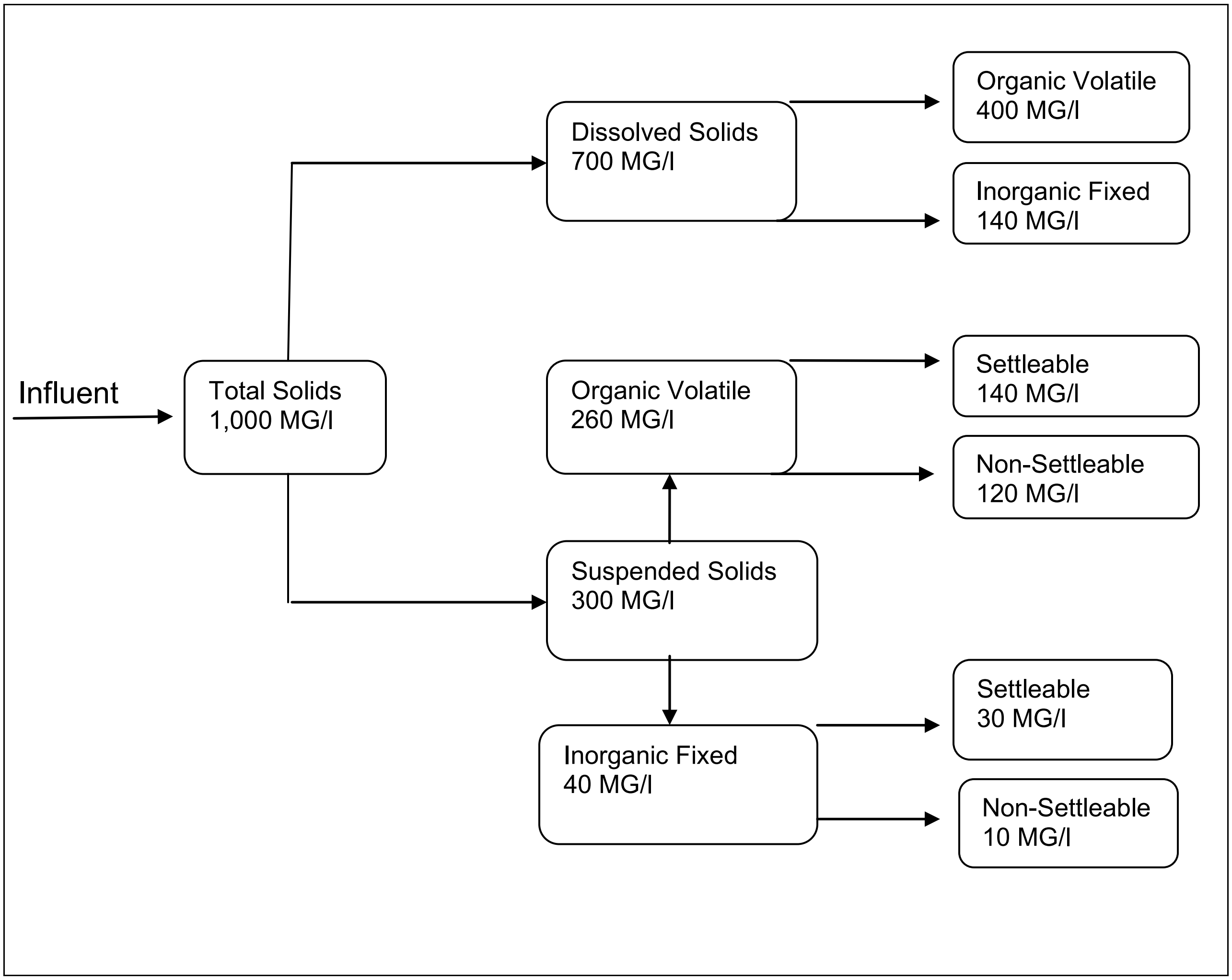
Part of the total solids are dissolved in wastewater. Much like sugar dissolves in coffee, many solids dissolve in water. Dissolved solids pass through a fine mesh filter. Normal wastewater processes using settling or flotation are designed to remove solids but cannot remove dissolved solids. Biological treatment units such as trickling filters and activated sludge plants convert some of these dissolved solids into settleable solids that are then removed by sedimentation tanks.

Those solids that are not dissolved in wastewater are called ***suspended solids****.* When suspended solids float, they are called ***floatable solids*** or scum. Those suspended solids that settle are called settleable solids, grit, or ***sludge****.* Very small suspended solids that neither float nor settle are called ***colloidal particles****.* Colloidal particles are often removed in the biological treatment units. They may also be removed by chemical treatment followed by sedimentation.

All the solids discussed above may be either organic or inorganic. *Organic solids* always contain carbon and hydrogen and when ignited to high temperatures (500°C to 600°C) burn to form carbon dioxide, water, and sometimes various other compounds. The burning or volatilization of organic solids has led to the term volatile solids*.* All solids that burn or evaporate at 500°C to 600°C are called volatile solids. These solids serve as a food source for bacteria and other living forms in a wastewater treatment plant. Most organic solids in municipal waste originate from living plants or animals.

Those solids that do not burn or evaporate at 500°C to 600°C but remain as a residue are called *fixed solids.* Fixed solids are usually inorganic in nature and may be composed of grit, clay, salts, and metals. Most inorganic solids are from nonliving sources. *Table 6-4* summarizes the types and amounts of the solids discussed in the preceding paragraphs.

Table 6-4 — Solids of a Typical Domestic Wastewater.



2.3.0 Chemical Characteristics

The chemical characteristics of wastewater of special concern to the Utilitiesman are pH, DO (dissolved oxygen), oxygen demand, nutrients, and toxic substances.

2.3.1 pH

The term *pH* is used to describe the acid or base properties of water solutions. A scale from 0 to 14 has been established where pH value of 7 is neutral. A pH value less than 7 is acidic. A pH value above 7 is alkaline or basic. *Figure 6-1* lists pH values for some common materials. A pH value less than 7 in the wastewater plant influent may indicate septic conditions of wastewater. The pH values less than 5 and more than 10 usually indicate that industrial wastes exist and are not compatible with biological wastewater operations. Pretreatment of these wastes at the source is usually required since extreme pH values may damage biological treatment units.

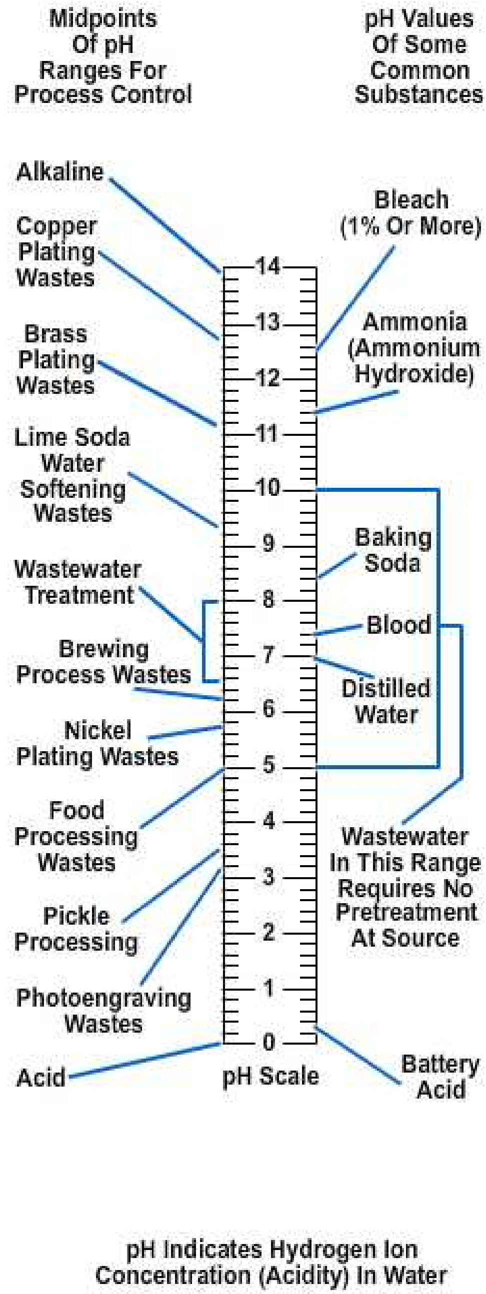


Figure 6-1 — Common substance pH values.

2.3.2 Dissolved Oxygen

Dissolved oxygen (DO) in wastewater has a great effect on the characteristics of the water. Wastewater that has DO is called aerobic or fresh. Aerobic raw sewage is usually gray in color and has a musty odor.

Wastewater that has no DO is called anaerobic or septic. Anaerobic raw sewage is usually black and has an offensive hydrogen sulfide or rotten egg odor.

2.3.3 Oxygen Demand

Oxygen demand is the amount of oxygen used by bacteria and other wastewater organisms as they feed upon the organic solids in the wastewater. Chemical tests such as the BOD (biochemical oxygen demand), the COD (chemical oxygen demand), the ODI (instantaneous oxygen demand or oxygen demand index), and the TOC (total organic carbon) measure the "strength" of sewage. These tests are discussed in detail later in this chapter. It is important that organic wastes be removed to protect the receiving body of water into which the wastewater plant is discharging. Sludge deposits, odors, and fish kills may occur if removal is not adequate.

2.3.4 Nutrients

Nutrients are life-supporting nitrogen and phosphorus. They stimulate excessive growths of algae and other aquatic plant life. They are always present in domestic wastewaters and are not removed during conventional primary and secondary treatment. Removal is accomplished by processes in addition to normal wastewater treatment or tertiary treatment, when specific reuse requirements require it.

2.3.5 Toxic Chemicals

Most military and industrial installations use various types of toxic chemicals, the discharges of which can be harmful to wastewater treatment processes. These toxic chemicals should be pretreated or removed before the wastewater enters the collecting system. *Table 6-6* lists some examples of these types of wastes.

Table 6-6 — Chemicals and Discharges Commonly Found at Military Installations.

Physical	Chemical	Biological
Solids from: Paint Photo lab Sandblasting Grease –valve, etc. Oils Cutting oils Heavy metals Rust Fiber (bacterial slime) Misc. solids (trash) Grit-rocks-sand Color-dyes Metal sulfides	Heavy metals (in solution)- chromium, nickel, lead, zinc, copper, iron oxide chlorine, aluminum, mercury cyanides Phenols Acids- sulfuric, hydrochloric, nitric Base-caustic soda, lime Salts-alum, brine, copper sulfate Ship chemicals Gases Pesticides Germicides Solvents Detergents Adhesives	Bacteria-fecal coliforms Iron and sulfur bacteria Special slimes, fungi, and oil-related growth Algae-green and blue-green Snails and clams Viruses

2.4.0 Biological Characteristics

The three biological organisms present in wastewater are bacteria, viruses, and parasites.

2.4.1 Bacteria

Sewage consists of vast quantities of bacteria, most of which are harmless to man. However, pathogenic (disease-causing) organisms such as typhoid, dysentery, and other intestinal disorders may be present in wastewater. Tests for total coliform and fecal coliform nonpathogenic bacteria are used to indicate the presence of pathogenic bacteria. Because it is easier to test for coliforms, fecal coliform testing has been accepted as the best indicator of fecal contamination. Fecal coliform counts of 100 million per 100 milliliters may be found in raw domestic sewage. Detectable health effects have been found at levels of 2,300 to 2,400 total coliforms per 100 milliliters in recreational waters. Disinfection, usually chlorination, is generally used to reduce these pathogens. Breakdown or malfunctions of chlorination equipment will probably result in excessive discharge of pathogenic organisms and can seriously affect public health.

Bacteria can also be classified according to their dissolved oxygen requirement. Aerobic bacteria are bacteria that require dissolved oxygen to live. Anaerobic bacteria cannot live if dissolved oxygen is present. Facultative bacteria can live with or without dissolved oxygen.

2.4.2 Viruses

Wastewater often contains viruses that may produce diseases. Outbreaks of infectious hepatitis have been traced through water systems because of wastewater entering the supply. Sedimentation, filtration, and disinfection, if used efficiently, usually provide acceptable virus removal.

2.4.3 Parasites

There are also many species of parasites carried by wastewater. The life cycle of each is peculiar to the given parasite. Some are dangerous to man and livestock, particularly during certain stages of the life cycle. Amoebic dysentery is a common disease caused by amoebic parasites. Chlorination, chemical precipitation, sedimentation, or sand filtration is used to ensure protection against parasites.

Test your Knowledge (Select the Correct Response)

1. What term is used to describe wastewater that contains dissolved oxygen?

   A. Anaerobic
   B. Aerobic
   C. Raw sewage
   D. Treated sewage

3.0.0 SEWAGE SAMPLING

Samples of sewage are taken to find out how well a treatment plant is working and what operating changes may need to be made. Some samples show how much the plant is reducing pollutants like BOD, solids, and so forth. Raw sewage entering the plant must be tested as well as the effluent from the plant and the receiving stream above and below the discharge point to determine how well the plant is removing pollutants. Since wastewater flows often change a great deal, daily sampling is suggested.

3.1.0 Representative Sampling

A sample should be taken in a way that will represent the wastewater being treated. No matter how good the lab analysis is, if the sample is not correctly collected, the lab data will not be correct. With the large changes in composition and flow rate, getting a representative sample can be very hard. Careful thought, planning, and training must be used to develop and carry out a good sampling program.

Samples may be taken by hand or automatically. Taking samples by hand may be as simple as tying an open bottle to a pole that can be lowered into the wastewater. *Table 6-7* explains some of the things that should be done when taking samples by hand. The automatic samplers may be purchased or made by the operator.

Table 6-7 — Procedures for Manual Wastewater Sample Collection.

Procedures	Special Cautions
Take samples where wastewater is well mixed.	Weirs are not good sampling points since settling of solids is enhanced upstream, and greases and oils build up downstream from the weir.
Take the samples from the center of the flow channel. To avoid floating scum, hold the mouth of the container below the liquid surface.	Solids often build up near the sides and bottom of the flow channel.
Take a representative sample.	Raw wastewater should be sampled after screening and grit removal. Deposits or nonrepresentative materials such as grease or scum should be excluded from the sample. Particles larger the 0.25 inch (6mm) in diameter should be excluded.
When compositing samples into other containers, thoroughly mix the contents of each before pouring.	If dissolved gases or volatile substances are to be tested, turbulence may be produced by gentle stirring.
Ensure that the sampling containers and sampling devices are clean and uncontaminated and suitable for the planned analysis.	Before the sample is taken, the container should be rinsed several times with the wastewater.
Ensure that the sampling places are easy to reach and that safety precautions are observed.	Proper sampling equipment should be available.

3.2.0 Grab Sampling

A grab sample is a single sample of wastewater taken over a short span of time, usually less than 15 minutes. This type of sample yields data about the wastewater at one time and place. The grab sample should be used where the wastewater does not change suddenly or change a great deal. For example, grab samples may be used to determine pH and temperature. Grab samples are also used when a batch dump or discharge is seen.

3.3.0 Composite Samples

A composite sample yields data about the wastewater over a longer span of time. A series of grab samples may be taken over a certain amount of time and combined to form a composite sample. These samples should show the time and frequency of the sample, for example, an 8-hour composite of 30-minute grab samples. The composite sample is used to find BOD, COD, suspended solids, and nutrients.

3.4.0 Flow Proportional Samples

The composite may be flow proportional. For this type of sample, the volume of the sample changes in proportion to the flow. The flow sludge proportional composite sample is most often run for 24 hours with a 2-hour interval between each collection. To collect this kind of sample, the volume needed for the tests and the average daily flow for the plant must be known. *Table 6-8* shows the volumes required for some tests. The following formula may be used to find the volume of sample to be taken at each interval.

$$\text{Liters required} = \frac{\text{Flow at sampling time}}{\text{Average flow}} \times \frac{\text{Total sample size}}{\text{Number of samples}}$$

For example, to collect an 8-hour composite sample with a 2-hour interval, five samples would be needed. If a total sample of 2 liters was needed, the average daily flow was 60,000 gallons (227 cubic meters), and the flow at the first sample time was 45,000 gallons per day (170 cubic meters), then the milliliters required for the first sample could be figured like this:

$$\text{Liters required} = \frac{45{,}000\ \text{gal/day}}{60{,}000\ \text{gal/day}} \times \frac{2\ \text{liters}}{5\ \text{samples}}$$

$$\text{Liters required} = \frac{170\ \text{cubic meters/day}}{227\ \text{cubic meters / day}} \times \frac{2\ \text{liters}}{5\ \text{samples}}$$

Liters required = .30

Milliliters required = (Liters required x 100) = 300

NOTE

264 gallons = 1 cubic meter (m^3)

Gallons x 0.003785 = cubic meters (m^3)

1 liter = 1,000 milliliters

Table 6-8 — Recommendation for Sample Volume and Preservation of Sample.

Measurement	Type of Sample	Vol. Req. (ml)	Container	Preservative	Holding Time
Acidity	G*	100	P, G**	Cool, 4°C***	24 hr
Alkalinity	G	100	P, G	Cool, 4°C	24 hr
Arsenic	PC****	100	P, G	HNO3 to pH 2	6 mo
BOD	PC	1,000	P, G	Cool, 4°C	6 hr
Bromide	G	100	P, G	Cool, 4°C	24 hr
COD	PC	50	P, G	H2SO4 to pH 2	7 days
Chloride	G	50	P, G	None req.	7 days
Chlorine	G	50	P, G	Cool, 4°C	24 hr
Color	G	50	P, G	Cool, 4°C	24 hr
Cyanides	G	500	P, G	Cool, 4°C NaOH to pH 12	24 hr
Dissolved Oxygen					
Probe	G	300	G only	Det. on site	No holding
Winkler	G	300	G only	Fix on site	No holding
Fluoride	G	300	P, G	Cool, 4°C	7 days
Hardness	G	100	P, G	Cool, 4°C	7 days
Iodine	G	100	P, G	Cool, 4°C	24 hr
MBAS	G	250	P, G	Cool, 4°C	24 hr
Metals					
Dissolved	PC	200	P, G	Filter on site	6 mo
				HNO3 to pH 2	
Suspended	PC			Filter on site	6 mo
Total	PC	1,100		HNO3 to pH 2	6 mo
Mercury Dissolved	PC	100	P, G	HNO3 to pH 2	38 days (glass)
				Filter HNO3 to pH2	13 days (hard plastic)
Nitrogen					
Ammonia	G	400	P, G	Cool, 4°C H2SO4 to pH 2	24 hr2
Kjeldahl	PC	500	P, G	Cool, 4°C H2SO4 to pH 2	24 hr2
Nitrate	PC	100	P, G	Cool, 4°C H2SO4 to pH 2	24 hr2
Nitrate	G	50	P, G	Cool, 4°C	24 hr2
NTA	PC	50	P, B	Cool, 4°C	24 hr
Oil & Grease	PC	1,000	G only	Cool, 4°C H2SO4 to pH 2	24 hr
Organic Carbon	PC	25	P, G	Cool, 4°C H2SO4 to pH 2	24 hr
pH	G	25	P, G	Cool, 4°C Det. on site	6 hr

Table 6-8 — Recommendation for Sample Volume and Preservation of Sample con't.					
Measurement	Type of Sample	Vol. Req. (ml)	Container	Preservative	Holding Time
Phenolics	G	500	G only	Cool, 4°C H3PO4 to pH 4 1.0 g CUSO4/1	24 hr
Phosphorus					
Orthophosphate, dissolved	G	50	P, G	Filter on site Cool, 4°C	24 hr[2]
Hydrolyzable	G	50	P, G	Cool, 4°C H2SO4 to pH 2	24 hr[2]
Total	PC	50	P, G	Cool, 4°C	24 hr[2]
Total, dissolved	PC	50	P, G	Filter on site Cool, 4°C	24 hr[2]
Residue					
Filterable	PC	100	P, G	Cool, 4°C	7 days
Nonfilterable	PC	100	P, G	Cool, 4°C	7 days
Total	PC	100	P, G	Cool, 4°C	7 days
Volatile	PC	100	P, G	Cool, 4°C	7 days
Settleable Matter	PC	1,000	P, G	None req.	24 hr
Selenium	PC	50	P, G	HNO3 to pH 2	6 mo
Silica	PC	50	P only	Cool, 4°C	7 days
Specific Conductance	G	100	P, G	Cool, 4°C	24 hr[3]
Sulfate	PC	50	P, G	Cool, 4°C	7 days
Sulfide	G	50	P, G	2 ml zinc acetate	24 hr
Temperature	G	1,000	P, G	Det. on site	No holding
Threshold Odor	G	200	G only	Cool, 4°C	24 hr
Turbidity	G	1,000	P, G	Cool, 4°C	7 days
*Type G sample = Grab.			**P, G = Plastic or Glass.		
***4°C = 4 Celsius.		****PC = Proportional Composite.			
1. If samples cannot be returned to the lab in less than 6 hours and holding time exceeds this limit, the final reported data should show the actual holding time.				2. Mercuric chloride may be used as an alternate preservative at a concentration of 40 mg/1, especially if a longer holding time is required. However, mercuric chloride should not be used if something better is available.	
3.If the sample is stabilized by cooling, it should be warmed to 25°C for reading, or temperature correction made and results reported at 25°C.				Note: It has been shown that certain samples properly preserved may be held beyond the recommended holding time. Consult designated authority.	

3.5.0 Sample Stowage

To get the best results, samples should be analyzed as soon as possible after they are collected. Some tests, such as DO, temperature, and pH, must be performed at the time of collection since the results can change while the sample is being carried to the lab. Some other tests may be delayed if the sample is properly stored. The most common means of preserving a sample is to cool it to 2°C to 10°C. *Table 6-8* shows some ways to preserve the sample.

3.6.0 Identifying samples

After the sample is collected, it should be identified with a label. The label should include the following information:

- Where the sample was taken
- Date and time of collection
- Type of sample (grab or composite, with the appropriate time and volume information)
- Anything that might change before laboratory testing, such as temperature, pH, and appearance
- Initials or name of the person who took the sample

Test your Knowledge (Select the Correct Response)

2. For proper storage, you should maintain the sample within what temperature range?

   A. 18°C to 26°C
   B. 10°C to 18°C
   C. 2°C to 10°C
   D. -2°C to -10°C

4.0.0 SEWAGE TESTING

Laboratory reports are useful in the operation of a wastewater treatment plant. The operator can use laboratory test results to keep the plant working at its best and to give early warning of operating problems. Laboratory testing programs vary with the type of treatment, size of the plant, local water quality requirements, and the NPDES permit requirements. Some of the most common laboratory tests for wastewater treatment plants are shown in *Table 6-9*. They are discussed later in this chapter. Laboratory tests required by NPDES are determined for each treatment plant and are cited in the discharge permit. The normal procedures for these tests are given in *Standard Methods for the Examination of Water and Wastewaters* and *Methods of Chemical Analysis of Water and Wastes*, published by the EPA.

Table 6-9 — Important Laboratory Tests.

Test to be Performed	Sampling Point	Recommended Means of Collection	Recommended Frequency of Collection
Settleable solids	1. Influent 2. Final effluent	Grab or composite	Daily
Suspended solids	1. Influent 2. Final effluent	Proportional composite	Weekly
BOD5 or COD	1. Influent 2. Effluent 3. Stream—above & below discharge	Proportional composite	Weekly
Dissolved oxygen	1. Influent 2. Final effluent 3. Stream—above & below discharge	Grab	Daily
pH	-----	Grab	Daily
Fecal coliform	Final Effluent	Grab	Weekly
Alkalinity	1. Final effluent 2. Digester	Proportional composite or grab	Daily
Chlorine residual	Final effluent	Grab	Daily (at least)

4.1.0 Laboratory Equipment

Examples of the various types of laboratory equipment are shown in *Figures 6-2* and *6-3*. In order for the operator to conduct accurate sewage tests, the laboratory must be equipped with a minimum of equipment. *Table 6-10* lists the types of equipment needed for some of the basic laboratory tests.

The operator should always maintain this equipment in a high state of repair and cleanliness. Any contamination of the test equipment may adversely affect the results. Refer to the manufacturer's instructions for the proper maintenance procedures for each piece of equipment. *Table 6-11* gives some basic guidelines for the maintenance and use of various types of laboratory equipment.

Safety should be vital to all personnel conducting sewage tests. Good housekeeping is essential in a laboratory to prevent mishaps and damage to expensive equipment. Each piece of equipment should be cleaned and returned to its proper place after being used.

When conducting sewage tests, it is always wise for the operator to avoid actual contact of the hands with the sewage samples or other filth. Hands must be kept out of the nose, mouth, and eyes. It is particularly important to use gloves when the hands are chapped or burned, or the skin is broken from any wound. Operators should thoroughly wash their hands with plenty of soap and hot water before eating.

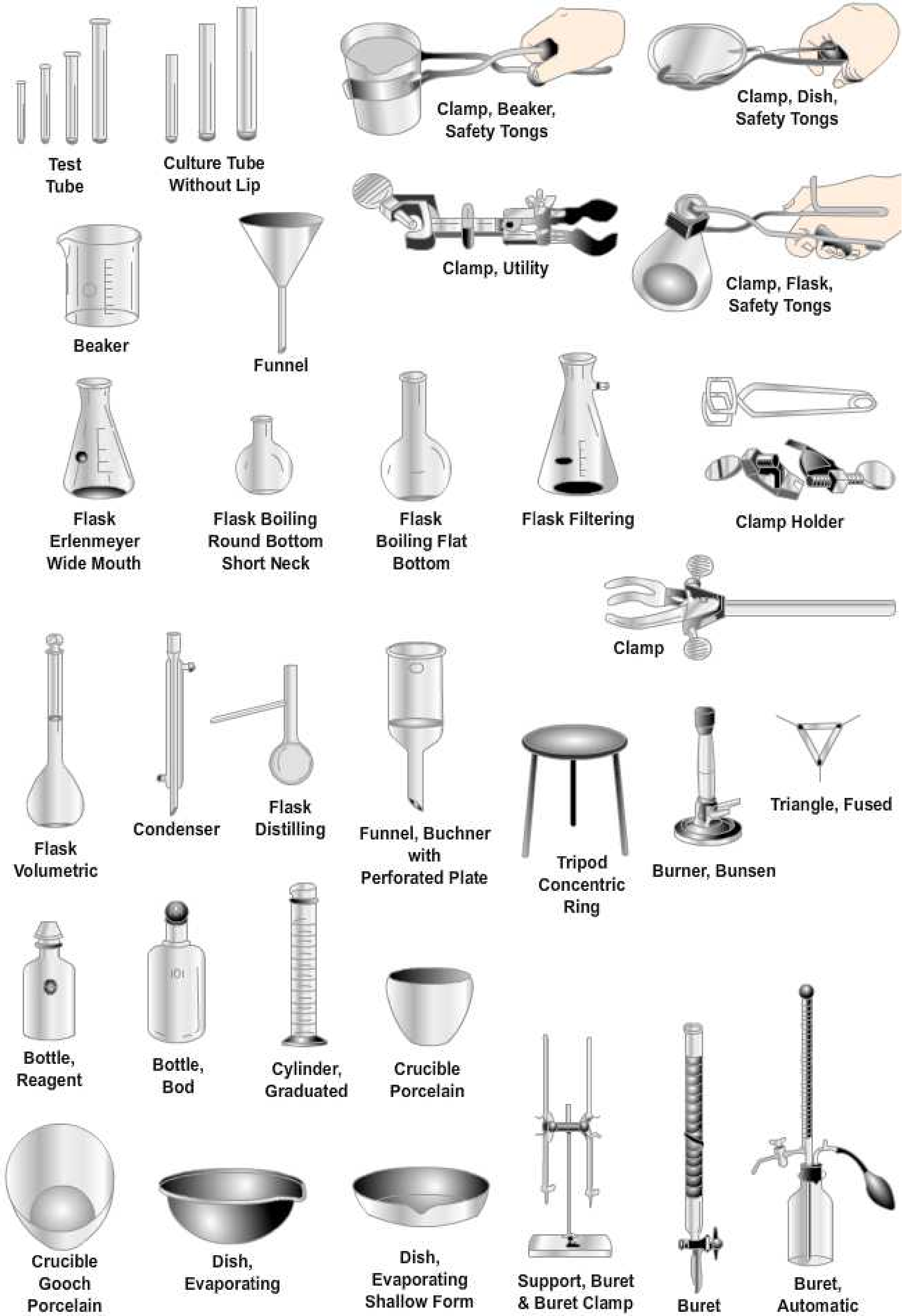


Figure 6-2 — General laboratory equipment.

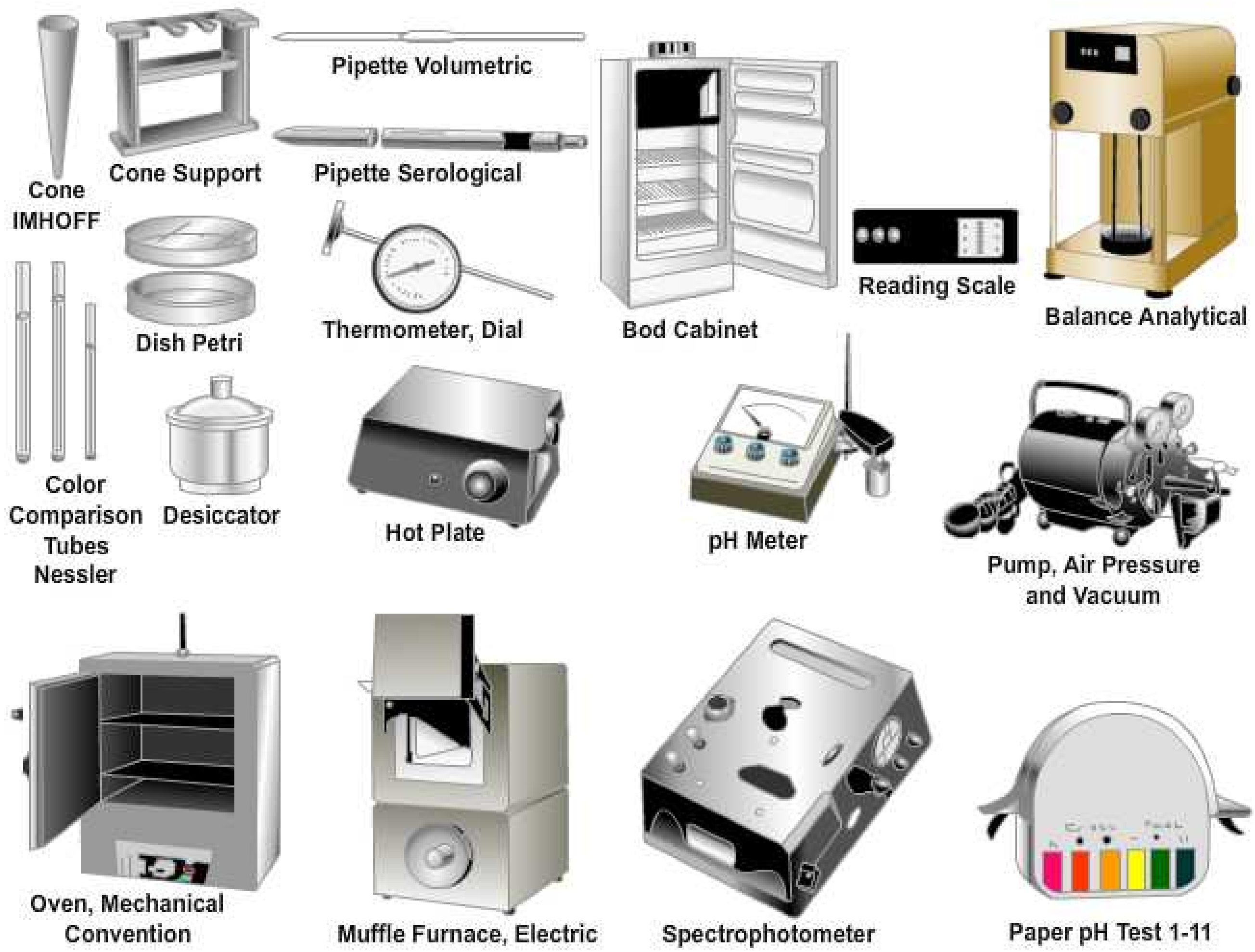


Figure 6-3 — General laboratory equipment.

Table 6-10 — Types of Equipment Needed for Various Laboratory Tests.

	Equipment Needed*																												
Constituents to be Analyzed	Atomic Absorption	600^0C Muffle Furnace	103^0C Drying Oven	Analytical Balance	Imhoff Cone	pH Meter	Lamotte Kit	BID Incubator	Vacuum Pump	Hot Plate	Kjedahl Unit	Condenser/Extract. Eq.	DO Meter & Probe	Autoclave	Amperometric Titrat.	35^0C Incubator	Gas Analyzer	Steam Bath	Magnetic Stirrer	Blender	Turbidity Meter	Carb. Adsorp. Unit	Desecrator	Spectrophotometer	Stirring Equip.	Vibrating Shaker	Total Org. Carb. Analy	Purity Meter	Water Still
Volatile Solids		x	x	x																			x						
Total Solids			x	x																			x						
Settleable Solids					x																								
pH						x																							
Total Sulfides							x																						
BOD								x																				x	x
COD										x		x								x								x	x
Suspended Solids				x	x				x														x						
Dissolved Oxygen													x																
Chlorine Residual															x														
MPN Coliform**																													
Volatile Acids										x		x																x	x
Alkalinity						x													x										
Gas Analysis																	x												
Grease				x	x				x	x		x						x											
Total Organic Carb.																											x		
Turbidity																					x								
Volatile SS		x	x	x					x														x						
Total Phosphorus																													
MBAS***																									x				
Sludge Filterability						x		x																					
Ash Analysis		x		x																									
Jar Test																									x				
Apparent Density				x																						x			
Isotherms			x	x					x												x					x			
Calcium Content				x																			x						
Ammonia Nitrogen										x		x																	
Organic Nitrogen										x	x	x																	
Nitrate Nitrogen																								x					
Heavy Metals	x																												

Table 6-11 — Maintenance Guide.

Equipment	Function	Used for	Instructions*
ANALYTICAL BALANCE	Precision weighing.	Preparation of standards. Weighing samples of total and suspended solids, sludge moisture, oils, and grease.	Install on heavy shockproof table away from vibration and extreme temperature variations. Keep level at all times.
TRIP BALANCE	Course weighing.	Weighing samples of MLSS, wet sludge filter cake, grit, and chemicals.	Maintain and use according to manufacturer's instructions.
pH METER	pH measuring.	Analysis of wastewater, industrial waste, and determining endpoints of alkalinity, acidity and ammonia tests, also streams, surface water, and various solutions.	Calibrate frequently with buffers at pH 4.0, 7.0, and 10.0. Be sure buffers are fresh. Immerse electrodes in distilled water while not in use. Discard electrodes with broken tips and deep scratches. Keep electrode reservoir filled. Rinse electrodes with distilled water after each operation. Keep sample mixed during test. Observe temperature of sample and adjust meter.
DRYING OVEN	Controlling drying of samples. Drying samples and glassware.	Drying samples suspended and dissolved solids and sludge. Also drying chemicals and glassware.	Equip with accurate thermometer. Be sure temperature controls are working properly. Keep doors fitted tight to prevent heat loss. Clean the oven frequently. Arrange samples to prevent cross-contamination. Locate away from heat-sensitive equipment.
MUFFLE FURNACE	Igniting (burning) volatile substances.	Determining amount of volatile and fixed solids in suspended, total, activated, and digested solids and/or sludge samples. Igniting barium sulfate precipitates in sulfate testing.	Be sure the furnace is equipped with an accurate temperature control. Keep heat chamber clean. Check frequently for deposits of soot and ash. Be sure that fumes are properly exhausted. Locate away from heat-sensitive equipment.

Table 6-11 — Maintenance Guide, Continued.

Equipment	Function	Used for	Instructions*
DESICCATOR	Providing moisture-free atmosphere for temporary storage of glassware, chemicals, and samples.	Drying chemical powders. Cooling glassware and samples before reweighing.	Check doors or lids for tight seal. Keep closed at all times except when inserting or removing materials. Be sure desiccant material is active. Replace or replenish inactive desiccant.
BOD INCUBATOR	Providing constant light-free temperature for BOD samples.	Incubating BOD samples at 20°C for 5 days.	Check temperature controls for accuracy. Be sure proper temperature is maintained at all times. Be sure door closes and seals properly. Keep chamber clean and free of biological growths.
WATER DISTILLATION UNIT	Distilling water to laboratory standards.	Providing high-quality water for chemical solutions, BOD dilution, bacteriological and chemical analyses. Also water for rinsing analytical glassware.	Check temperature control for accuracy. Be sure boiler, condenser coils, and tubing are free of deposits and scale. Clean frequently. Use borosilicate glass storage containers with tight covers to exclude airborne dust, gases, and organisms. Test pH and conductivity frequently to help ensure purity.
DEIONIZER	Purifying water by ion exchange rather than by distillation.	Same as for water distillation unit.	Use ion exchange cartridges of proper type. Discard cartridges at once when exchange capacity is exhausted. Be sure water feed rate is not exceeded. Store deionized water same as distilled water.
CALORIMETER OR SPECTROPHOTOMETER	Quantatively measuring water quality by calorimetric method.	Testing for phosphorus, nitrate, nitrite, hexavalent chrome, color, sulfate by turbidity method, phenols, residual chlorine, and others.	This equipment is delicate. Handle with care. Keep adequate stock of replacement parts. Be sure the equipment is properly calibrated before use for transmittance or absorbance readings. Be sure to use proper filter for test being performed.

Table 6-11 — Maintenance Guide, Continued.

Equipment	Function	Used for	Instructions*
REFRIGERATOR	Low temperature storage.	Storage of wastewater and sludge samples at 4°C. Also storage of unstable chemicals.	Check temperature controls for accuracy. Keep interior clean and free of biological growths. Provide refrigerator(s) with adequate capacity for laboratory needs.
AUTOCLAVE	Sterilization by steam.	Sterilization of dilution water, glassware, sample media, and related items for bacteriological testing.	Check time, temperature, and pressure controls for accuracy. Confirm sterilization by use of test strips or other indicators. Be sure sterilized materials are properly wrapped, sealed, and stored to prevent contamination.
HOTPLATE OR HEATER	Healing liquids and solids.	Preparing analytical solutions. For evaporation concentration, hydrolysis digestion, and other analytical operations.	Check temperature controls for accuracy. Be sure units are adequate for laboratory needs. If controls are manual, do not leave hotplates unattended.
DISSOLVED OXYGEN ANALYZER	Instrumental measuring of dissolved oxygen.	Testing wastewater, industrial waste, streams, and BOD samples for dissolved oxygen.	Check accuracy of instruments frequently. Recalibrate, if necessary, using approved standards. Store probe in water or in moisture-saturated air. Keep probes clean. Change membranes and replace electrolytes as recommended by manufacturer.
BACTERIA INCUBATOR	Providing constant temperature during incubation of samples.	Coliform and other bacteriological tests.	Check accuracy of temperature controls. Keep storage chamber clean and free of spillage and bacteriological growths. Check doors for proper closing and sealing. Locate unit where not exposed to extreme temperature changes.
WATER BATH INCUBATOR	Providing constant temperature for water bath incubation of samples.	Testing coliform and nitrate samples. Also digestion of wastewater samples.	Check accuracy of temperature controls. Keep storage chamber clean and free of rust, scale, and sediment. Check cover and seal for proper fit. Maintain bath water at correct level.

Table 6-11 — Maintenance Guide, Continued.

Equipment	Function	Used for	Instructions*
CONDUCTIVITY METER	Measuring electrical conductance/resistance of a solution.	Testing distilled water, water, and wastewater samples.	Calibrate frequently against known reference. Keep electrode clean and stored in distilled water between tests. Observe between tests. Observe sample temperature and make necessary adjustment.
TOTAL ORGANIC CARBON ANALYZER	Analyzing carbon fractions by combustion/infrared methods.	Rapid analysis of total inorganic and organic carbon in water and wastewater samples.	Due to the complexity of this unit, problems should be referred to specially trained technicians.
ATOM ABSORPTION SPECTROPHOTOMETER	Analyzing metal ions by atomic absorption/emission method.	Testing samples for heavy metal or toxic metal ions.	Be sure the unit is properly installed with fume exhaust system. Problems with the unit should be referred to a specially trained technician.
*Always follow manufacturer's instructions for maintenance and operation.			

4.2.0 Dissolved Oxygen Test

The DO test finds the milligrams per liter (mg/l) of oxygen that are dissolved in water or wastewater. Oxygen exists as a gas and can dissolve in water in only a limited amount. Pure water at 20°C at sea level can hold a maximum of 9.17 mg/l of DO. Raising the temperature, salt content, or altitude will lower the DO level in the water. An important thing to remember is that this test should be run as soon as possible after the sample is taken. It must always be run as a grab sample. It is best to test several samples taken at different times during the day because the DO content of wastewater may vary. If incoming wastewater has no DO, it is septic. Most wastewater treatment plants are not built to treat septic wastewater. A great deal of plant and animal life that lives in water and wastewater, including necessary microorganisms, needs DO just as we need oxygen from the air. If the DO is used up, aerobic organisms will die and the water will become anaerobic or septic, and foul odors will develop. If this occurs, you should check for flow problems within the sanitary system upstream of the treatment plant.

4.3.0 Hydrogen Ion Concentration (pH Value) Test

The measure of acidity or basicity (alkalinity) of something is called the pH. The effect of pH on some parts of wastewater treatment makes it an important test. A low pH of domestic wastewater may mean that the wastewater is septic, or it can mean that industrial or commercial acid wastes are entering the system. A pH of 6.5 to 8 is about right for treatment plant influent. Test results showing a very high or low pH may mean someone is breaking sewer use regulations. Sudden changes of 0.5 or more on the pH scale may mean that operating problems are starting. Grab samples should be taken for pH tests.

4.4.0 Settleable Solids Test

The settleable solids test on wastewater can tell the operator a lot about what kind of wastewater is coming into the plant and how the solids are settling. Also, the settleable solids test can help the operator estimate the volume of sludge to be expected in the clarifier.

Either grab or composite samples will work for this test. The test is done using an Imhoff cone. The Imhoff cone (*Figure 6-3*) can be either glass or plastic. It can hold 1 liter and is marked off in milliliters (ml).

Before running the test, you should allow the sample to settle for 45 minutes. After 45 minutes, you should run a glass or plastic rod gently down the inside of the cone and turn it to loosen solids clinging to the sides. Settling should then continue for another 15 minutes. The depth of the solids in the bottom is then read from the scale and recorded as milliliters of settleable solids per liter of wastewater.

4.5.0 Activated Sludge Settleability Test

The settleability test is often used with all kinds of activated sludge plants to find the amount of solids in aeration units. The results help the operator to decide when to waste sludge and to find the rate of sludge return. The activated sludge settleability test can be run in a 1,000 ml graduated cylinder or in any clear, wide-mouthed container. The container should be ruled off into 10 units, such as centimeters, milliliters, or inches. The sample is poured into the cylinder or jar up to the top mark and allowed to settle. Readings are taken from time to time to find settling rates. The sample should be allowed to settle for about 30 minutes.

4.6.0 Five Day Biochemical Oxygen Demand (BOD_5) Test

The BOD_5 test is the most important test for finding the polluting strength of a wastewater. It is the most widely used way to check how the treatment plant is running. The BOD_5 test indirectly measures the amount of organic material in the sample. Either grab or composite samples may be used for this test.

NPDES permits often state that influent and effluent flow-proportional composite samples be taken for the BOD_5 test. Normal domestic wastewater coming into the plant should be in a 200 to 300 mg/l BOD_5 range. The effluent must comply with the plant's NPDES permit.

To run the test, the amount of oxygen is measured in a portion of diluted wastewater, and another portion like the first one is stored at 20°C for 5 days. The glass bottles shown in *Figure 6-3* are used for this test. During the 5 days, the microorganisms eat the organic matter in the wastewater and use oxygen at the same time. At the end of 5 days, the amount of oxygen consumed by the microorganisms times the dilution factor of the sample gives the sample's 5-day BOD. The dilution factor is the number of milliliters of dilution water added to a given number of milliliters of sample.

4.7.0 Chemical Oxygen Demand (COD) Test

Like the BOD5 test, the chemical oxygen demand (COD) test finds the amount of oxygen required to consume the organic matter in a wastewater sample. The COD test does not measure the amount of oxygen used by the microorganisms. It uses a strong chemical--concentrated sulfuric acid silver sulfate solution. It is a good operating control test because the results can be obtained in as little as 1 hour. COD test results are equal to or greater than BOD5 test results. The chemical used in the COD test attacks more organisms in the wastewater than the slower BOD5 organisms. BOD5 data can often be related to COD data by a multiplying factor. For instance, the 200 to 300 mg/l BOD5 of normal wastewater influent is about two-thirds of its usual 300 to 450 mg/l COD value. If such a factor can be figured for a certain kind of wastewater, COD data can be used to predict BOD 5 test results that will not be known for 5 days.

4.8.0 Total Suspended Solids Test

Total suspended solids are those solids in wastewater that can be taken out with a filter having a specified pore size. Suspended solids are made up of settleable solids and nonsettleable solids. Suspended solids tests can be run with either grab or composite samples, but flow proportional composite samples are the best for this test. Influent wastewater may have as much as 400 mg/l of suspended solids.

4.9.0 Mixed Liquor Suspended Solids Test

The suspended solids test that is run on the aeration tank mixed liquor is called the mixed liquor suspended solids test or MLSS test. It is used as a control test to help find out whether to increase or decrease the rate of sludge return and when to waste sludge. The very high solids content of mixed liquor requires a larger diameter filter (11 centimeters instead of 2.4 centimeters) to prevent rapid clogging.

4.10.0 Chlorine Residual Test

When chlorine is used to disinfect the effluent, tests are needed to see if the chlorine residual requirement has been met. The chlorine residual test may be run using the *iodometric* or *amperometric* methods. Since grab samples are used for these tests, most states suggest that the test be run within 30 minutes after taking the sample.

4.11.0 Fecal Coliform Test

The fecal coliform test is an indicator of harmful bacteria in the wastewater. Both the membrane filter and most probable number (MPN) can be used to run the test. If the sample is not prepared for the test on the site, it should be cooled to 4°C within 30 minutes and then tested within 6 hours.

4.12.0 Alkalinity

The alkalinity test can tell the operator a lot about the wastewater in the plant. A very high alkalinity in the wastewater may mean that an alkaline industrial waste has entered the system. The alkalinity test is often used to see how the anaerobic sludge digesters are working. The alkalinity in treatment lagoons usually goes down as the lagoon becomes septic. The alkalinity usually shows a 20 to 30 mg/l change before there is a change in pH.

4.13.0 Laboratory Records

Records can be used to find the best operating controls for a wastewater plant, problems that might arise in the plant, and the future needs of the plant. Records may also be used in court if a lawsuit is filed against the treatment plant.

The treatment plant should keep three kinds of records: physical records that describe in detail all areas of the plant itself, maintenance records that show what repair and cleaning have been done or needs to be done, and performance records that show the plant’s operating data.

Physical records include operation and maintenance (O&M) manuals, actual plans and blueprints for the plant, shop drawings, O&M guides from equipment manufacturers, costs for all units, a hydraulic profile showing the height of water in all treatment units, and an equipment record. Under Public Law (PL) 92-500, consulting engineers are required to provide operation and maintenance (O&M) manuals for the treatment plants they design. These O&M manuals must meet the requirements of *Considerations for Preparation of Operation and Maintenance Manuals,* EPA, Washington, D.C., 1974.

Preventive maintenance in the treatment plant can reduce costly repairs and downtime on equipment. One of the key steps in a good maintenance program is keeping records. These records include the data needed to make a maintenance schedule, to estimate a maintenance budget, and to build up enough spare parts.

A record of all equipment in the plant must be made. This can be done on index cards. Each piece of equipment should be given a number based on where it is located in the plant. This number is written on an index card with the name of the equipment, its location in the plant, the name and address of the manufacturer or supplier, the cost, and the date of installation. The card should also have the type, model, serial, and any other code numbers, along with the capacity or size rating. The same card or another set of cards should include the type of maintenance required and how often it is needed, the special lubricants or coatings needed, and a record of all work done on the unit, including the labor, parts, and total cost. This data should be considered when planning to buy new equipment and making a maintenance schedule.

Making a maintenance schedule requires careful thought. Good records can serve as a guide. Some large treatment plants now use a computer to plan maintenance schedules and keep records up-to-date. Preventive maintenance should be scheduled so it can be done during good weather and not during times of peak load at the plant. Also, the schedule must leave time for repair work. A large chart showing what needs to be done daily, weekly, monthly, quarterly, semiannually, and annually can help in setting up a work schedule.

A spare parts inventory should be established. The command supply procedures should be followed but these steps may assist you if needed. Many spare parts must be ordered several days or weeks before they are delivered. These spare parts should be stocked at the treatment plant so the plant will not have to be shut down until the part arrives. A list or inventory of spare parts makes reordering simpler. A written record of parts used and replaced should be kept. The operator should record the date an item was ordered, the date delivered, its cost, and the name of the supplier each time a part is ordered and delivered.

In addition to the above records you must also maintain performance records. There are three types of performance records: laboratory records, operator's log, and NPDES forms.

A complete set of laboratory records should be kept for all laboratory tests. The laboratory record should have the date and time the sample was taken, the method used to take the sample, the name of the person who took the sample, the place where the sample was taken, the test performed on the sample, and the results of the laboratory test. These records should be kept in a bound notebook so they can be used as a part of legal testimony about the operation of the plant if need be. A monthly or quarterly report is also required at most plants.

A monthly report is required for all wastewater plants on a military installation. Since no two treatment plants are exactly the same, the operator will find that a special log designed for the treatment plant is helpful. The operator should report on special features of the treatment plant under the blank columns in the log. Operators at each treatment plant are required to complete the log. Navy plant operators use the *Wastewater Treatment Plant Operating Record,* NAVFAC 11340/1 (6-75).

Finally, every treatment plant that discharges to a body of water must get an NPDES permit from the EPA or the designated state agency. The permit lists standards for the effluent, tests required, frequency of running the tests, and the sampling method of each test. The treatment plant must submit a monthly or quarterly report to the EPA or the designated state agency with all the laboratory tests required by the permit. These reports and laboratory records must be kept for at least 3 years.

Use performance records to check the plant. The performance records at a treatment plant can provide good process control data to the operator. Results of laboratory tests that differ a lot from previous records may show an equipment breakdown, an industrial waste discharge, or a break in the collection system. *Table 6-12* shows some changes from normal values and some causes for these changes.

Table 6-12 — Variations in Performance and Some Common Causes.

Variation	Possible Cause	Solution
BOD_5 (or COD): Increase	Increased organic loading. Population growth. Industrial expansion.	Identify source of increase. If overloading is permanent, adjust treatment plant processes for maximum efficiency. Require adequate pretreatment. Enforce sewer use regulations if violations are found. Install holding tanks (ponds) if feasible. Modify or expand treatment units.
	Septic influent.	Freshen by aeration or chlorination.
	Septic conditions in treatment plant units.	Check on detention time and sludge pumping schedule. See if dissolved oxygen requirements of aerated units are being met.
BOD_5 (or COD): Decrease	Decrease in organic loading.	No problem.
	Wastewater organisms killed by toxic waste.	Find source of toxic waste. Require neutralization or exclude from treatment facility by enforcing sewer use regulations. When toxic waste is found, immediately notify appropriate military and regulatory authorities. Immediately seek advice from qualified specialists as to disposal of toxic waste remaining in the plant. Disposal after neutralization and/or dilution may be no problem.
Suspended Solids: Increase	Industrial expansion or population increase. Changes in industrial processes.	Generally, same procedure as for BOD_5 increase, unless growth and expansion are the causes. Check pretreatment for operation. Also check for industrial “dumping.” Enforce sewer use regulations, if applicable.
Suspended Solids: Decrease	Collection sewers blocked (clogged).	Inspect, clean, and flush if needed.
	Broken or completely blocked sewer resulting in bypassing.	Clean and flush sewer if clogged. Repair or replace if sewer is broken or settled out of position. If wastewater is bypassing, treat with chlorine at once.

pH: Increase	Industrial discharge. Inadequate pretreatment.	Try to find source of alkaline (basic) discharge and require pH adjustment before discharge to collection system. Check on operation of pretreatment units.
pH: Decrease	Industrial discharge. Inadequate pretreatment.	Try to find source of acidic discharge and proceed as suggested above.
	Septic influent.	Check sewers for low velocity (flat grades) and blockage (clogging). Clean and flush sewers. Chlorinate if necessary. Check lift station wet wells for proper detention time (not more than 30 minutes in warm weather). If the cause cannot be remedied, then freshen the septic wastewater at the head of the treatment plant by using aeration and/or chlorine. If the pH remains too low for satisfactory operation, adjust by applying alkaline chemical such as lime or soda ash.
Wastewater Flow: Increase	Population and industrial expansion	Consider installing holding ponds or tanks. Consult with industry to prevent “dumping” during high flow periods. If increased flow is expected to be continually above treatment plant design capacity, plant expansion and/or modifications should be considered.
	Infiltration-Inflow.	Check collection system for unauthorized storm and surface water connections. Enforce sewer use regulations. Repair or replace broken or cracked pipes and leaky joints. Raise or provide good surface drainage for manhole covers in low areas. Install holding ponds or tanks.
Wastewater Flow: Decrease	Bypassing leakage (exfiltration).	Check collection system for leaks and bypassing. Make necessary repairs. Notify appropriate regulatory officials at once. Request their advice.
	Decreased water use.	Recirculate enough of the treatment plant effluent to primary clarifier, trickling filter (or other unit) to prevent excessive detention time and provide better operation.
Temperature Influent: Increase	Discharge of hot wastes.	Enforce sewer use regulations if temperature is high enough to hinder operation.
Temperature Influent: Decrease	Infiltration—inflow of storm water.	Locate points of entrance. Repair if needed. Enforce sewer use regulations, if applicable.
Chlorine Demand: Increase	Inefficient operation due to septic conditions, poor settling, and other operating problems.	Check on efficiency of each treatment unit. Adjust controls to secure maximum efficiency. Check sludge-pumping schedule and rate, recirculation of effluent, aeration rate, trickling filter operation, and return of digester supernatant. Check for proper detention time in clarifiers and aeration tanks.
	Industrial discharges. Slug loading or “dumping.”	If possible, secure cooperation of industry in controlling time and rate of discharging strong waste.
	Chlorine feed equipment not properly working.	Check accuracy of dosing equipment. The problem could be improper dose instead of increased chlorine demand. Find out if chlorine and wastewater are being properly mixed.
	Temperature.	Wastewater with high temperature usually requires more chlorine to satisfy the chlorine demand.

5.0.0 DISPOSING of and MONITORING SEWAGE EFFLUENTS

The wastewater treatment process includes taking the solids out of the wastewater, getting rid of the solids, and getting rid of the treated wastewater or effluent in a way the federal and state regulating agencies approve.

All plants that discharge an effluent must have NPDES permits issued by the EPA or by a state agency for the EPA. Before these permits are given to the plant, officials make a careful survey of the water use nearby that might be hurt by the effluent of the treatment plant. The permit may list top, bottom, or average limits for some kinds of pollutions. It may also state in what way the plant can dispose of its effluent. If the plant does not meet the limits on the permit, the operator should contact the regulating agency at once. The permit can be changed or revoked by the agency. Sometimes the plant may be allowed to discharge more than the limit on the permit, but that is up to the regulating agency. The purpose of the permit is to protect human health and natural resources. All operators should know the permit limits and make every effort to ensure that the treatment plant complies with them.

5.1.0 Effluent Discharge Methods Laboratory Equipment

The two major methods of discharging effluent are continuous discharge and intermittent discharge.

Most treatment plants discharge an effluent to a receiving water all the time. The effluent may go to an ocean, gulf, bay, lake, or stream. The point of discharge may be above or below the surface of the receiving water. Continuous discharge is often cheaper than other methods because it takes less manpower, equipment, and storage to operate. However, a very good monitoring program must be used to make sure toxic waste is not discharged. After a toxic waste is discharged, there is no practical way to stop or isolate the toxic substance.

Intermittent discharge means that the effluent is not discharged all the time, but only from time to time. This type of discharge requires a place to store the effluent. It is not often used at large plants. But it does work well at lagoons and small treatment plants that have holding or “polishing” ponds.

Intermittent discharge lets the operator choose the time and rate of discharge. A controlled amount of effluent can usually be discharged without hurting the quality of the receiving water if the operator picks the right time for all discharges. In some cases, the receiving water has even been improved. Intermittent discharge may cost more to build, but it does not require as costly a monitoring program. When there is no discharge, there is no effluent to be tested.

A special type of intermittent discharge is seasonal discharge. This type of discharge is often used to protect high-quality streams, especially during the season when the stream is used a great deal for recreation. More storage is needed for seasonal discharge because there are usually only two discharges, one in spring and one in autumn. The effluent is discharged under controlled conditions approved by the regulating agencies.

5.2.0 Methods of Disposing and Monitoring Sewage Effluents

Several methods of disposing of sewage effluents are used today. All methods must conform to the NPDES permit requirements and must be closely monitored. This section discusses these methods as well as troubleshooting problems with sewage effluent quality.

5.2.1 Direct Discharge to Receiving Water

Most treatment plants discharge effluent right into the receiving water. The abilities of the receiving water to dilute and accept the effluent is shown in the NPDES permit limits. The NPDES permit also considers the use of the receiving water. The effluent may come from a final clarifier, a disinfection contact basin, a lagoon, a polishing pond, or a storage pond. However, it must pass through some type of outfall sewer to the point of discharge.

The outfall sewer may be an enclosed pipe or an open channel or some of both. It is used to transport the effluent from the final treatment or storage unit to the point of discharge. The outfall sewer may be built to include cascades or stair steps, channels, mechanical aerators, or a filter bed of coarse rock. The purpose of these aerators is to increase the DO content of the effluent.

The NPDES permit requires that certain tests be made on the effluent on a regular schedule. Effluent testing may include, but is not limited to, flow measurement, temperature, BOD or COD, suspended solids, pH, DO, coliform count, and chlorine residual. Test results must be reported to the regulating agency. Along with the required tests, operators should check the receiving water, especially on small streams and lakes. Laboratory tests and visual checks may show that a problem exists in the receiving water and that something needs to be done. Plant operators cannot usually test large rivers, bays, lakes, and gulfs.

If an effluent containing a toxic substance is accidentally discharged to a receiving water that is used downstream as a drinking water supply, for recreation, or for livestock watering, operators must call the regulating agency and the downstream water users at once. Regulating agencies can then help curb the problem, and drinking water suppliers will have enough time to close their water intake lines until the problem is stopped. This will also warn people in recreation areas and give farmers and ranchers time to move livestock to a safe water supply.

5.2.2 Discharge to Recycling

In some areas where there is a shortage of water, wastewater effluent is recycled for industry, recreation, irrigation, and fire control use. Many industries can use treated wastewater for cooling and cleaning. Often this is cheaper for the industry than using potable (drinking) water. Lakes for fishing and boating have been maintained with recycled wastewater. Records show that these man-made lakes are often no more hazardous to the users than natural lakes. Recycled wastewater is seldom used as a drinking water supply.

Monitoring of effluent discharged for recycling is very important. Only by monitoring can the operator be sure that the effluent is good enough to be used. Recycling units may include extended settling and biological stabilization in holding ponds, sand filtering, and disinfection. Quality control is a must since the recycled water must be safe.

5.2.3 Evaporation and Percolation Basins

Evaporation and percolation basins are used to dispose of wastewater effluent by letting it evaporate and by letting it percolate or seep into the soil. The correct use of these ponds depends on the area of the basin compared to the amount and kind of the wastewater effluent to be processed. The larger the surface and bottom of the pond, the faster the wastewater evaporates and percolates. The climate and kind of soil are important in finding out whether this type of disposal can be used in a given area. This kind of system can be a good and cheap way to dispose of wastewater effluent.

It is often better to build two basins or one basin with a dike that separates it into two parts. After a time, suspended solids will change to settleable solids and build up in the pores or openings of the soil. Percolation will slow down and sooner or later will stop. To get the basin back in working order, it must be drained, dried, and cleaned. Scars must be cut in the bottom. With two basins, one can be kept in service while the other is being restored. The bottoms of the ponds should be sloped for quick and complete draining. The berms or dikes must be checked often for erosion and rodent damage. The dikes and surrounding areas should be mowed often to keep vegetation at a maximum height of 6 to 10 inches (15 to 25 centimeters). This will help keep rodents out of the area. The area should be fenced to keep out larger animals.

Signs should be built to show that the ponds are wastewater treatment plants and are dangerous. As with wastewater lagoons, trees should not be allowed to grow within about 500 feet (150 meters) of the pond. There must be enough surface drainage around the edge of the pond to keep surface water from entering the unit.

Since there is no discharge from the system, there is no need for testing the pond effluent. All bodies of surface water and all wells in the area should be tested often to see if they have been polluted by the pond. Too many suspended solids discharged to the pond will stop up the unit. A suspended solids test should be performed daily to find out if the treatment plant units are working well or if operative controls need to be changed. The ponds should be checked each day. Any changes in the way the plant looks or smells or any changes from normal operation need to be checked out. Laboratory tests may help find the problem and suggest ways of correcting it.

5.3.0 Troubleshooting

Table 6-13 describes some problems and solutions for these problems with wastewater effluent. Refer to manufacturers' manuals for more specific troubleshooting and operating guides for various types of treatment plants. Effluent quality usually depends on the operation and maintenance of upstream process units.

Odors and unsightly conditions are the most common subjects of complaints. Toxic wastes and wastes with high fecal coliform count are more dangerous but are more difficult to detect. Therefore, fewer complaints are made regarding these two hazards.

Complaints must be received with courtesy and investigated at once to see if the complaint is valid. Be sure to inform the complaining person(s) as to your findings, what can be done or what is being done to remedy the problem. A careful investigation may show that the source of the problem is not related to the wastewater treatment plant.

If the treatment plant is the source of the problem, use all available operating controls to obtain maximum plant efficiency. Notify designated regulatory officials at once as to the nature of the problem. If the solution to the problem appears to be beyond operator control, request advice and/or assistance.

Table 6-13 — Troubleshooting Effluent Disposal.

Indicator	Likely Causes	Actions to Take
Effluent BOD or COD too high.	1. Organic overload.	1. Control organic loading by sewer use regulations. Improve plant upkeep. Use all available operating control.
	2. Septic conditions in plant units and the collection system.	2. Check sludge pumping schedule for proper removal. Inspect pumps to see if they are working. Inspect sludge pipes and valves for clogging, check for sludge deposits (pockets) that are not being pumped out of the clarifiers. Inspect all plant units whether primary or secondary for proper operation. Refer to manufacturer's instructions for process information. Inspect the collection system, including lift stations, for septic conditions.
	3. Not enough aeration.	3. Maintain the recommended DO level in all aerated units, usually about 2 mg/1. Inspect air diffusers for even distribution of air and good mixing.
Effluent settleable solids content too high.	1. Hydraulic overload.	Try to control hydraulic loading by maintaining the collection system. Install holding ponds or tanks to handle peak load. Check on wastewater flow rate often to see if plant capacity is exceeded. Inspect settling tanks for short circuiting (channeling).
	2. Sludge collection and removal equipment not working right.	
Effluent suspended solids content too high.	1. Secondary units organically overloaded.	1. Keep organic loading of secondary units within design capacity if reasonably possible. Carefully inspect aerated units for DO content and mixing.
	2. Hydraulic overload.	2. Same action as for too many settleable solids in the effluent due to hydraulic overload.
Effluent pH too low or too high.	1. Industrial discharges not properly pretreated.	1. Inspect and sample the wastewater from the collection system to find the source. Require or provide proper pretreatment.
	2. Septic conditions in collection system or in the treatment plant.	2. Inspect both collection system and plant for detention time in sewer pipes, wet well, and clarifiers. Clean and flush clogged or partly clogged sewers. Aerate and/or chlorinate the influent wastewater for temporary relief.
Wastewater organisms killed, very little treatment being provided.	Toxic material leaking or being discharged to the collection system.	Immediately notify downstream users and regulatory authorities, giving all available information as to type and quantity of toxic substance, also time of release. If the operator has advance warning of a spill or discharge of toxic waste, then all available storage should be used to contain the toxic material instead of letting it pass through the plant. If it cannot be contained, use all available methods to neutralize and/or dilute the toxic waste. Try to find the source of the toxic material and use every reasonable means to prevent its discharge to the system.
Coliform count above permit requirement.	1. Not enough chlorine being applied.	1. Test several times daily for "free" chlorine residual, especially during and immediately after peak flows. Adjust dose of chlorine according to test results. Inspect chlorine feed pump for working condition. If chlorine compounds such as HTH and others are being used, be sure of its percentage of

		chlorine content when adjusting the feed rate (dose).
	2. Chlorine not well mixed with the wastewater.	2. Inspect mixing equipment to be sure the chlorine and wastewater are well mixed immediately. Test for free chlorine residual in several areas of the contact tank to be sure of proper mixing.
	3. Contact time too short.	3. Carefully check the contact (detention) time of the tank to be sure that 15 to 30 minutes' contact time is provided. Remove sludge deposits, if any are present, from the contact tank.

Test your Knowledge (Select the Correct Response)

3. For a wastewater plant that discharges effluent to a body of water, what type of permit must be obtained from the EPA or designated state agency?

   A. NPDES
   B. Operating
   C. Discharge
   D. COD

6.0.0 SEPTIC TANKS, CESSPOOLS, and LEACHING FIELDS

Septic tanks, cesspools, and leaching fields are used for sewage treatment processes where common sewers are not available. These facilities are for the most part underground receptacles. If properly designed, constructed, located, and operated, these receptacles work without objectionable odors over long periods of time with a minimum amount of attention.

6.1.0 Septic Tanks

Septic tanks may be used to serve small or scattered installations where the effluent can be disposed of by dilution, leaching wells or trenches, subsurface tile, or artificial subsurface filter systems (*Figure 6-4*).

The septic tank capacity should equal a full day's flow plus an additional allowance of from 15 to 25 percent for sludge capacity. The minimum acceptable size of a septic tank is 1,000 gallons. *Table 6-14* outlines the minimum tank capacities required by the *National Standard Plumbing Code*. Septic tanks are constructed of reinforced concrete. The length of the tank should not be less than two or more than three times the width.

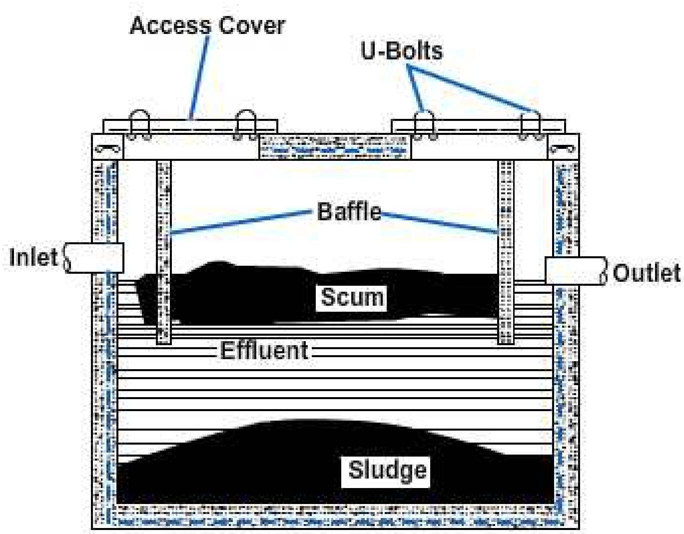


Figure 6-4 — Septic tank.

The liquid depth should not be less than 4 feet for the smaller tanks and 6 feet for the larger ones. Manholes should be provided over the inlet and outlet pipes and over the low points in the bottom of hopper-bottom tanks. The roof of the tank may be covered with earth, but access openings should extend at least to the ground surface. Although ells or tees may be used at inlet and outlet connections, straight connections are better for rodding. Instead of ells, wooden baffles, located approximately 18 inches from the ends of the tank and extending 18 inches below and 12 inches above the flow line, are provided. Elevations should permit free flow into and out of the tank. The bottom of the inlet sewer should be at least 3 inches above the water level in the tank. The inlet and outlet connections should be sufficiently buried or otherwise protected to prevent damage by traffic or frost.

Table 6-14 — Capacity of Septic Tanks.

Single family dwellings Number of bedrooms	Multiple dwelling units or apartments One bedroom each	Other uses Maximum fixture units served	Minimum septic tank capacity in gallons
1-3		20	1,000
4	2 Units	25	1,200
5 or 6	3	33	1,500
7 or 8	4	45	2,000
Extra bedroom 150 gal. ea.	5	55	2,250
Extra dwelling units over 10,250 gal. ea.	6	60	2,500
Extra fixture units over 100, 25 gal. per fixture unit.	7	70	2,750
	8	80	3,000
	9	90	3,250
	10	100	3,500

When a tank will discharge into a leaching field greater than 500 feet in length, a dosing tank and siphon should be incorporated into the system (*Figure 6-5*). The rush of sewage that occurs when the siphon discharges results in better distribution throughout the leaching field. While the dosing tank is refilling, the resultant resting period is favorable to maintaining aerobic conditions in the receiving soil. The dosing tank should have a capacity about 60 to 75 percent of the interior capacity of the leaching pipe to be dosed at one time and should automatically dose once in 3 to 4 hours. Double the amount of dosing siphons for each additional 500 feet of leaching tile or pipe.

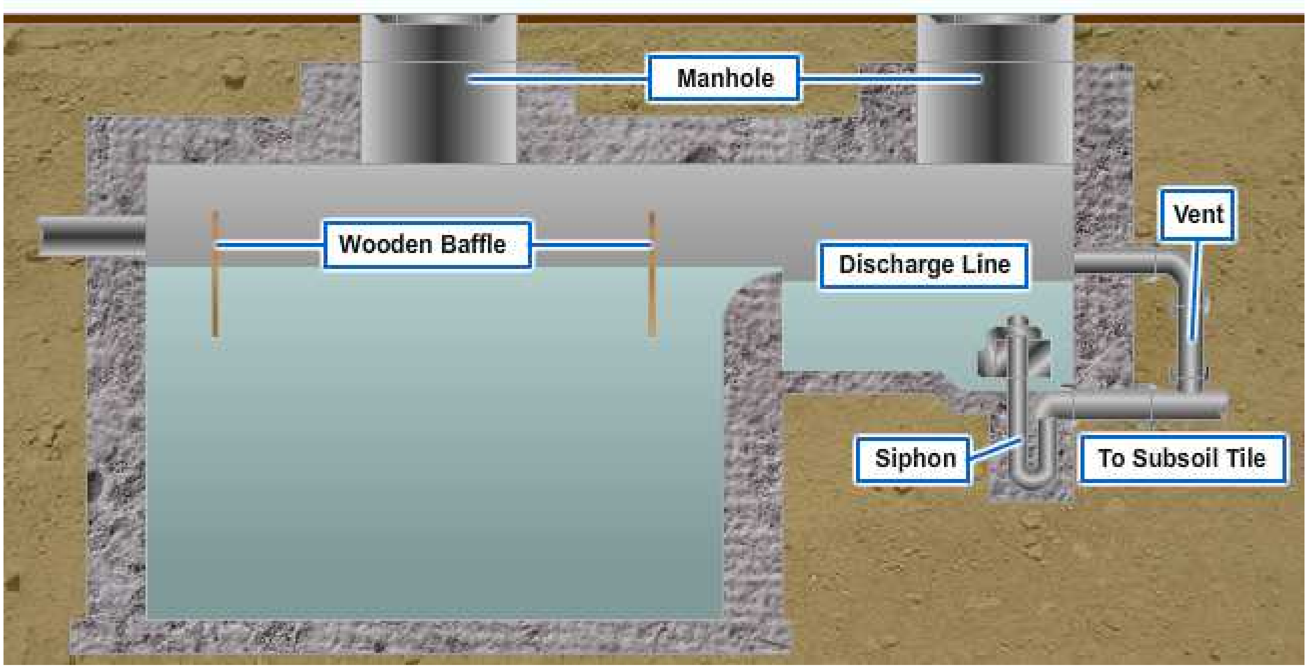


Figure 6-5 — Septic tank with dosing siphon.

Although properly designed septic tanks require little operating attention, they must be inspected periodically. The frequency is determined by the size of the tank and the population load. The minimum frequency should be once every 2 months at periods of high flow. The inspection should assure that the inlet and outlet are free from clogging, that the depth of scum and sludge accumulation is not excessive, and that the effluent passing to subsurface disposal is relatively free from suspended solids. A high concentration of suspended solids in the effluent quickly clogs subsurface disposal facilities. Sludge and scum accumulation should not exceed one-fourth the tank capacity. It should not be assumed that septic tanks liquefy all solids, that they never need cleaning, and that the effluent is pure and free from germs. Perhaps 40 to 60 percent of the suspended solids are retained and the rest are discharged in the effluent. Separating sludge and scum from the liquid in septic tanks is difficult. In small tanks these wastes are customarily mixed, and the entire contents are removed when the tanks are cleaned. The material removed contains fresh or partially digested sewage solids. It must be disposed of without endangering public health. Disposal through manholes in the nearest sewer system, as approved by local authorities, or burial in shallow furrows on open land is recommended. A diaphragm type of sludge pump is best suited for removing the content of the tank. The contents should be transported in a watertight, closed container.

When installing a septic tank system for sewage treatment, you must take into consideration the location with respect to wells or other sources of water supply, topography, water table, soil characteristics, area available, and maximum building occupancy. Building occupancy is a key factor in determining tank size. *Table 6-15* shows common sewage uses based on type of facility and gallons per person per day of usage.

Table 6-15 — Sewage Flows According to Type of Establishment.

Type of Establishment	Gallons used
Schools (toilet and lavatories only)	15 gal per day per person
Schools (with above plus cafeteria)	25 gal per day per person
Schools (with above plus cafeteria and showers)	35 gal per day per person
Day workers at schools and offices	15 gal per day per person
Day camps	25 gal per day per person
Trailer parks or tourist camps (with built-in bath)	50 gal per day per person
Trailer parks or tourist camps with central bathhouse	35 gal per day per person
Work or construction camps	50 gal per day per person
Public picnic parks (toilet wastes only)	5 gal per day per person
Public picnic parks (bathhouse, showers, and flush toilets)	10 gal per day per person
Swimming pools and beaches	10 gal per day per person
Country clubs	25 gal per locker
Luxury residences and estates	150 gal per day per person
Rooming house	40 gal per day per person
Boardinghouses	50 gal per day per person
Hotels (with connecting baths)	50 gal per day per person
Hotels (with private baths--two persons per room)	100 gal per day per person
Boarding schools	100 gal per day per person
Factories (gallons/ person per shift)	25 gal per day per person
Nursing homes	75 gal per day per person
General hospitals	150 gal per day per person
Public institutions (other than hospitals)	100 gal per day per person
Restaurants (toilet and kitchen wastes per unit of serving capacity)	25 gal per day per person
Kitchen waste from hotels, camps, etc. serving 3 meals per day	10 gal per day per person
Motels	50 gal per bed space
Motels with bath, toilet, and kitchen wastes	60 gal per bed space
Drive-in theaters	5 gal per car space
Stores	400 gal per toilet room
Service stations	10 gal per vehicle served
Airports	3-5 gal per passenger
Assembly halls	2 gal per seat
Bowling alleys	75 gal per lane
Churches (small)	3-5 gal per sanctuary seat
Churches (large with kitchens)	5-7 gal per sanctuary seat
Dance halls	2 gal per day per person
Laundries (coin operated)	400 gal per machine
Service stations	1,000 gal, 500 gal (each add. bay)
Subdivisions or individual homes	75 gal per day per person
Marinas—Flush toilets	36 gal per fixture per hr
Urinals	10 gal per fixture per hr
Washbasins	15 gal per fixture per hr
Showers	150 gal per fixture per hr

The physical location of a septic tank in relation to wells must be no closer than 100 feet from a shallow well and no closer than 50 feet from a deep well. In general, a shallow well is less than 100 feet in depth and a deep well is more than 100 feet in depth. *Figure 6-6* shows a typical septic tank system layout with minimum distances noted. Keep in mind that septic tanks, cesspools, and leaching fields must be located downhill from any water source.

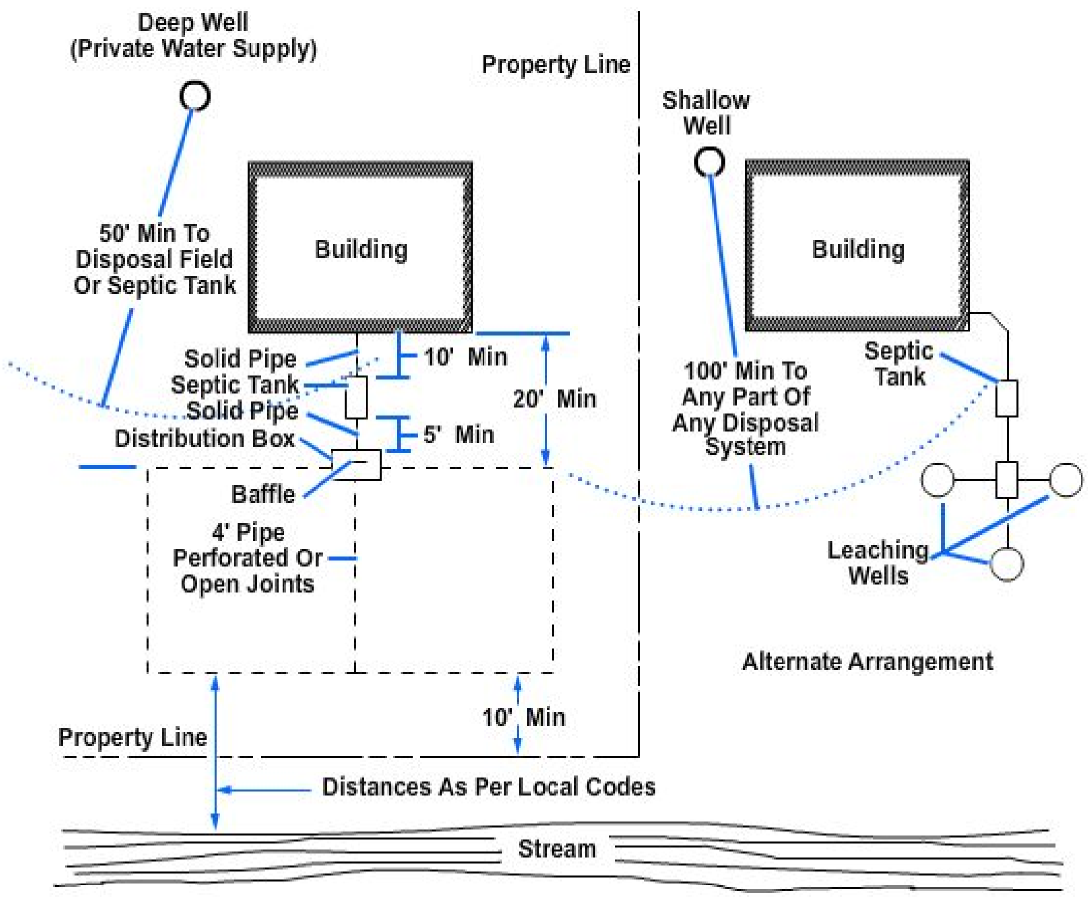


Figure 6-6 — Minimum distances for private disposal system.

6.2.0 Cesspools

Sewage from private dwellings and farmhouses in outlying areas may discharge into cesspools if a common sewerage system is not available. Cesspools are usually dry-laid masonry or brick-lined wells without any masonry at the bottom. The sewage flows into them and leaches out into the soil. Floating solids collect at the top and settling solids collect at the bottom of the well. The leaching capacity of the well is exhausted when the solids accumulate and clog the soil. The use of chemicals is not recommended to increase the useful life of a cesspool.

When the first cesspool becomes filled, a second well may be built to take the overflow from the first. In such cases, the first cesspool should operate as a septic tank to collect the settling and floating solids and provide a trapped outlet on the connection leading to the next leaching cesspool. Septic tanks may be placed advantageously ahead of leaching cesspools in larger installations. Leaching cesspools should not be placed closer together than 20 feet by out-to-out measurement of walls.

Leaching cesspools should be used only where the subsoil is porous to a depth of at least 8 or 10 feet and where the ground water is normally below this elevation (*Figure 6-7*). When they are located in fine sand, the leaching area can be increased by surrounding the walls with graded gravel.

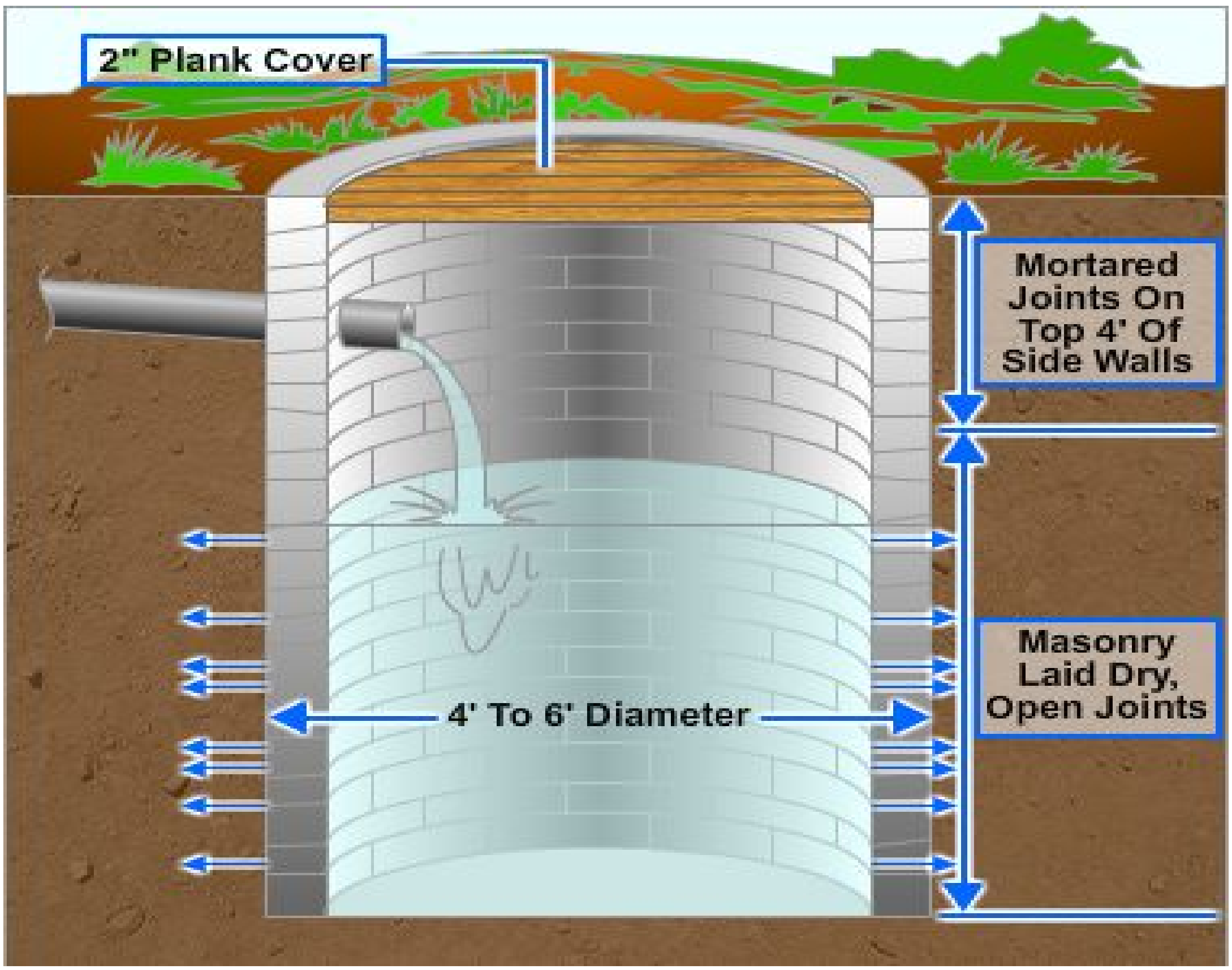


Figure 6-7 — Leaching cesspool.

The number and the size of cesspools required depend on the quantity of sewage and the leaching characteristics of the total exterior percolating area above the ground water table, including bottoms and sidewalls below the maximum-flow lines. The allowable rate of sewage application per square foot per day, based on the recommended leaching test, is given below in *Table 6-16*. Soils that require more than 30 minutes for a fall of 1 inch are unsatisfactory for leaching. Some other disposal method should be used.

Table 6-16 — Allowable Rate of Sewage Application per Square per Day.

Time for water to fall 1 inch (minutes)	Allowable rate of sewage application (gallons per sq ft of percolating area per day)
1	5.3
2	4.3
5	3.2
10	2.3
30	1.1

The test for leaching should be made by digging a pit about one half of the proposed depth of the cesspool, with a test hole 1 foot square and 18 inches deep at the bottom. The test hole is filled with 6 inches of water and allowed to drain off. Six inches of water is again added, and the downward rate of percolation is measured in minutes required for the water surface to lower 1 inch in the hole.

6.3.0 Leaching Fields

Leaching fields are an integral component of a septic tank individual sewage disposal system. Leaching field may be referred to as tile fields or absorption trenches. Whichever term is used, the function, testing, construction, and maintenance techniques of this component remain the same.

The lines in a leaching field are built of 4-inch PVC perforated pipe. Many types of perforated pipe are commercially available for use in leaching-field construction.

The following conditions are important for the proper functioning of a leaching field:

- Groundwater levels well below that of the leaching field
- Soil of satisfactory leaching characteristics within a few feet of the surface extending several feet below the leaching pipe
- Subsurface drainage away from the field
- Adequate area
- Freedom from polluting drinking water supplies, particularly from shallow wells in the vicinity

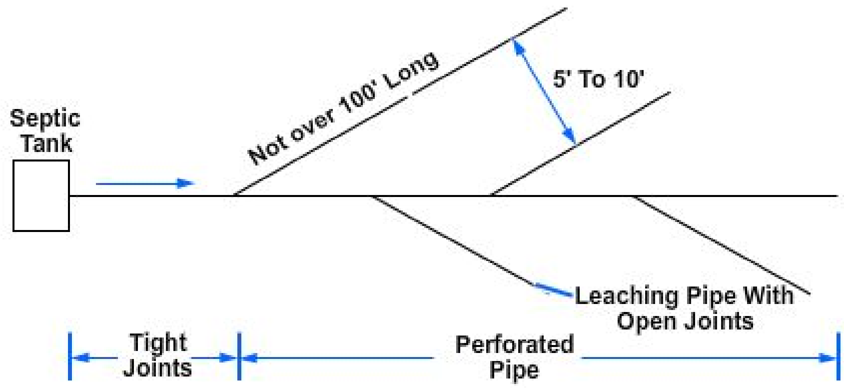
Before installing a leaching field in a specified area you must perform a percolation test. This test determines whether the area selected is suitable for subsurface sewage disposal; it also helps you to determine the overall size of the leaching field in relation to trench dimensions and pipe lengths.

The test consists of digging a test pit 2 feet square and at least 1 foot in depth. The optimum depth should be at the deepest point that the leaching pipe will be laid. Next dig a hole 1 foot square by 1 foot deep in the test pit. Fill this hole with 7 inches of water for wetting purposes. Allow the water to drop to 6 inches before recording the drop time. Then note the time required for the level to drop 1 inch (from 6 to 5 inches) in depth. You can then determine the length of pipe in the leaching field by using *Table 6-17*. Note that this table is based on the assumption that 4-inch pipe will be used as recommended by the *National Standard Plumbing Code.*

Table 6-17 — The Tile Length for Each 100 Gallons of Sewage per Day.

Time in minutes for 1 inch drop	Tile length for trench widths		
	1 ft	2 ft	3 ft
1	25	13	9
2	30	15	10
3	35	18	12
5	42	21	14
10	59	30	20
15	74	37	25
20	91	46	31
25	105	53	35
30	125	63	42

In the construction of a leaching field, the installer takes into consideration the results of the percolation test, type of soil, size of pipe, depth in reference to the ground water level and frost line, and standard requirements of materials placed in the absorption trench. *Figure 6-8* shows a typical layout of a leaching field.



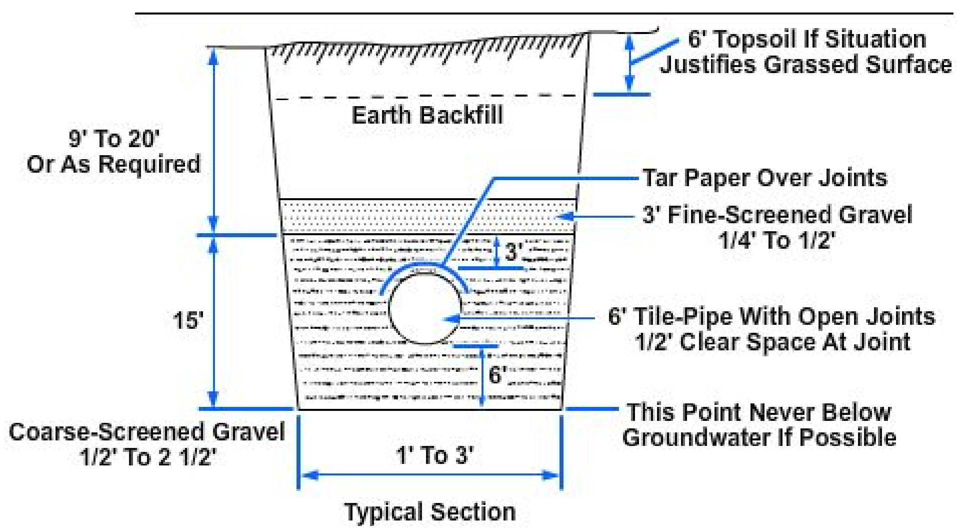


Figure 6-8 — Typical layout of a subsurface tile system.

The type of soil at the location of the field will dictate the width of the trench. Sand and sandy loam requires a width of 1 foot, loam and sand and clay mixture 2 feet, clay with some gravel 3 feet. Note these are minimum trench widths based on the type of soil encountered at the jobsite.

Placing the leaching pipe below the frost line to prevent freezing is not necessary. Under no circumstances can you lay leach pipe below the ground water level. When digging the absorption trenches, you must consider the lengths of each lateral and their spacing in relation to each other. Do not make any lateral longer than 100 feet in length. *Table 6-18* shows the size and spacing requirements for disposal fields.

Table 6-18 — Size and Spacing for Disposal Fields.

Width of trench at bottom (in.)	Recommended depth of trench (in.)	Spacing tile lines * (ft)	Effective absorption area per lineal ft of trench (sq. ft)
18	18 to 30	6.0	1.5
24	18 to 30	6.0	2.0
30	18 to 36	7.6	2.5
36	24 to 36	9.0	3.0
• Greater spacing is desirable where available area permits			

After the trenches are laid out and dug, filler material must be placed along with the actual pipe. The filler material may be washed gravel, crushed stone, slag, or clean bank-run gravel ranging in size from 1/2 to 2 1/2 inches. Filler material in the trench should not be less than 6 inches deep below the bottom of the pipe. It should be at least 2 inches above the pipe. To prevent backfill soil from filling the voids in the filler material, it is recommended that a 3-inch layer of medium-screened gravel with another layer of fine-screened gravel, untreated paper, or straw of 2 to 3 inches in depth be placed in the trench.

Pipe should be laid with a minimum pitch of 2 inches to a maximum pitch of 4 inches per 100 feet. When open joints are used, they must not be spaced more than 1/2 inch apart. Asphalt-treated paper should be used to cover the joint. The open joint allows for free discharge of solids from the line to the trench. The asphalt-treated paper prevents gravel from entering the pipe.

The layout of the field requires attention to detail to prevent future maintenance and operation troubles. When the field is laid on sloping ground, the flow must be distributed so each lateral gets a fair portion of the flow. Individual lines should be laid nearly parallel to land contours, Leaching fields are commonly laid out either in a herringbone pattern or with the laterals at right angles to the main distribution pipe. Little or no maintenance is required for leaching fields. Preventive measures such as excluding all vehicle traffic and not planting trees or shrubs in the field area should ensure trouble-free operation for many years. When a leaching field becomes inoperable, you must replace it with a new system. Tree or shrub roots are a major factor in leaching-field failure. This requires the replacement of field components and complete root removal.

Test your Knowledge (Select the Correct Response)

4. What is the minimum acceptable size of a septic tank, in gallons?

   A. 2,000
   B. 1,250
   C. 1,000
   D. 500

Summary

The proper treatment and disposal of sewage are important for a healthy lifestyle and can affect morale. As a UT, you have the responsibility to treat and remove the waste. In this chapter, you learned some techniques on how to test, treat and dispose of this waste. Knowing the importance of your job and taking charge in doing it right, will make you a better UT and keep your shipmates safe.

Additional Resources and References

This chapter is intended to present thorough resources for task training. The following reference works are suggested for further study. This is optional material for continued education rather than for task training.

OSHA Regulations (Standards – 29 CFR)

Naval Construction Force Manual, *NAVFAC P-315*, Naval Facilities Engineering Command, Washington, D.C., 1985.

Facilities Planning Guide, NAVFAC P-437, Volumes 1 and 2, Naval Facilities Engineering Command, Alexandria, VA, 1982.

Maintenance and Operation of Water Supply , Treatment and Distribution Systems, NAVFACMO - 210 , Naval Facilities Engineering Command, Alexandria, VA, 1984.

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Water Purification Unit , Reverse Osmosis 600 – GPH Trailer Mounted, TM-5-4610-215-24, Department of the Army, Washington, DC, 1983.

Water Supply Point Equipment and Operation, FM-10-52-1, Headquarters Department of the Army, Washington, DC, 1991.

Plumbing Manual, Volume II, NTTC Course 140-B, NAVFAC P-376, NAVFAC Technical Training Center, Navy Public Works Center, Norfolk, VA, 1965.

Safety and Health Requirements Manual, EM-385-1-1, Department of the Army, U.S. Army Corps of Engineers, Washington, DC, 1992.

Chapter 10,National Standard Plumbing Code, Illustrated, National Association of Plumbing-Heating-Cooling Contractors, Falls Church, VA, 1990.