Subsurface
SEWAGE DISPOSAL

by

JOHN E. KIKER, JR.

Professor of Civil Engineering

Bulletin No. 23
Fourth Printing – July 1955

December, 1948

FLORIDA ENGINEERING AND INDUSTRIAL EXPERIMENT STATION
College of Engineering ● University of Florida ● Gainesville

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The Florida Engineering and Industrial Experiment Station
College of Engineering
University of Florida
Gainesville, Florida

JOSEPH WEIL, *Director*

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Foreword

Much of the urban population of the State of Florida lives outside the corporate lines of cities and towns. In most instances these people are not served by sewerage systems connected with modern sewage treatment plants.

Many requests have come to the University of Florida for information that will aid in the design of disposal units for cases where sewerage is not available. This bulletin has been prepared with the purpose of furnishing details for subsurface sewage disposal units that would normally be approved by the State Board of Health.

Professor Kiker has combined an intimate knowledge of the problem, gained through many years of experience, with the co-operation of the Bureau of Sanitary Engineering of the State Board of Health in preparing this manual of working information.

A new term, "percolation coefficient," has been introduced as a proposed standard for classifying soils with respect to their ability of receiving sewage. A simple mathematical formula for measuring this important soil characteristic is believed to have been developed for the first time. It is thought that this contribution may be welcomed by engineers engaged in the design of subsurface sewage disposal systems since it will eliminate the necessity of referring to a chart or table for computing the disposal areas required.

C. D. Williams
Head Professor of Civil Engineering

Acknowledgement

For reading the manuscript and for offering helpful suggestions, the author wishes to thank the following persons in the Civil Engineering Department:

Earle B. Phelps, Professor of Sanitary Science.

C. D. Williams, Head Professor of Civil Engineering.

George R. Grantham, Assistant Professor of Sanitary Engineering.

L. J. Ritter, Associate Professor of Civil Engineering.

Grateful acknowledgement is also made for similar contributions by Miss Rachel Albertson, Editor of this Station, and by members of the engineering staff of the Florida State Board of Health, especially by the Chief Sanitary Engineer, Mr. David B. Lee, who checked the manuscript against the requirements of the Florida State Sanitary Code.

Mr. Edward R. Williams, Public Health Engineering student in the Civil Engineering Department, prepared all of the drawings used as illustrations.

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JACKSONVILLE 1

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DIRECTOR

DIVISION OF ENTOMOLOGY
JOHN A. MULRENNAN, B.S.A.
DIRECTOR

October 4, 1948

IN REPLY PLEASE REFER TO
PW&S - Gen.
U. of Fla. /1

Mr. John Kiker, Jr.
Associate Professor of Public Health Engineering
College of Engineering
University of Florida
Gainesville, Florida

Dear Mr. Kiker:

This bulletin has been reviewed by staff members of the Bureau of Sanitary Engineering of the Florida State Board of Health, and it is the opinion of the State Board of Health that this bulletin is in keeping with the standards of the Florida State Sanitary Code.

We would like to point out that the Florida State Sanitary Code does not permit the use of dry wells, seepage pits, and cesspools; but other than the material in Appendix 3, any individual sewage disposal system constructed and placed into operation in accordance with this bulletin should meet the approval of the Florida State Board of Health.

You and the Engineering and Industrial Experiment Station are to be congratulated upon this endeavor.

Very truly yours,

David B. Lee

David B. Lee
Director & State Sanitary Engineer
Bureau of Sanitary Engineering
Florida State Board of Health

DBL: rfm

SUBSURFACE SEWAGE DISPOSAL

Introduction

Dwellings, business establishments, camps, hotels, schools and institutions that do not have access to public sewers have to provide their own facilities for the disposal of sewage. Such disposal may be underground unless the quantity of sewage is large or the soil unsuitable. In disposing of the sewage it is necessary to prevent the contamination of water supplies and to prevent public health nuisances resulting from overflowing sewage that has not been properly treated. In Florida, geological conditions and high ground water tables necessitate extreme caution in the selection of the disposal facilities. On the other hand, installations of facilities in excess of those needed represent merely a waste of money. The ideal is to provide facilities that will just meet the needs under the conditions to be encountered. This is a basic engineering principle. In order to approach the ideal, it is necessary that the disposal systems be designed scientifically. Inquiries are frequently received by the University as to how this can best be done. The purpose of this bulletin is primarily to answer these inquiries.

Subsurface sewage disposal systems designed, constructed and operated in accordance with the criteria herein contained, may be expected to last about twenty years. The design details are based upon Florida conditions where difficulties due to freezing do not exist. In northern latitudes, the sewers leading from buildings should be about a foot lower than the depths herein indicated.

Due consideration to the problem of subsurface sewage disposal is especially necessary at certain real-estate developments where public sewers are not available. Because of the importance of realty subdivisions in Florida, a special discussion of the subject as related to sewage disposal is included in an appendix (see page 57).

PART I

General Considerations

ESTIMATES OF SEWAGE QUANTITIES

The first step in the design of any subsurface sewage disposal system is to determine the quantity of sewage to be discharged and the sizes or capacities of the disposal units. Where there are water meters in existing buildings, the quantity of sewage can best be estimated from the meter readings.

In using meter readings for estimating the quantity of sewage to be contributed, some allowance should be made for maximum conditions that may not be readily apparent from the readings. For example, an ordinary family of four may use a mean average of 60 gallons per person per day over a period of three months. This may represent a minimum average of perhaps 40 gal. per person per day on certain days and something in excess of 100 gal. per person per day when water consumption is heaviest as on "wash days." In addition, some allowance should be made for the sewage contributed by occasional guests. For these reasons, a factor of safety should be used when computing sewage flows from average meter readings. In general, a minimum safety factor of about 25 per cent should be allowed. Thus the design of a disposal system for the family of four that uses an average of 60 gal. per person per day, should be based upon a computed maximum usage of at least 75 gal. per person per day, or a total sewage flow of 300 gal. per day.

Conversely, unusually high meter readings may be caused by lawn sprinkling or by leakage of water which does not enter the disposal system. Due allowances should be made for abnormalities of this kind.

Where measurements of water consumption are not possible, as, for example, when water meters are not available or where disposal facilities are being planned for a new building, it is necessary to use other methods of estimating the amount of sewage to be discharged. One way is to base the computed flow on the number of bedrooms or the number of plumbing fixtures. If the building is used as a restaurant, the number of patrons or the number of meals served may be the best criterion. The competent designer will base his estimates upon a combination of the various influencing factors. He will consider each case on its own merits, especially where disposal facilities are to be constructed for a large institution where the cost of construction will run into a considerable amount of money. If definite information and accurate water measurements are not available, the quantity of sewage may be estimated from experiences at establishments similar to the one for which the new sewage disposal facilities are being designed. Table I may be helpful in such cases.

TABLE I

QUANTITIES OF SEWAGE FLOW

Type of establishment	*Gallons per day per person*
Small dwellings and cottages	50
Large dwellings with numerous fixtures	75 - 100
Multiple family residences	50
Rooming houses	40
Boarding houses	50
Hotels with connecting baths	50
Hotels with all private baths (2 persons per room)	100
Restaurants (toilet and kitchen wastes per patron)	7 - 10
Restaurants (kitchen wastes per meal served)	2½ - 3
Kitchen wastes at hotels, camps, boarding houses, etc. serving 3 meals per day	7 - 10
Tourist camps or trailer parks with central bathhouse	35
Tourist camps or trailer parks with individual bath units	50
Resort camps (night and day) with limited plumbing	50
Luxury camps	75 - 100
Work or construction camps (semipermanent)	50
Day schools without cafeterias, gymnasiums or showers	8
Day schools with cafeterias but no gyms or showers	12
Day schools with cafeterias, gyms and showers	20
Boarding schools	75 - 100
Day workers at schools and offices	15
Hospitals	150 - 250+
Public institutions other than hospitals	75 - 125
Factories (gal. per person per shift, exclusive of industrial wastes)	15 - 35
Public picnic parks (toilet wastes only), gal. per picnicker	5
Picnic parks, with bathhouse, showers and flush toilets	10
Swimming pools and bathing places	10
Luxury residences and estates	100 - 150
Country clubs per resident member	100
Country clubs per member present	25 - 50

Depending upon the degree of treatment required, it is sometimes economical to construct separate disposal systems for different types of wastes at a given establishment. The decision as to the number of disposal systems may also be influenced by conditions of terrain, topography, and locations of the buildings contributing to the wastes. At large camps, for example, and at some resorts, kitchens and central dining facilities may be located an appreciable distance from the cottages or cabins. Under such circumstances, the kitchens may be provided with separate disposal systems including facilities for the removal of grease, ahead of the septic tank, as discussed in Part III of this bulletin. Separate facilities may also be installed for community bathhouses. When this is done, the total per capita flow must be broken down into its component parts, and some allowance must be made for the amount of sewage tributary to the different disposal systems. Table II illustrates how this may be done where there are no definite data as to the exact distribution of flow.

TABLE II

DISTRIBUTION OF SEWAGE FLOWS IN GALLONS PER DAY PER PERSON

Kitchen wastes	....	7	10	10	15
Toilet wastes	10	15	20	25	30
Showers, washbasins, etc.	15	18	20	25	35
Laundry wastes	....	....	....	15	20
Total Flow	25	40	50	75	100

Example:

> In a household contributing 75 gal. of sewage per day per person, as shown in column 4, an average breakdown for each of the four types of wastes listed might be about 10 gal. per day per person for kitchen wastes, 25 gal. per day per person for toilet wastes, 25 gal. per day per person for shower wastes, bathtubs and washbasins, and about 15 gal. per day per person for laundry wastes.

For certain types of new establishments the designing engineer may be unable to obtain from his clients accurate estimates as to the number of patrons to be served by the disposal facilities. This is particularly true in the case of recreational places such as picnic areas, country clubs and the like. In such cases, computations and estimates may best be made from the number of plumbing fixtures installed. Table III indicates average values for quantities of sanitary wastes per fixture at country clubs with modern plumbing.

TABLE III

SEWAGE FLOW FROM COUNTRY CLUBS

Type of fixture	*Gallons per day per fixture*
Showers	500
Baths	300
Lavatories	100
Toilets	150
Urinals	100
Sinks	50

Table IV shows one method used by the National Park Service in estimating the amount of sewage discharged hourly during the hours when public parks are open.

TABLE IV

SEWAGE FLOW AT PUBLIC PARKS

Type of fixture	*Gallons per hour per fixture*
Flush toilets	36
Urinals	10
Showers	150
Faucets	15

SELECTION OF THE DISPOSAL SYSTEM

Once the quantity of sewage has been computed, it is necessary to select the method of treatment or disposal. Both the solids and the liquid portions of sewage must be disposed of satisfactorily. Both portions must be treated in such a manner that nuisances and public health hazards will be prevented. For small plants, the most satisfactory and the most economical method of obtaining adequate treatment for the liquid portion is by filtration or percolation into the soil. In the use of this method, however, it is essential that preliminary removal of as much as possible of the solid matter be undertaken in order to prevent rapid clogging of the filter area.

Disposition by percolation into the soil is the "regular" method of disposal and will be discussed in Part II of this bulletin. Additional disposal methods are covered in Part III. The latter are applicable primarily at institutional and large private systems if conditions preclude disposal by percolation into the soil.

PART II

Regular Disposal Methods

With Emphasis on Small Private Systems

Experience has shown that the most satisfactory and convenient method of disposing of sewage from private dwellings and small business establishments in unsewered rural areas is by subsurface means. The most common method of subsurface disposal is illustrated in Fig. 1 as

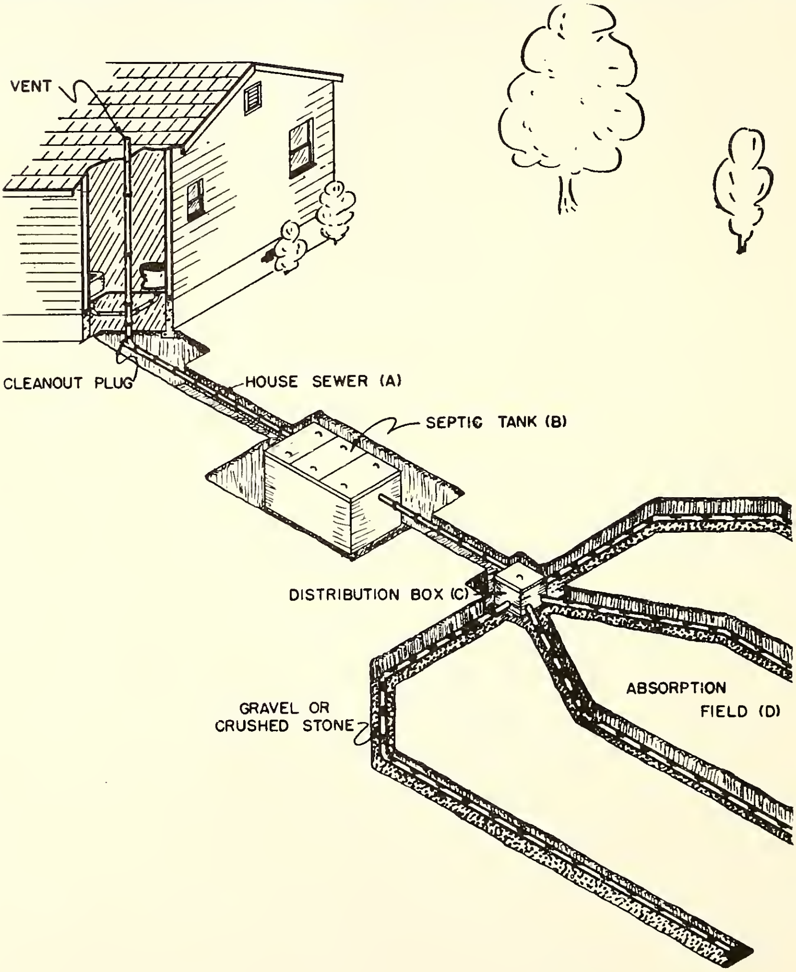


FIG. 1.— SEPTIC TANK SEWAGE DISPOSAL SYSTEM

shown on page 14. The liquid contents of the house sewer (A) are discharged first into a septic tank (B), thence to a distribution box (C), and finally into a subsurface absorption field (D).

HOUSE SEWERS

A house sewer or building sewer is the pipe line conveying sewage from the house or building to the septic tank or to the first manhole if the manhole is located ahead of the septic tank. The Florida State Sanitary Code requires that the minimum grade on the house sewer shall be 6 in. per 96 ft., but that a grade of 24 in. per 96 ft. or ¼ in. per ft. be maintained wherever possible. Buildings should be planned so that the latter slope can be obtained.

The house sewer is required to be of cast-iron pipe or such other material as may be approved by the State Board of Health. Cleanout plugs with brass screw cleanouts on Y-branch openings are required at each change of direction and at intervals not greater than 75 ft. The minimum size pipe for the line to the septic tank is 4 in. The relationship of minimum sizes to the slopes and number of fixtures is indicated in Table V.

TABLE V

MINIMUM SIZES OF HOUSE SEWERS

*Water Closets or Equivalents**	*Slope 12 in. per 96 ft.*	*Slope 24 in. per 96 ft.*
2	4 in.	4 in.
3-4	4 in.	4 in.
5-12	6 in.	5 in.
13-50	8 in.	6 in.
51-120	8 in.	8 in.
121-180	10 in.	10 in.
181-320	12 in.	12 in.

*In using Table V, 2 laundry trays, urinals, showers or floor drains are counted as the equivalent of one water closet; as are 3 bathtubs, 4 sinks or 6 lavatories.

Below the septic tank, or below the first manhole if there is one ahead of the septic tank, the sewer line may be of vitrified clay pipe with bell and spigot joints. The minimum size of clay pipe between a manhole and septic tank is 6 in. Below the tank, the minimum size of clay pipe is 4 in. In event the sewer line runs within 50 ft. of any well or suction line from a well, or within 10 ft. of any drinking water supply line under pressure, or within 5 ft. of any basement foundation, it should be made of cast-iron pipe with leaded joints. Cast iron is also required wherever the line crosses under driveways with less than 3 ft. of earth cover.

Where sewer lines are in the vicinity of trees or dense shrubs, and are not constructed of cast iron as indicated above, the joints should be made with special root-proofing material. For this purpose, special copper rings may be used with cement mortar, or the mortar may be treated with copper sulphate or coarse salt to prevent roots from entering the joints and clogging the sewer. Certain coal-tar products are also resistant to root growths and may be used as jointing compounds. Asphalt is not satisfactory for this purpose.

Bends should be limited to 45° or less wherever possible ahead of the septic tank. If 90° bends cannot be avoided they should be made with two 45° ells or a long-sweep quarter curve.

SEPTIC TANKS

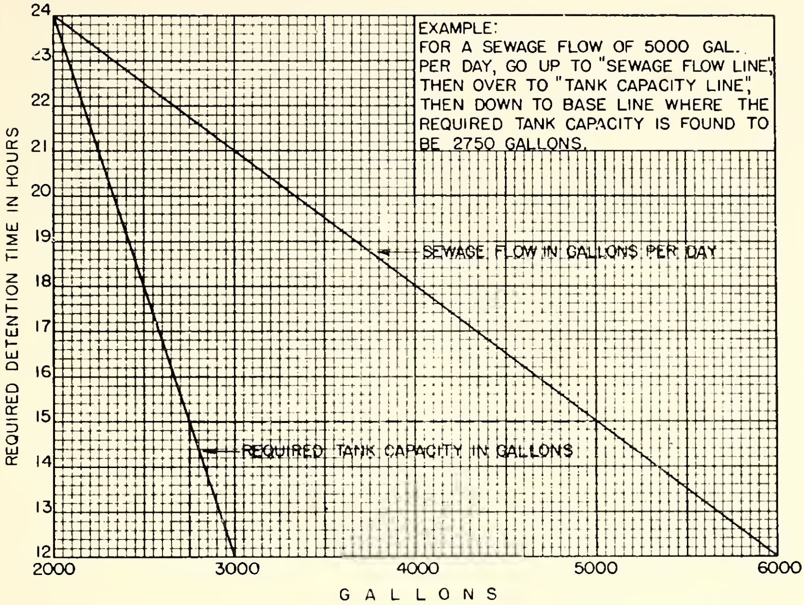
The removal or separation of sewage solids is usually accomplished by settling in septic tanks. These are almost always preferred when the flow is less than 10,000 gal. per day. They are frequently preferred where flows are higher than that. They are relatively easy to build, and they require a minimum of maintenance.

If properly designed and constructed, septic tanks are quite effective in removing solids from the sewage. The heavier solids settle to the bottom of the tank, forming a blanket of sludge. The lighter solids, including fats and grease, rise to the surface and form a layer of scum. A considerable portion of the sludge is liquified through a process of decomposition or digestion. During this process gas is liberated from the sludge, carrying a portion of the solids to the surface where they accumulate with the scum. Ordinarily, they undergo further digestion and a portion settles again to the sludge blanket on the bottom. This action is retarded if there is much grease in the scum layer. The settling is also retarded because of the gasification in the sludge blanket. Furthermore, there are wider fluctuations in flow in small tanks than in the larger units; hence the normal detention time should be proportionately increased as the sizes of the units decrease.

The Florida State Board of Health requires that the effective septic tank capacity be equal to a full day's sewage flow where the total flow is less than 2,000 gal. per day. With sewage flows greater than 6,000 gal. per day the effective tank capacity should be equal to one-half day's flow. For intermediate flows, the net capacity of the septic tank must be equal to 1,500 gal. plus one-fourth the daily sewage flow. In other words:

$$V = 1{,}500 + 0.25\ Q$$

where "V" is the net volume of the tank in gallons and "Q" is the sewage flow in gallons per day. The required tank capacity for flows between 2,000 and 6,000 gal. per day may also be obtained from the chart shown in Fig. 2.



EXAMPLE:
FOR A SEWAGE FLOW OF 5000 GAL. PER DAY, GO UP TO "SEWAGE FLOW LINE", THEN OVER TO "TANK CAPACITY LINE", THEN DOWN TO BASE LINE WHERE THE REQUIRED TANK CAPACITY IS FOUND TO BE 2750 GALLONS.

FIG. 2.—SLIDING SCALE FOR REQUIRED SEPTIC TANK CAPACITY FOR DAILY SEWAGE FLOWS FROM 2000 TO 6000 GALLONS.
(FROM 1948 TECH. MEMO NO. 1, BUREAU OF SANITARY ENGINEERING, FLORIDA STATE BOARD OF HEALTH)

For flows appreciably above 10,000 gal. per day, up to about 100,000 gal. per day, Imhoff tanks are more satisfactory than septic tanks. For flows above 100,000 gal., still other types of sedimentation tanks are more economical. These fall into the category of design for municipal systems, and will not be discussed in this bulletin.*

A word of caution is offered at this point about the degree of "purification" obtained in a septic tank. Contrary to popular belief, septic tanks do not accomplish high removal of bacteria. Ordinarily, only about half of the germs in sewage are removed in a septic tank. By the 37° count, which is a measure of bacteria capable of development at

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*The economics of sewage treatment plant design for small Florida municipalities will be the subject of another bulletin of this Station as soon as research work that is now under way reaches a point where conclusions may be justified.

body temperature and hence is indicative of intestinal organisms, the average number of bacteria in raw sewage is in the neighborhood of 10,000,000,000 per gal. With only 50 per cent removal there are still 5,000,000,000 bacteria per gallon remaining in the liquid discharged from the tank. Many of these may be kinds that produce disease. In fact, the liquid that is discharged from a septic tank is in many respects more objectionable than that which goes in. It is more stale or more septic, and it becomes malodorous. This, however, does not detract from the value of the tank. Its only purpose is to remove suspended solids from the sewage and to liquify the major portion of the solids that have been removed. It does this to the extent of about 60 to 90 per cent, which is quite as good as the results obtained in other types of tanks.*

SPECIFICATIONS FOR SEPTIC TANKS

Most states have their own specifications for the construction of septic tanks. The standards are fairly uniform and follow closely the recommendations of a joint committee on rural sanitation. The committee was composed of represenatives of the Conference of State Sanitary Engineers, the United States Public Health Service, the U. S. Department of Agriculture, the National Housing Agency, and several other important organizations. In general, the requirements of the Florida State Sanitary Code are in harmony with the committee report, but they contain certain minor modifications to meet Florida conditions. The criteria given below are based on the Florida requirements. Deviations therefrom should not be made unless first approved by the State Board of Health.

LOCATION:

Septic tanks should be located where they cannot contribute to the contamination of any well or spring or other source of water supply. Underground contamination may travel in any direction and for very great distances unless filtered effectively through material such as sand. Sewage from disposal systems occasionally contaminates wells having higher surface elevations. Obviously, the elevations of disposal systems are almost always higher than the level of water in such wells as may be located nearby, hence pollution from a disposal system having a lower *surface* elevation may still travel downward to the water-bearing stratum. Experience has demonstrated, however, that underground pollution *usually* follows the general contour of the ground surface. Primarily for this reason it is generally recommended that septic tanks be located downhill from wells or springs. They should also be kept as far as reasonably

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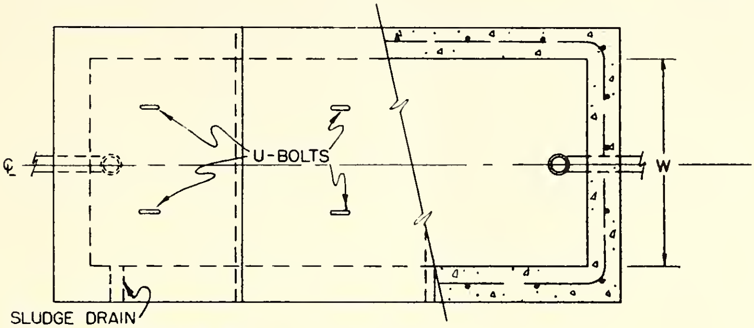
*Nottingham and Ludwig report 89 to 99 per cent removal of settleable solids, and 75 to 96 per cent removal of suspended solids during tests over a period of three months with two types of septic tanks.

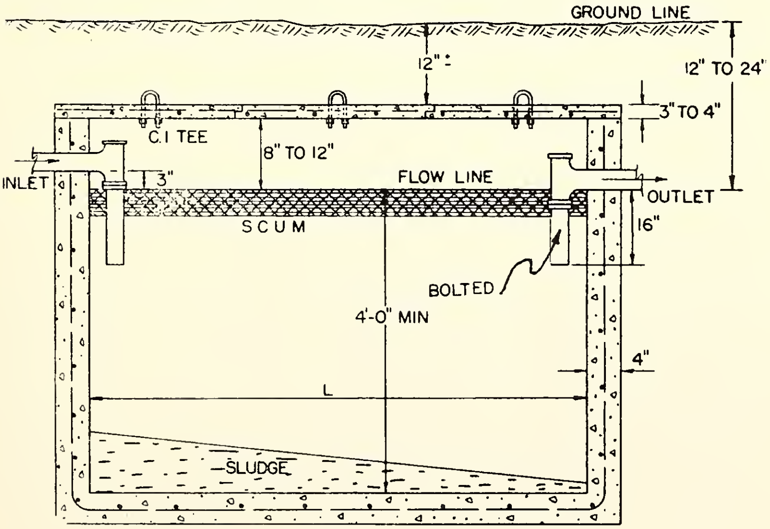
possible from any source of water supply; never less than 50 ft. away. No part of a septic tank or disposal system should be located within 5 ft. of any building. The tank should not be located in swampy areas or in areas subject to flooding. The tank site should be located where the largest possible area will be available for the disposal field.

CONSTRUCTION FEATURES:

In the design illustrated in Fig. 3, the essential features are a



PLAN



SECTION ON ℄

FIG. 3.— SMALL SEPTIC TANK

watertight reinforced concrete structure, a removable slab concrete cover, an inlet tee extending down 16 in. below the flow line, and an outlet tee with an extension similarly submerged to prevent the escape of floating scum.

The concrete may either be precast or cast in place. The concrete should have a unit compressive strength of at least 3,000 lb. per square inch. This can be usually obtained from a mixture of one part cement, two parts clean sand and three parts of clean gravel or broken stone. The ingredients must be thoroughly mixed with only enough water to produce a workable mixture. The concrete will be weakened if too much water is used.

For cast-in-place concrete septic tanks, the excavation should be prepared and the wall forms set in place. The walls, bottom and top should have minimum thicknesses of 4 in. to 6 in., depending upon the size and depth of the tank. In large tanks they should be reinforced, usually with 3/8 in. reinforcing steel set 6 in. on centers, both laterally and longitudinally. Except in roof slabs, reinforcing is not usually required for small household tanks. Even in the smaller tanks, however, some reinforcing is recommended to improve construction and prevent cracks. Heavy wire fencing with a 2-in. mesh has been found suitable for this purpose. Two layers of 10- to 14-gauge wire mesh are suggested. Each layer of the fencing should be placed so as to overlap at least 1 ft. at the ends and edges. If 3/8-in. reinforcing rods are used, a 15-in. overlap should be provided where the ends of rods in the same line meet. Overlapping rods or overlapping metal fabric or wire mesh should be securely wired together at the laps.

Small precast septic tanks should have a minimum wall thickness of 2 in., and should be adequately reinforced to facilitate handling. The bottoms of such tanks should have a minimum thickness of 4 in. Precast tops should have a thickness of at least 3 in. Each slab should weigh 200 lb. or less. The length of the tank should be at least twice the width but not more than three times the width of the tank.*

TANK SIZES:

Septic tanks should always be made large enough to satisfy the maximum anticipated need, not just the present number of persons to be

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*The requirement that the length of a septic tank be between two to three times the width of the tank is common practice in most states. It has become practically a "standard" specification. It is more justified by economics, however, than by tank efficiencies. A properly baffled circular tank will give very good efficiency in the removal of settleable solids. Long rectangular tanks give higher efficiencies than short rectangular tanks with single inlets and outlets.

served. Tanks that are made too small have to be cleaned frequently. Tanks that are properly designed and operated need only be cleaned every two to five years. Tanks that are operated seasonally or intermittently may be cleaned even less frequently if of ample capacity. This is because the major portion of the solids that accumulate in the tanks is given more time in which to become digested or liquified.

In the past, tank capacities of 300 gal. or less were permitted in most states for an ordinary family of four persons. Such tanks usually needed cleaning about once a year. Experience has demonstrated, however, that a 500-gal. tank serving the same family would operate roughly five times as long before the solids began to appear in the tank effluent. Upon considering that the cost of cleaning small tanks generally runs upwards of $25, it becomes readily apparent that the installation of the larger tank is good economy. Partly for this reason, and partly for the reason that tanks usually were not cleaned until the solids issuing therefrom caused the final disposal area to become clogged, most progressive health departments are now prohibiting the installation of any tank having an effective capacity of less than 500 gal. In Florida, a 500-gal. tank is permitted for a two-bedroom house or for a family of four at two persons per bedroom. The size of the tank is required to be increased by 100 gal. for each bedroom over two, or by such additional volume as may be necessary to obtain a net capacity equal to a full day's flow if the daily flow is less than 2,000 gal.

For example, an 800-gal. septic tank is acceptable for a five bedroom house where the average flow is less than 800 gal. per day. If the flow exceeds 800 gal. per day, a proportionately larger tank would be required.

CLEANING SEPTIC TANKS

Septic tanks should be cleaned whenever solids begin to appear in the effluent. Unless this is done, the final disposal area will become clogged and begin to overflow. This generally necessitates reconstruction of the disposal area. It is good economy, therefore, to examine the tank about once a year and have it cleaned whenever the combined volume of the sludge and scum occupies one-quarter to one-third the total tank volume below the flow line. As previously indicated, a tank ordinarily needs cleaning every two to five years.

Cleaning is usually accomplished by pumping the entire contents of the tank into a portable container or tank truck. The material may be buried in uninhabited places or emptied into the nearest sanitary sewer system. It should never be emptied into storm drains or discharged directly into any stream or watercourse.

GENERAL INFORMATION ON SEPTIC TANKS

The functional operation of septic tanks is not usually improved by the addition of disinfectants or other chemicals. In general, the addition of chemicals to a septic tank is not recommended. When certain chemicals are used, some of the bacteria producing the septic action in the tank may be destroyed. Frequently, however, this point is overemphasized. Small amounts of chlorine when added ahead of the tank for odor control will have no bad effects. Small quantities of lye if added to plumbing fixtures for unclogging is not objectionable. If the septic tanks are made as large as herein recommended, dilution of the lye in the tank will be adequate to overcome any deleterious effects that might otherwise occur.

When a large septic tank is being cleaned, care should be taken not to enter the tank until it is thoroughly ventilated and gases have been removed. Anyone entering the tank should have one end of a stout rope tied around his waist and the other end held above ground by another person strong enough to pull him out if he should be overcome by gas remaining in the tank.

Storm water or rain water from house roofs or gutters should not be allowed to enter the septic tank. If permitted to do so, heavy rains may flood the tank, stir up its contents and carry some of the solids into the outlet line. The disposal field below the tank may likewise become flooded or clogged and may fail prematurely.

Septic tanks should be made watertight, especially if there are wells or other sources of water supply in the vicinity. As a safety precaution, however, the tanks should still be located where they will not contaminate the water supply if leaks should occur.

Septic tanks of brick or concrete block may be used where practicable and where permitted by local authority. They are generally to be avoided in built-up areas where water is obtained from private wells.

If a domestic garbage grinder is to be installed on a line discharging to a septic tank, the capacity of the tank should be increased approximately 50 per cent above the capacity hereinbefore specified. The purpose of this is to provide additional sludge storage space. The addition of ground garbage to the sewage will not interfere with the operation of the tank if the garbage is finely ground and if the tank volume or the sludge storage space is adequate.

Vents are not desirable at septic tanks. Adequate venting is obtained through the building plumbing if the tank and the plumbing are designed and installed properly.

Toilet-paper substitutes should not be flushed into a septic tank. Newspaper, wrapping paper, rags and sticks will not decompose in the tank and are likely to lead to trouble.

DISPOSAL OF LIQUID PORTION

The effluent or liquid that is discharged from a septic tank is usually disposed of by some method of filtration. Three methods are commonly used. They include disposal in absorption fields, artificial subsurface sand filters, and seepage pits. Of these, the first two are acceptable in Florida.

Where soil conditions are favorable, advantage is taken of one of nature's gifts and filtration or final disposal is accomplished in absorption fields or subsurface tile systems laid in porous soil, preferably sand. Where the natural soil is so tight that the required absorption cannot be accomplished, artificial subsurface sand filters may be used. This method of treatment and disposal is usually, but not always, employed where large quantities of sewage are encountered. It will be discussed in conjunction with the design of large disposal systems in Part III of this bulletin. Cesspools, dry wells and seepage pits are generally prohibited in Florida. In other sections of the country, where soil conditions provide better protection against direct contamination of ground waters, they are permissible.

ABSORPTION FIELDS

An absorption field, or subsurface tile system, consists of a field of porous tile laid in such a manner that flow from the septic tank or sedimentation basin will be distributed with reasonable uniformity into natural soil.

LOCATION:

The same general considerations that govern the location of septic tanks should control the location of absorption fields. The fields should be kept 100 ft. or more from any source of water supply. They should be located downhill from underground sources of supply, or on ground which slopes away from such sources. They should be at least 25 ft. from any stream and not less than 10 ft. from dwellings or property lines. They should be in open unshaded areas and should be kept away from trees in order to avoid disruption by roots. They should be located in porous soil. They will not work satisfactorily in hardpan, impervious clay, or rock. When tight formations of such character are encountered, it is generally advisable to defer building until a public sewerage system is installed. Otherwise, it may be necessary to adhere to primitive methods of sewage disposal, such as "privies," or to revert to one of the more expensive methods of sewage treatment described in Part III of this bulletin. Sometimes the cost of such treatment may run several times the value of the lot on which the treatment facilities are to be located, hence it is advisable to explore fully the absorptive qualities of the soil before embarking upon construction of sewage disposal facilities. It is essential that the test described in the following paragraph be carefully applied in order to accomplish best results.

PERCOLATION TEST:

The percolation test has been successfully employed as a quantitative measure of the absorptive characteristics of a soil. It can be made with little trouble and almost no expense by the following technique:

1. Dig a hole about 1 ft. square to the depth at which it is proposed to lay the tile drain.
2. Fill the hole with water and allow the water to seep away. When the water level falls to within 6 or 8 in. of the bottom of the hole, observe the rate at which the water level drops (Fig. 4).
3. Continue these observations until the soil is saturated and the water seeps away at a constant rate. (Keep adding water until the rate becomes constant.)
4. Compute the time required for the water to drop 1 in. after the soil becomes saturated. This is the standard percolation time, t.

Experience and an extensive series of observations by engineers in New York State, upon disposal systems that had failed or were about to fail after having operated successfully for a period of about twenty years, have demonstrated a close correlation between the standard percolation time, t, of a given soil and the rate at which that soil could be expected to receive and effectively dispose of settled domestic sewage continuously for a period of some twenty years.

This relation, *established empirically,* may be formulated:

$$G = \frac{29}{t + 6.24}$$

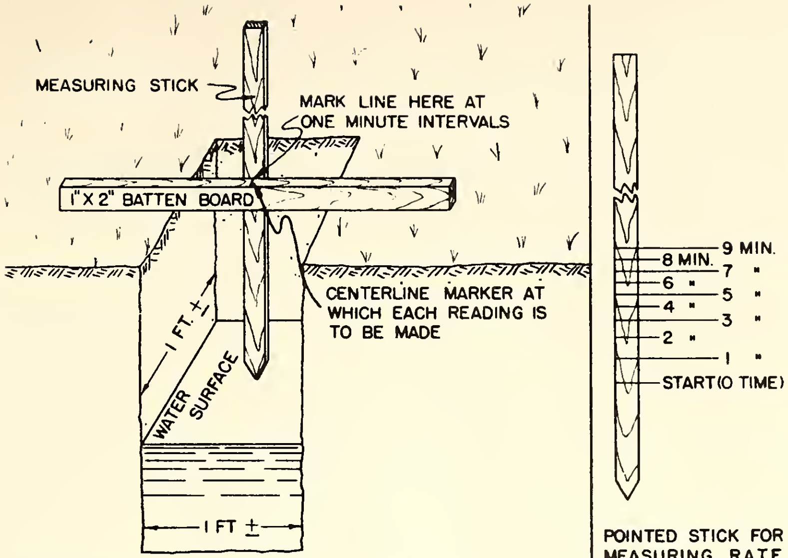
where t is the standard percolation time in minutes per inch, and G is the rate of sewage application in gallons per day per square foot of bottom trench area.

PERCOLATION COEFFICIENT:

For the purpose of classifying soils and of providing a standard measure of an important soil characteristic it is here proposed to designate the time function:

$$\frac{t + 6.24}{29}$$

as the percolation coefficient, C, of the soil.



POINTED STICK FOR MEASURING RATE OF PERCOLATION

NOTE:
LEAVE BATTEN BOARD IN PLACE. BE CAREFUL NOT TO MOVE IT DURING TEST

NOTE:
If the rate *after saturation* is more rapid than one inch per minute no further measurements need be made because the maximum allowable rate of sewage application is based on that fall. When slow rates are encountered, constancy of fall can sometimes be obtained during only one filling of the hole. The test should be prolonged, however, when there are peculiar influencing factors which must be taken into account. This is especially true in clay and in soils which swell after wetting. It is also true where high water tables are encountered and in areas where hardpan is found below a shallow stratum of sand. In general, absorption fields should not be developed in such areas.

Dimensions of the test holes are relatively unimportant. Holes about 1 ft. square are suggested merely for convenience when dug with a shovel. Small round holes dug with a post hole digger or even a 4-inch auger may be used if soaking is prolonged; but the percolation rates should always be checked by tests in duplicate holes until the results are assuredly authentic.

FIG. 4.— METHOD OF MAKING PERCOLATION TESTS

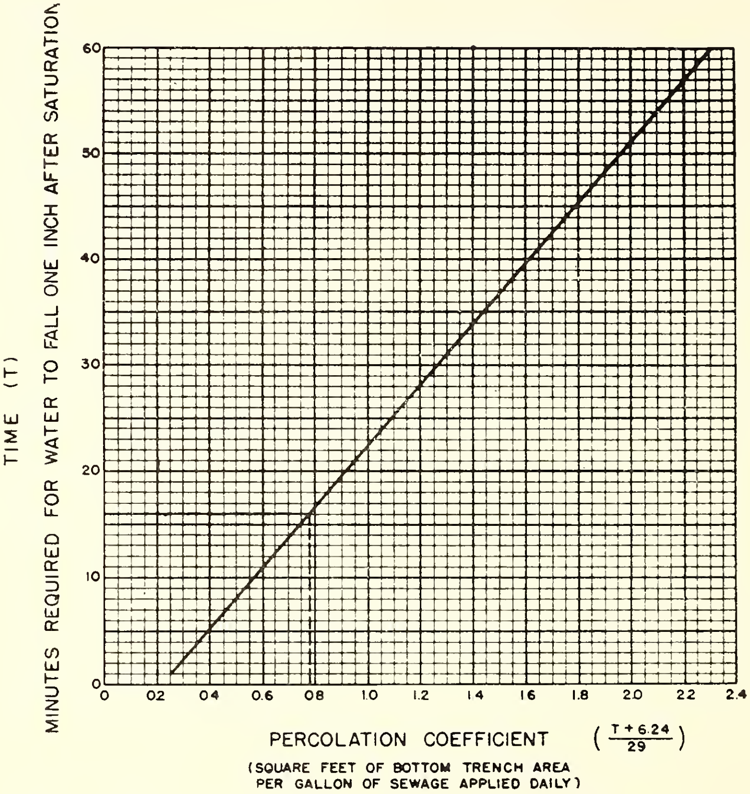
By definition, therefore, the percolation coefficient of an absorption bed or tile field is the reciprocal of the rate, in gallons per day per square foot of trench bottom, at which sewage may be safely applied to a field that has been properly constructed and designed with a life expectancy of twenty years. It also represents the number of square feet of bottom trench area required for each gallon of sewage applied daily to a tile field designed and constructed as defined above.

To facilitate computation of the percolation coefficient, its relation to percolation time is shown graphically in Fig. 5.

Up to a percolation rate of 1 in. in 30 min., shown by Fig. 5 to represent a percolation coefficient of about 1.25, values obtained by the formula:

$$C = \frac{t + 6.24}{29}$$

coincide almost perfectly with the reciprocal of loading values obtained



EXAMPLE:

IF 16 MIN ARE REQUIRED FOR THE WATER TO FALL ONE INCH AFTER SATURATION, THE PERCOLATION COEFFIECIENT IS 0.8 AND 0.8 SQUARE FEET OF BOTTOM TRENCH AREA WILL BE REQUIRED FOR EACH GALLON OF SEWAGE APPLIED DAILY.

FIG. 5.— METHOD OF DETERMINING PERCOLATION COEFFICIENT

from a chart published initially by the New York State Department of Health on the basis of original work in 1926-27 by one of its former employees, Mr. Henry Ryon, who was then with the State Engineer's Office. The chart has since appeared in several texts and has gradually become accepted as a standard in many sections of this country. Beyond the 30-min. rate, results obtained from the formula herein advocated are more conservative than indicated in the earlier chart. However, they coincide more closely than the earlier chart with a curve based on all points studied in Ryon's basic work. Thus they are considered more accurate than the chart previously used as a standard, and they are more amenable t mathematical representation.

An approximate relationship between the absorption rate, the type of soil and the percolation coefficient is given in Table VI.

TABLE VI

NORMAL SOIL CHARACTERISTICS

Type of Soil	*Approximate range of Percolation Coefficient*	*Relative Absorption*
Coarse sand or fine gravel	to 0.3	Rapid
Fine sand or light loam	0.3 to 0.6	Medium
Sandy clay or heavy loam	0.6 to 1.3	Slow
Medium clay	1.3 to 2.0	Semi-impervious
Tight clay or rock	above 2.0	Impervious

The approximations given are very rough and may not be relied upon as a substitute for the percolation test. Trained observers after hundreds of tests in all types of soils cannot with consistent accuracy predict the results of percolation tests from looking at samples of soil or even observing the holes from which the samples are taken.

Experience has shown that no absorption field should be designed or approved until or unless percolation tests have been conducted and proper allowances have been made for the percolation quality of the soil. In general, percolation tests are most desirable during the wettest season of the year when the water table is highest, but it is not usually necessary to delay the tests if discretion and good judgment are used in their interpretation. If they are made during an unusually dry season, it is necessary merely to be sure that the soil is saturated when the readings are taken and to ascertain the minimum depth of the water table during wet weather. The latter information can generally be obtained by probing below the test hole with a crowbar or by inquiring of some local resident or representative of the state or local health department. The absorption field should be laid above the water table. If there is any doubt as to seasonal changes in the water table an engineer with the State Board of Health should be consulted.

It is to be remembered that the size of an absorption field is controlled by the percolation test and the total sewage flow; not by the size of the septic tank.

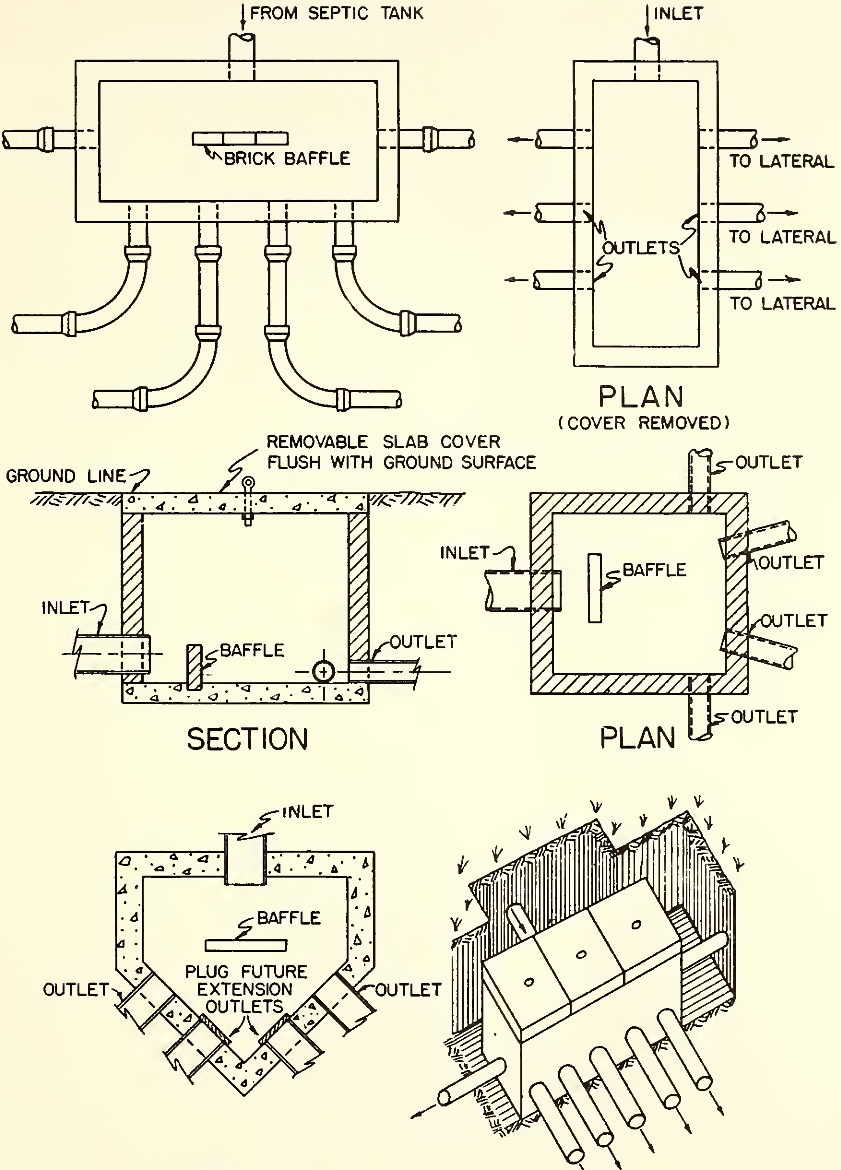
CONSTRUCTION FEATURES:

In order for an absorption field to function satisfactorily, the sewage must be dosed uniformly to all laterals. Uniform application of sewage can best be accomplished by distribution boxes. In Florida, distribution boxes are usually required for all absorption fields where the drain lines or laterals exceed 75 ft. in total length; also for laterals which cannot be laid in one continuous line. Properly designed distribution boxes allow both for flexibility of operation and future additions of tile laterals in the disposal field. They are the means through which the tile layout can be varied to meet the topographic conditions that are encountered. They are especially important when the disposal field is on sloping terrain. Typical designs of distribution boxes, taken principally from U. S. Public Health Service Reprint No. 2461, are illustrated in Fig. 6.

The drains or laterals in a disposal field are usually made of 12 in. lengths of 4 in. agricultural drain tile, or perforated clay or composition pipes which may be used in longer lengths.

The tile should be laid in a trench and surrounded by clean gravel, cinders, broken shell, broken brick, washed rock or similar aggregate. The material may range in size from ½ in. to 2½ in. Where fine material must be used, enough coarse material should be provided around the joints to prevent the fine material from entering the tile lines. The material should extend from a minimum distance of 4 in. below the drain tile to a level 2 in. above the top of the tile. The top of the stone should be covered with building paper or a 2-in. layer of hay, straw, pine needles, or similar material before placing the earth backfill. This will help prevent the stone from becoming clogged with the earth backfill. Where sloping ground is used for the disposal area, it is usually necessary to construct a small dike or a surface water diversion ditch above the field to prevent the disposal area from being washed out by rain. The dike should be maintained or the ditch kept free of obstructions until the field becomes covered with grass.

Unless the drain tiles are provided with bell and spigot joints, or unless sleeve joints are used as in the case of some kinds of perforated pipe, the upper half of the tile joints should be covered to exclude soil from



NOTE:
INVERTS OF OUTLET PIPES TO BE SET CAREFULLY TO THE SAME ELEVATION.
BAFFLES TO BE ADJUSTED SO FLOW WILL BE DISTRIBUTED EVENLY TO ALL LATERALS.
CONNECTIONS BETWEEN DISTRIBUTION BOX AND LATERALS TO HAVE TIGHT JOINTS

FIG. 6.—DISTRIBUTION BOXES

the tile lines. Metal spacers with covers for the upper half of the joints may best be used for this purpose. Tar-paper strips are an acceptable substitute. The metal spacers are commonly called drain-tile connectors, or collars, and are generally made of galvanized iron or copper, the latter being more serviceable but also more expensive. A manufacturer of the copper drain-tile connectors claims that the metal is effective in preventing root growths, and that the action is similar to that of copper sulphate which has frequently been used in eliminating roots from sewer lines.*

The bottoms of trenches in which tile lines are laid are generally made from 18 in. to 24 in. wide. The widths may be reduced to 12 in. but this increases the cost per square foot of bottom trench area. The widths may be increased to 30 in. in some cases. However, wide trenches may not give best results in the more porous soils where the tendency is for the sewage to percolate rapidly downward without much lateral spread. As the porosity decreases, of course, the lateral flow increases and downward flow decreases. In general, therefore, and especially where there is adequate area for the disposal field, the width of the trenches should be based on the permeability of the soil. The following criteria are suggested:

1. Use 18-in. trenches when the percolation coefficient is less than 0.4.
2. Use 24-in. trenches when the percolation coefficient is between 0.4 and 1.0.
3. Use 30-in. trenches when the percolation coefficient is between 1.0 and 2.3.

Where 12-in. trenches are used it is advisable to slope the sides in order to provide adequate leg-room for the workmen laying the tile. Slopes are also necessary for wider trenches in loose earth to prevent the soil from sliding while the gravel is being laid. Proper precautions should be taken to keep the gravel as clean as possible. In Florida, only the bottom trench area is used in computing the effective leaching area. Under certain conditions in other places, an extra square foot is allowed per running foot if the depth of the gravel is increased by an extra 6 in. This is permitted only in tight soils where the available disposal area is limited and where the circumstances tend to preclude other methods of disposal. It would not ordinarily be permitted for new buildings.

Many different designs may be used satisfactorily in laying out sub-

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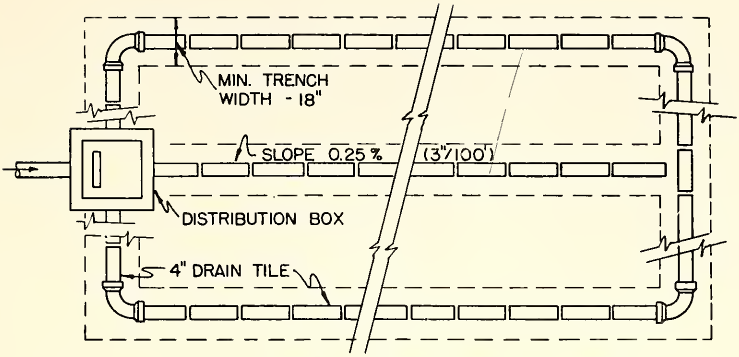
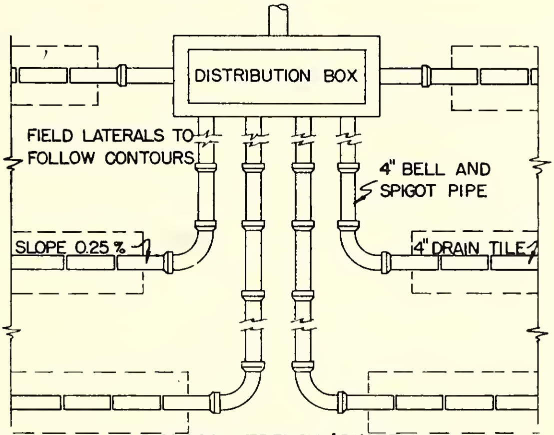
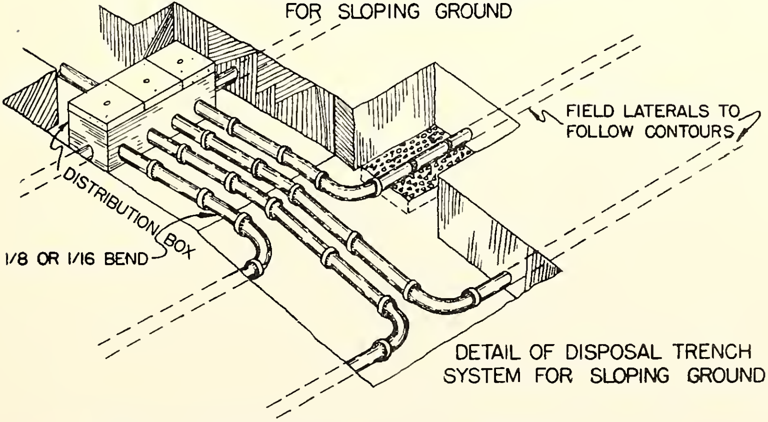
*The chemical, 2,4-D, is also effective in killing certain types of roots that penetrate sewer joints. It is likely to kill any broad-leaf plant with which it comes in contact and should be used with caution in the neighborhood of valuable shrubs.



DISPOSAL TRENCH SYSTEM FOR LEVEL GROUND

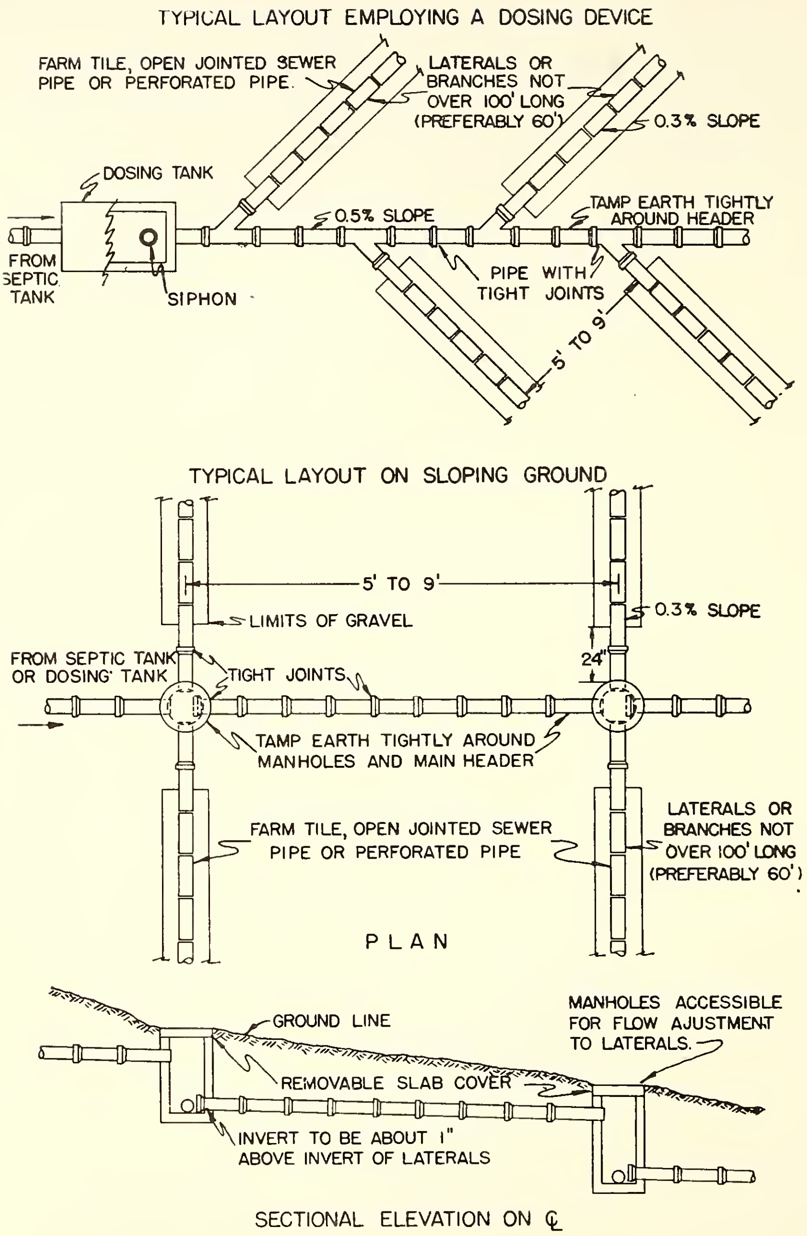


DISPOSAL TRENCH SYSTEM
FOR SLOPING GROUND



DETAIL OF DISPOSAL TRENCH
SYSTEM FOR SLOPING GROUND

FIG. 7.-SUBSURFACE ABSORPTION FIELDS
(AFTER U.S.P.H.S. REPRINT NO. 2461)



TYPICAL LAYOUT EMPLOYING A DOSING DEVICE

TYPICAL LAYOUT ON SLOPING GROUND

SECTIONAL ELEVATION ON ℄

FIG. 8.—ALTERNATE LAYOUTS OF ABSORPTION FIELDS
(AFTER N.Y. STATE DEPT. OF HEALTH BULLETIN NO. 1)

surface disposal fields. The choice may depend largely upon the size of the lot or available disposal area, the length of tile required, and the topography of the disposal area. Typical layouts are illustrated in Figures 7 and 8. Typical details or sections of the trenches are shown in Fig. 9.*

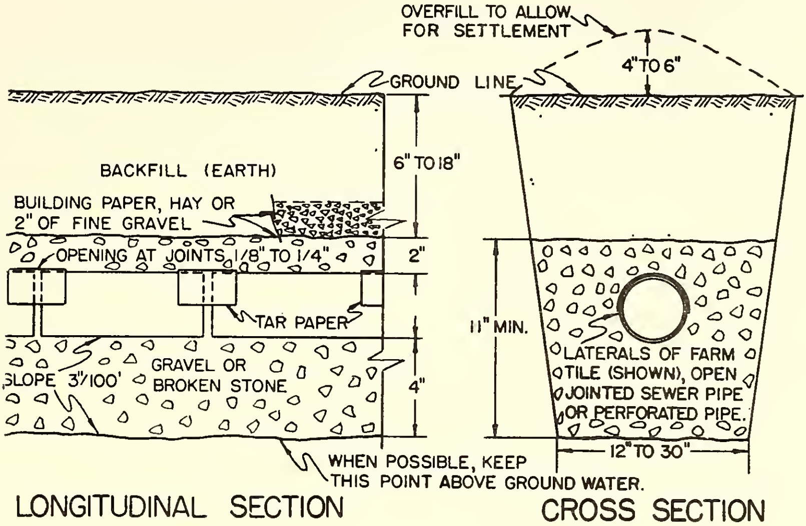


FIG 9. — ABSORPTION TRENCH AND LATERAL

The minimum distance between walls of adjacent trenches is 3 ft., but 5 ft. or more is preferable.

In order to obtain proper distribution of sewage throughout the lengths of the trenches, the individual laterals ordinarily should not be over 75 ft. long. For small household installations the maximum length should preferably be limited to 60 ft. or less. In large installations, where dosing siphons are used, the lengths of individual laterals should never

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*Clean gravel or crushed stone is preferred for use in absorption trenches. In most parts of Florida these materials are not readily available. Even where available, their cost may be too high to warrant their use. Under these circumstances, broken brick, broken tile, broken concrete block, sea shells, oyster shells, cinders, Brooksville limestone, or other durable material may be used as a substitute for the gravel or crushed stone. Such aggregates should be properly graded, however, and coarse material must be used around each tile joint. Sea shells, especially, contain too much fine material which must be removed by screening. Because of its cementing qualities, Ocala limerock should not be used as a substitute for Brooksville limestone.

exceed 100 ft. and should be limited to 80 or 90 ft. wherever possible. The lower ends of all laterals and distributors should be plugged.

A new absorption trench should be well tamped and should be overfilled with about 4 in. to 8 in. of earth. Unless this is done the top of the trench may settle to a point lower than the surface of the adjacent ground. This may cause the collection of storm water in the trench, which may lead to premature saturation of the absorption field and possibly to complete washouts of the trenches. A heavy vehicle will readily crush the tile in a shallow absorption field. For this reason, trucks should be excluded from the disposal area unless special provision is made to support the weight.

INSPECTION

After a sewage disposal system has been installed, and before it is used, the entire system should be tested and inspected. The septic tank should be filled with water and allowed to stand overnight to test for leaks. If leaks occur they should be repaired. The absorption field should be checked to ascertain that proper distribution of sewage is obtained in the laterals. This should be done before the laterals are covered.

PART III

Additional Disposal Methods

With Emphasis on Institutional and Large Private Systems

In providing sewage disposal for institutions, rural hotels, large private estates, and similar places, certain additional or alternative features are often found necessary or economical.

When an appreciable amount of grease is contained in the sewage, grease traps or interceptors are required to be used ahead of the septic tanks.

Percolation becomes more critical in the larger plants. When the quantity of sewage exceeds the amount that can be disposed of in about 500 lineal ft. of tile, dosing tanks and automatic siphons are needed just beyond the septic tank. If the soil in the disposal area is practically impervious, as indicated by a very high percolation coefficient, ordinary absorption fields will not work and may have to be replaced with sand filter trenches. This sometimes applies even to the smaller systems. If the space available for the disposal area is too small, artificial subsurface sand filters may be necessary. The same may be called for if the quantity of sewage is too large to justify filter trench construction.

If the sewage from a subsurface filter has to be discharged on a watershed of a public water supply, chlorination may be required for the filter effluent. Any disposal system that must be located on a watershed from which drinking water supplies are taken should be planned in cooperation with the State Sanitary Engineer.

GREASE TRAPS

Most premature failures of septic tanks are due in some measure to accumulations of grease within the tanks. Sewer lines frequently clog because of grease collections. Grease traps, also called grease interceptors and grease separators, are used to congeal the grease by cooling and prevent its entrance into the septic tanks. The grease floats to the top of the interceptors and the liquid from which the grease has been removed is discharged from a lower elevation. The grease must be removed at frequent intervals. Grease traps should always be used on kitchen waste lines from institutions, hotels, restaurants, schools with lunchrooms, and other places where the volume of kitchen wastes is large. After passing through the grease trap, the kitchen wastes must still be treated in the septic tank or in another settling tank before being discharged to the disposal field. Kitchen wastes from which grease is removed will not interfere with the action in a septic tank.

LOCATION:

Grease traps should be placed in an accessible location. Small commercial grease traps may be located inside the building. Some are placed under the kitchen sinks just below the sink trap, with connections only to the kitchen waste line. Large commercial or homemade grease traps are usually located just outside the building, near the kitchen.

CONSTRUCTION DETAILS:

Commercial grease traps are usually made of metal. Various manufacturers put out traps of their own design. Some of the designs are based on fundamental studies and research and are quite satisfactory. Others are less satisfactory and appear to have been developed primarily to meet competitive needs. As the result also of price competition, commercial traps are sometimes too small to serve their purpose adequately. Too frequently they are purchased purely from the viewpoint of cost, without consideration of design or capacity.

Homemade grease traps may be constructed of concrete, brick, vitrified or concrete pipe, or of metal.

Whether grease traps are ready-made, or constructed at the job site, the most important considerations of design are: (1) the capacity of the trap; (2) facilities for insuring that both the inlet and outlet are properly trapped; (3) the ease and convenience with which the traps can be cleaned; (4) inaccessibility of the traps to insects and vermin; and (5) distance between inlet and outlet, which should be as far as possible to insure that the grease will be properly cooled and not escape through the outlet.

These principles are illustrated in Fig. 10, which shows typical details of construction of homemade traps.

CAPACITY:

The capacity of a grease trap will depend primarily upon the number of people for whom meals are prepared in the kitchen served by the trap. The smaller the trap, the more frequently it will have to be cleaned. A net capacity of 2½ gal. per person has been found large enough to hold the flow from one meal long enough for the liquid to cool and allow the grease to rise. The minimum allowable capacity should be about 30 gal. for small installations serving ten or fewer people, with proportionately larger capacities for larger populations. As in the case of septic tanks, however, it is generally good economy to build grease traps that are somewhat oversize.

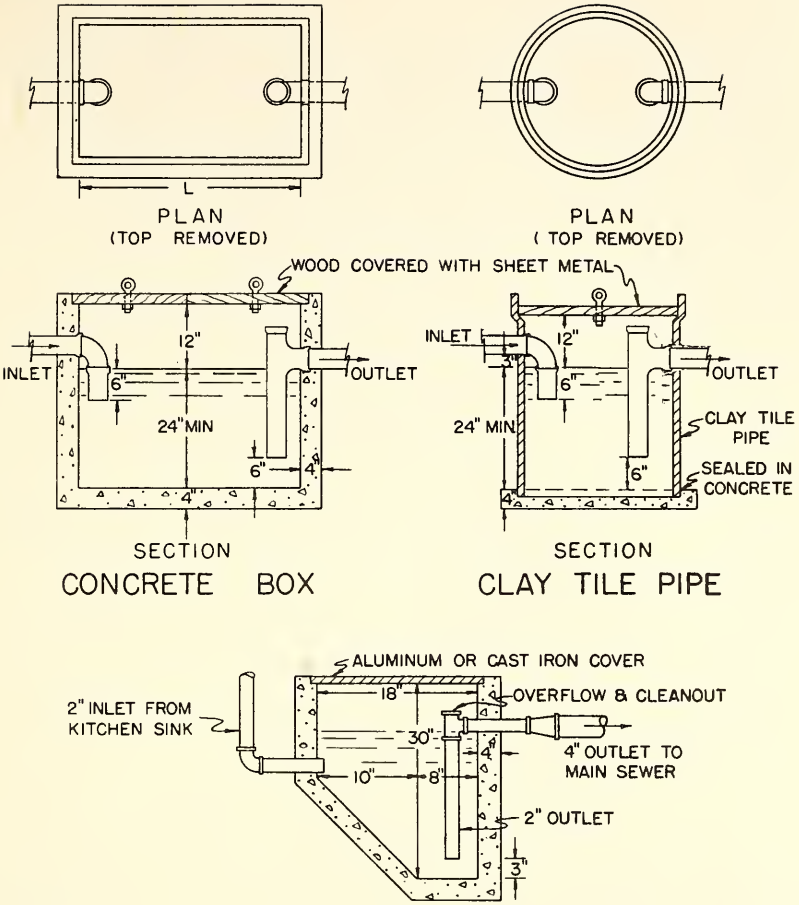


FIG. 10.— HOMEMADE GREASE TRAPS.

(AFTER U.S.P.H.S REPRINT 2461 & N.Y. STATE HEALTH DEPT. BULLETIN NO. 32).

OPERATION:

In order to be effective, grease traps must be operated properly and cleaned regularly. They should be cleaned often enough to prevent the escape of grease into the septic tank. Small commercial traps in large kitchens have been known to require cleaning every day. On the other hand, monthly cleanings may be adequate for large traps. The frequency of cleaning at any given installation can best be determined by experience. Ordinarily, the traps need not be emptied completely every time they are cleaned. The usual procedure is to skim them several times before they are completely emptied. Experience has demonstrated, however, that the cleanings must be scheduled on definite days if the operation is to be performed with uniformity. Traps that are supposed to be cleaned "every month" or "every week" or even "every other day" may be almost never cleaned. Much better results are accomplished if the operation is scheduled for a certain hour every day, or every Monday, or the first of every month, and if a check system record is kept of the cleanings. In place of submerged inlets and outlets, some commercial traps designed for inside use have baffles that are easily removed. Cooks and kitchen attendants are sometimes tempted to remove the baffles as a means of eliminating the necessity of cleaning, and baffles have often been found lying on the inside bottom of the traps. Needless to say, this completely defeats the purpose of the traps.

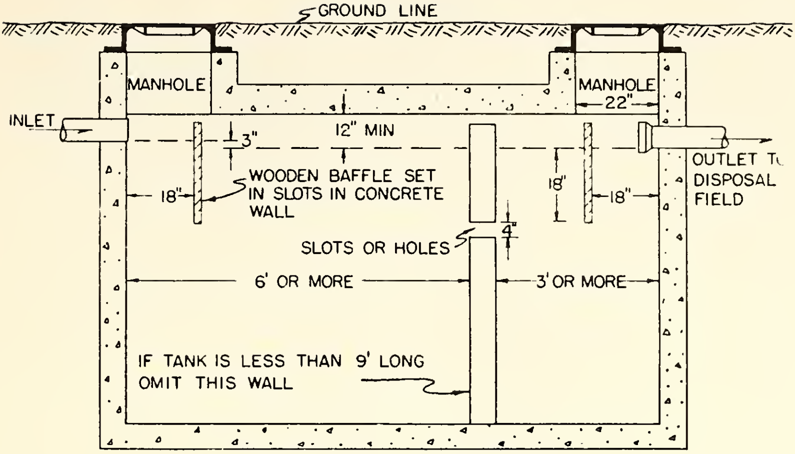
Grease removed from the traps may be clarified by heating or melting down (i. e. rendering) and recovered as fat. It may be used for making soap and for other manufacturing purposes.

Grease traps must be kept tightly covered in order to exclude insects and vermin. Flies and roaches seem especially to be attracted to the environment of outdoor grease traps unless tight covers are provided and used. Even with covers that are apparently tight, the area inside and around some outdoor traps may have to be sprayed with suitable insecticides to prevent the insects from breeding.

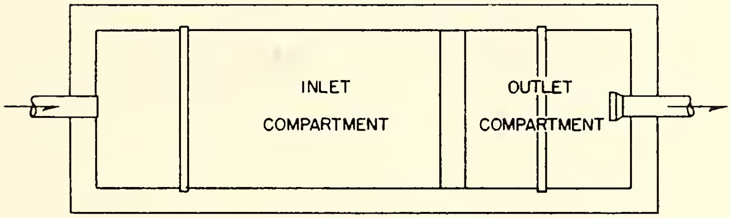
TWO-COMPARTMENT SEPTIC TANKS

Septic tanks with lengths less than 9 ft. usually have a single compartment. Longer tanks may function better if divided into two compartments with slots or ports in the dividing wall about 18 in. below the flow line. The slots may contribute to a better flow pattern, and the second compartment can be used more or less as an observation well to determine when the tank needs cleaning. The relative absence of solid material in the second compartment serves as an indication that the first compartment is functioning satisfactorily and does not require cleaning. The second compartment should have a capacity about one-third to one-half that of the first compartment. A typical design of a two-compartment septic tank is shown in Fig. 11.

The same effect of a two-compartment tank can be accomplished by using two tanks in series with the second tank having a capacity about one-third to one-half that of the first. This arrangement is generally preferred in some of the larger installations. It lends itself to a flexible



SECTIONAL ELEVATION



PLAN (ROOF REMOVED)

FIG. 11.—TWO-COMPARTMENT SEPTIC TANK

design whereby either of the tanks can be conveniently by-passed and taken out of operation for cleaning or repairs.

In Florida, no allowance is made for the second compartment in a two-compartment septic tank. In effect, the Florida State Sanitary Code requires that when two-compartment tanks are used, the first compartment shall have the same capacity that is required where only one compartment is used. This requirement was initially recommended by Federal and State representatives comprising the Joint Committee on Rural Sanitation. In some states, however, the total capacity required for a large two-compartment tank is exactly the same as if a single compartment tank were employed.

DOSING TANKS

When the quantity of sewage exceeds the amount that can be disposed of in about 500 lineal ft. of tile, a dosing tank should be used in conjunction with the septic tank in order to obtain proper distribution of sewage throughout the disposal area and in order to give the absorption bed a chance to rest and dry out between dosings. Rest periods are always advantageous, especially when the soil is dense. The dosing tank should be equipped with an automatic siphon. The siphon should not discharge more frequently than once every three or four hours. The tank should have a capacity equal to about 70 to 80 per cent of the interior capacity of the tile to be dosed at one time. (Allow 0.5 gal. per ft. length when 4-in. tile is used). Fig. 12 illustrates a dosing tank of the same width as the septic tank.

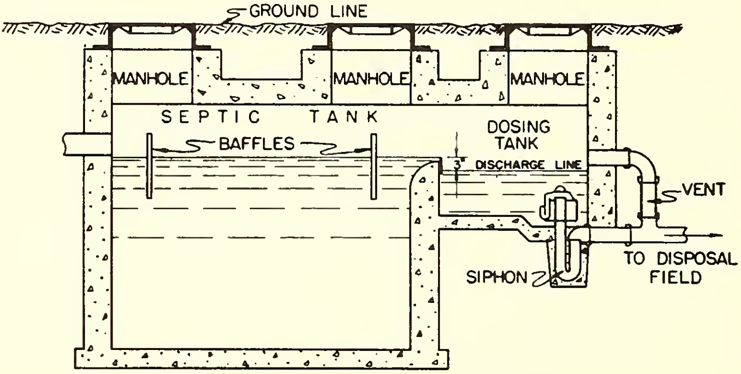
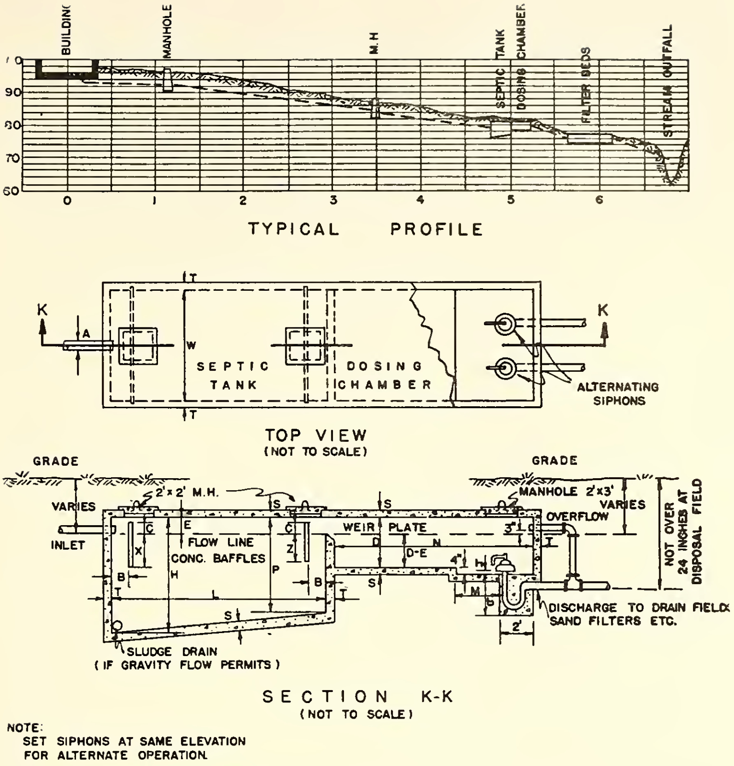


FIG. 12—SEPTIC TANK WITH DOSING TANK AND SIPHON

Where the total length of the tile laterals exceeds 1,000 ft., the dosing tank should generally be provided with two siphons. Florida requirements in this regard are typical. A single siphon is required in installations with from 500 to 1,000 ft. of drain tile, and two siphons are specified where the total length of tile is between 1,000 and 3,000 ft. However, installations involving more than 3,000 ft. of tile are not permitted in Florida. Present policy specifies that if " . . . conditions are such as to indicate more than 3,000 ft. of drain tile are needed some other form of secondary treatment will be required."

Each siphon should serve one-half the tile field, and should dose alternately. Alternating service should be specified when the siphons are ordered. For details and standard capacities of sewage siphons the manufacturers' bulletins should be consulted.

Fig. 13 shows a septic tank and dosing compartment with alternat-



TYPICAL PROFILE

TOP VIEW
(NOT TO SCALE)

SECTION K-K
(NOT TO SCALE)

NOTE:
SET SIPHONS AT SAME ELEVATION
FOR ALTERNATE OPERATION.

SPECIFICATIONS		
NET CAPACITY SEPTIC TANK (APPROX)		
POPULATION SERVED BY PLANT	DOMESTIC PERSONS	
	SCHOOL PUPILS	
DIMENSIONS OF SEPTIC TANK	A	
	L	
	W	
	H	
	P	
	B	
	C	
	X	
	Z	
	E	
	S	
	T	
SIZE SIPHON ______	NORMAL DISCHARGE ____ G.P.M.	

DIMENSIONS OF DOSING CHAMBER	N	
	D	
	D-E	
	M	
	b	
	h	
REINFORCING AREA & SPACING OF STEEL FOR TOP & BOTTOM SLABS		
REINFORCING AREA & SPACING OF STEEL FOR ALL WALLS		
DIMENSIONS OF FILTERS		

FIG. 13.—SEPTIC TANK AND DOSING TANK WITH ALTERNATING SIPHONS
(FLORIDA STATE BOARD OF HEALTH DESIGN)

ing siphons as illustrated in suggested plans and designs developed by the Florida State Board of Health. The figure also shows elevations or profiles through a typical system in which twin siphons may be used.

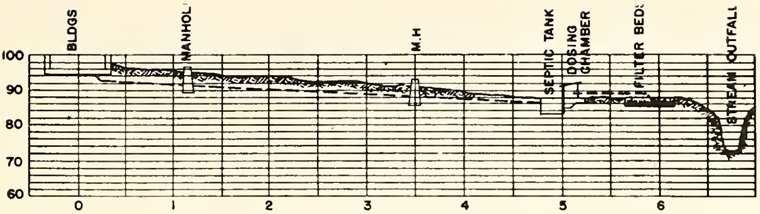
Separate siphon compartments already equipped with siphons are made by some manufacturers. Duplex siphon compartments equipped with two siphons which operate alternately are also prefabricated.

New siphons should be primed by filling with water when the system is first started. If inadequate head is available to permit the use of a siphon, intermittent pumps may be used to obtain proper dosing of the sewage as shown in Fig. 14.

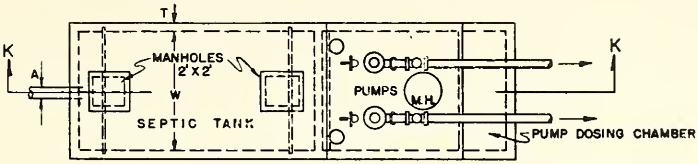
SAND FILTER TRENCHES

In porous soil, absorption trenches of the type illustrated in Fig. 9 generally provide the best underground method of disposing of sewage from which the settleable solids have been removed. The absorption trench method of disposal should be used wherever possible. In soil where the percolation coefficient is greater than 2.0, however, this method of disposal is unsatisfactory. It becomes more expensive as the percolation cofficient increases, and it may not be economically feasible when the coefficient exceeds about 1.5. The exact point at which absorption trenches are no longer desirable will depend primarily upon the relative costs of labor and material in the locality where the disposal system is to be constructed. The decision as to whether to use absorption trenches may also be influenced by the area available for the disposal field. Where land is at a premium, absorption trenches become less attractive. They begin to require excessive areas when the percolation coefficient exceeds 1.0.

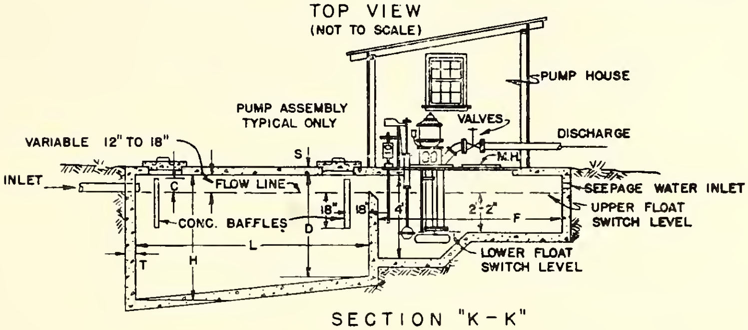
When absorption trenches are impractical, the possibility of treating the sewage in subsurface sand filter trenches should be considered. The filter trenches are somewhat similar to absorption trenches, the major difference being that the filter trenches are deeper, generally somewhat wider, contain an intermediate layer of sand as filtering material, and are provided with underdrains for carrying off the filtered sewage. The sewage is not absorbed, except to a limited extent. It is simply filtered and must be disposed of when it leaves the trench. For this reason, filter trenches are properly regarded as a means of sewage *treatment* and not sewage *disposal*. They accomplish a high degree of purification, however, and the sewage effluent coming from a filter trench that is properly designed can usually be disposed of by discharging into ditches, small streams, or dry stream beds. If perforce the receiving stream contributes to a source of water supply, chlorination may be required as hereinafter explained.



TYPICAL PROFILE



TOP VIEW
(NOT TO SCALE)



SECTION "K-K"

SPECIFICATIONS

NET CAPACITY SEPTIC TANK (APPROX.)		
POPULATION SERVED BY PLANT	DOMESTIC PERSONS	
	SCHOOL PUPILS	
DIMENSIONS OF SEPTIC TANK	A	
	L	
	W	
	H	
	D	
	F	
	S	
	T	
	C	
REINFORCING AREA & SPACING OF STEEL TOP & BOTTOM SLABS.		
REINFORCING AREA & SPACING OF STEEL FOR ALL WALLS.		

PUMP ASSEMBLY DATA

________ GALLONS PER MINUTE

DELIVERED AT ________ FEET

TOTAL DYNAMIC HEAD.

________ R. P. M.

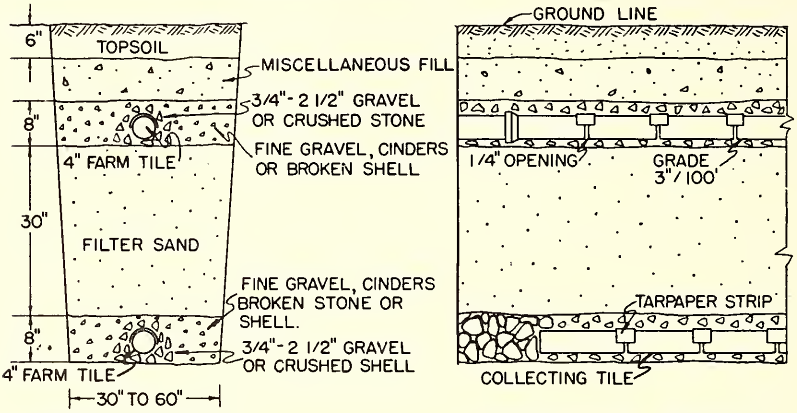
TYPE OF PUMP:

FIG. 14.—SEPTIC TANK AND PUMP DOSING CHAMBER
(FLORIDA STATE BOARD OF HEALTH DESIGN)

Approval should be obtained from the state or local Board of Health before filter trenches are installed. This method of sewage treatment becomes less economical and less desirable as the quantity of sewage and the required area increases.

CONSTRUCTION FEATURES:

Typical details of an underdrained sand filter trench are shown in Fig. 15. For all-year service, filter trenches should be designed for a filtration rate of 50,000 gal. per acre per day. This is equivalent to a percolation coefficient of 0.87, which is to say 0.87 sq. ft. of surface area in the trench per gallon of sewage applied daily.



CROSS SECTION

SECTION OF TRENCH

FIG. 15.–UNDERDRAINED SAND FILTER TRENCH

The filtering material should be clean, coarse sand, all passing a screen having four meshes to the inch. The sand should have an effective size between 0.25 and 0.50 mm., and a uniformity coefficient not greater than 4.0.* The sand should not be less than 30 in. deep. Tile distributors and underdrains, above and below the sand, should be surrounded by coarse screened gravel or crushed rock. All of the gravel or rock should pass a 2½-in. screen and should be retained on a ¾-in. screen. Fine gravel, cinders, or broken shell may be used above and around the coarse material, both at the distributors and the underdrains.

The slope of the distributors should be about 0.5 per cent, and the underdrains about 0.5 to 1.0 per cent. It is essential that the distributors

---

*"Effective size is that size than which 10 per cent of the sample by weight is smaller; uniformity coefficient is the ratio of the size, than which 60 per cent of the sample is smaller, to the effective size."—Metcalf and Eddy.

be laid accurately to grade and that the sand be thoroughly settled by flooding or other means before the distributors are placed at the final grade.

SUBSURFACE SAND FILTERS

As indicated previously, filter trenches are not economical for large installations. Subsurface sand filters are cheaper, they require less area, and they will do the job just as well as filter trenches. They require more care in design and construction, but this is more than offset by savings in cost. As a rough guide, filter trenches are usually impracticable when the amount of sewage, and consequently the filter area or the length of tile distributors, is enough to require the use of dosing siphons. Subsurface sand filters are generally indicated when dosing siphons are needed in conjunction with artificial filtration.

The principles of design of subsurface sand filters are similar to the fundamentals involved in the layout of filter trenches. Both types of installations have distributors and underdrains, with filter sand in between. The essential difference in the two is that filter trenches are smaller and the filter material is laid in trenches as implied in the name. When two or more trenches are used, natural earth is permitted to remain between them. For subsurface sand filters, on the other hand, the entire filtration area is filled in artificially, usually after excavation.

CONSTRUCTION FEATURES:

The sand in a subsurface filter should be of a quality at least equal to that specified for a filter trench, with an effective size between 0.25 and 0.5 mm. and a uniformity coefficient less than 4.0. The gravel or crushed stone should likewise be equal to the quality previously specified. The same depth of sand is used, and the required filter area is the same (0.87 sq. ft. per gal. of sewage applied daily or 50,000 gal. per acre per day) with one exception. Where the filters are constructed solely for seasonal use and have long rest periods over the greater part of the year, the filters have been found to work satisfactorily if dosed at rates as high as 100,000 gal. per acre per day (i. e. area as low as 0.43 sq. ft. per gal.) provided that the sand has an effective size between 0.35 and 0.5 mm.

Dosing tanks should be provided where the total filter area exceeds 1,800 sq. ft. and where the distributors exceed 300 lineal ft. The capacity of the dose should be 70 to 80 per cent of the volume of the distributors dosed at one time. Where an installation has over 800 ft. of distributors, best results can be obtained by constructing the filter in two or more sections with alternating siphons.

Underdrains may be of agricultural tile, or bell and spigot pipe. Perforated pipe is recommended for the distributors. It comes in long lengths and has special joints which hold to better alignment than ordinary vitrified pipe with bell and spigot joints. If farm tile is used for distributor laterals, it should be laid on grade boards. In any event, the distributors should be laid accurately to grade *after* the filter sand has been thoroughly settled by flooding or other means.

Where dosing tanks are used, the distributors should be laid to 0.3 per cent grade, otherwise to a grade of about 0.5 per cent.

A typical plan and section of a subsurface sand filter are given in Fig. 16.

SUPERFICIAL SAND FILTERS

In some sections, the ground water table is found too near the surface to permit construction or successful operation of any subsurface method of sewage disposal. The construction of buildings and sewage disposal systems should generally be avoided in such places. Sometimes, however, the elevation of the water table may be found to fluctuate over a wide range unexpectedly. Due to floods or other hydrologic conditions, areas which for decades may have experienced a water table appreciably below the ground may suddenly be faced with a condition wherein the ground water approaches or even covers the surface. Sometimes such occurrences are brought about artificially, as by the construction of dams or dikes, and the conditions may be likely to remain relatively permanent.

In these events it may be necessary to completely forego the construction or renovation of subsurface methods of sewage treatment and disposal. The circumstances may require treatment and disposal by superficial means above the surface of the ground. This frequently necessitates pumping but it can be accomplished in superficial sand filters constructed as shown in Fig. 16 except that the ends and sides must be surrounded by a masonry wall or earth dike for retaining the filter bed. The filters may be completely above the ground, or only partly above the surface, depending primarily upon the depth to ground water. From the standpoint of operation, sewage filters do not have to be covered, but a shallow earth cover of about 6 in. is recommended to prevent odors and other nuisances from the septic sewage. While open filters are accessible for cleaning and can be operated at higher rates than those which are covered with earth, they ordinarily require daily attention and are not usually advisable for private installations. They are more suitable for municipalities where sewage plant operators are employed. In such cases the filters generally follow a conventional primary settling tank, and the method of distribut-

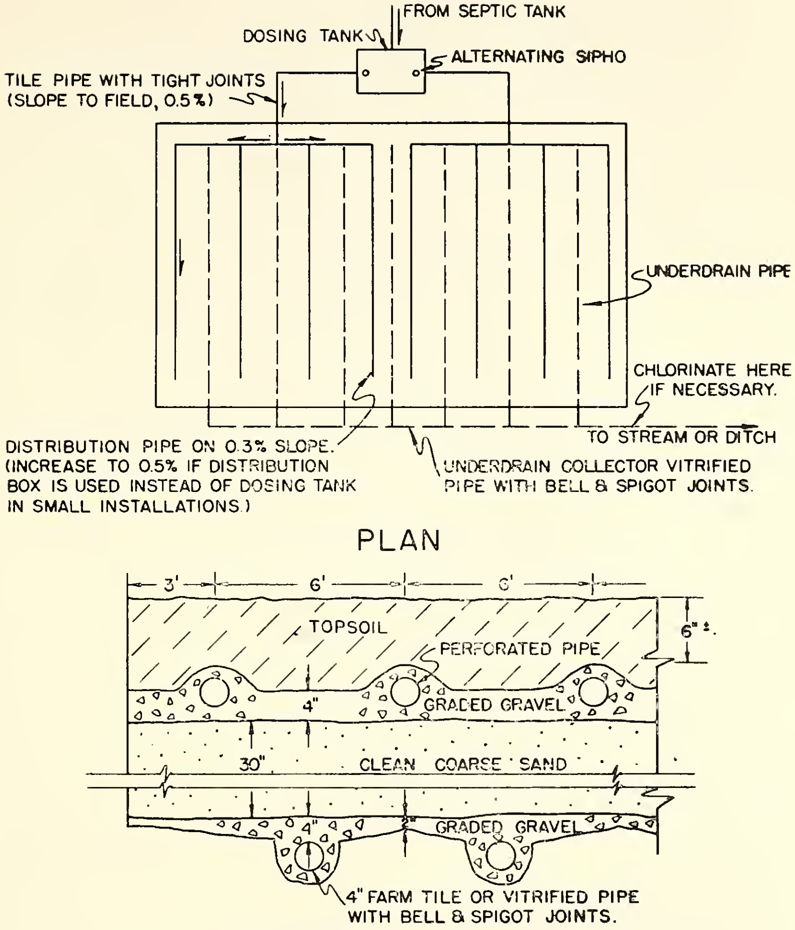
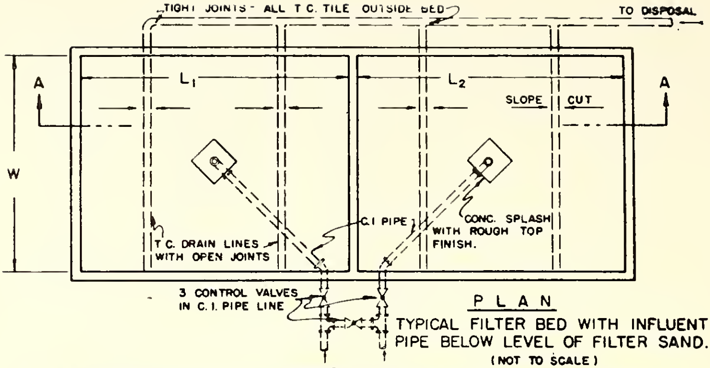


FIG. 16.—TYPICAL PLAN AND SECTION OF SUBSURFACE SAND FILTER

ing sewage onto open filters is different from that indicated for covered filters. Fig. 17 illustrates an installation of open filter beds as designed by the Chief Sanitary Engineer of the Florida State Board of Health.

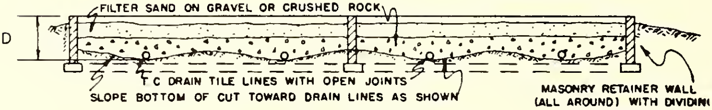
Open filters are operated intermittently and are known as intermittent sand filters. They should always be divided into not less than two units.



PLAN

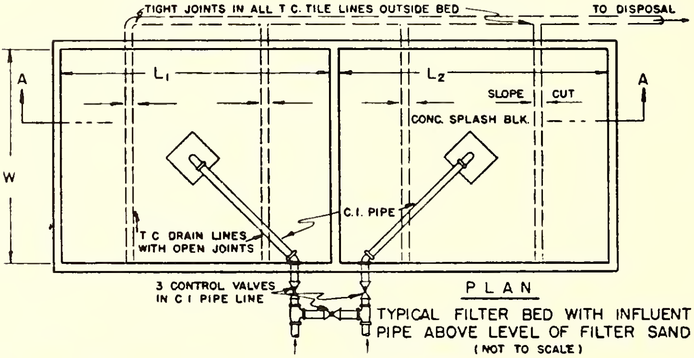
TYPICAL FILTER BED WITH INFLUENT PIPE BELOW LEVEL OF FILTER SAND.

(NOT TO SCALE)



TYPICAL SECTION AT A-A

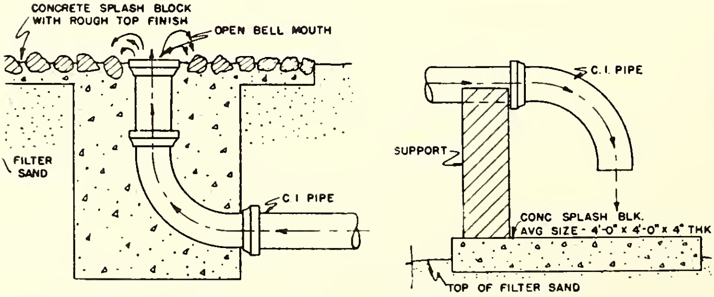
(NOT TO SCALE)



PLAN

TYPICAL FILTER BED WITH INFLUENT PIPE ABOVE LEVEL OF FILTER SAND

(NOT TO SCALE)



(BELOW LEVEL OF FILTER SAND)

(ABOVE LEVEL OF FILTER SAND)

DETAIL — TYPICAL DISCHARGE FOR INFLUENT PIPE

FIG. 17.— OPEN FILTER BED LAYOUT

(FLORIDA STATE BOARD OF HEALTH DESIGN)

Sand specifications and depths are the same as for subsurface sand filters. In Florida, filtration rates as high as 150,000-200,000 gal. per acre per day may be used in ordinary open filters if not located on a limited watershed used for water-supply purposes. Dosing tanks should have capacities that will provide for flooding the beds to depths of 1 to 4 in. Discharge from the dosing tanks should be at least the maximum rate of flow of the raw sewage.

Since different states have different requirements or policies regarding open filter installations, the State Sanitary Engineer should always be consulted before filters of this type are designed.

CHLORINATION

Filter trenches and artificial sand filters that are properly designed and operated will remove better than 99 per cent of the bacteria contained in sewage. Some of the remaining bacteria may still be capable of producing disease, however, and the sewage effluent must be disinfected if it is discharged into a stream that contributes to a nearby source of water supply used for drinking or for swimming. Chlorine is the disinfectant most commonly used.

Present custom is to apply chlorine in the amount necessary to obtain a chlorine residual of 0.5 to 1.0 parts per million after 15 min. contact. On an average, this requires a chlorine dosage in the neighborhood of six parts per million for sand filter effluents. This is equivalent to ½ lb. of chlorine for every 10,000 gal. of sewage, or less than 1 oz. per 1,000 gal.

Chlorine may be obtained in steel cylinders in which the gas is compressed into liquid chlorine. It may also be obtained from sodium or calcium hypochlorite.

In the steel cylinders, which usually contain 100 or 150 lb. of chlorine, the gas is under a pressure which varies with the outside temperature. The pressure ranges from about 40 lb. per sq. in. at 32° F. to 150 lb. per sq. in. on hot days.

Sodium hypochlorite is available only as a solution. Upon drying, it decomposes. Solutions of hypochlorite are obtainable in strengths ranging from 5 per cent to 15 per cent available chlorine. This material is corrosive to ordinary metals and should be handled in stoneware crocks. Wooden barrels may be used for temporary installations.

Calcium hypochlorite is obtainable only in a dry form, of which there are two types. *Hypochlorite of lime* or "bleaching powder" contains about 35 per cent available chlorine when manufactured, and *high-test* *hypochlorite* contains about 70 per cent available chlorine. The ordinary hypochlorite of lime or bleaching powder is not stable and may lose a large percentage of its chlorine content if stored for long periods. When made into a water solution it also has the undesirable characteristic of forming a scale of calcium carbonate which tends to clog the feeding apparatus. It is cheaper than high-test hypochlorite, however, and it can be used satisfactorily with certain types of feeding equipment if large solution tanks are employed and if proper precautions are taken in the preparation and utilization of the solution. The undissolved portion must be allowed to settle out of the solution and only the clear supernatant liquid fed through the feeding apparatus.

High-test hypochlorite is more stable and more convenient to handle than ordinary hypochlorite of lime. It is available under several trade names, such as "H.T.H.," "Perchloron," and "Pitt-chlor." When made up into water solutions containing 1 per cent to 2 per cent available chlorine, hypochlorite does not give much trouble with calcium-carbonate deposits, but precautions should still be taken to feed only the clear supernatant portion of the solution through the feeding equipment.

The decision as to whether to apply chlorine as a gas or in liquid form as a hypochlorite is sometimes dependent upon the availability of power. All hypochlorinators being manufactured at present require either electric current or clean water under pressure for their operation. In some remote places, these are not available. In such cases, chlorinators using chlorine in cylinders can be operated without any outside power source. Usually, however, power is available and the decision as to whether to use hypochlorite or chlorine gas is dependent upon their relative costs. Gas is the cheaper of the two, but equipment for controlling it is much more expensive than simple hypochlorite feeders. In general, hypochlorite is preferred when the amount of chlorine required is less than 2 lb. or 3 lb. per day. In other words, hypochlorite would normally be used for disinfecting the effluent from a sand sewage filter for sewage flows up to about 50,000 gal. per day. For chlorinating a septic tank effluent, the sewage flow limit for hypochlorinators would be about 10,000 gal. per day. Beyond these quantities, savings in the cost of the chlorine gas will usually offset the higher priced original investment in equipment.

The decision between sodium hypochlorite or calcium hypochlorite should depend upon the relative costs of the two materials in the locality of the job. Information as to their costs can usually be obtained from the suppliers of the hypochlorinators.

Several satisfactory types of hypochlorinators are available. Various types of chlorinators are also made. Both kinds of apparatus are being gradually improved. Both require occasional maintenance. Therefore, in choosing the make of apparatus to be purchased the first consideration should be that of service. It is practically always advisable to purchase a chlorinator from a manufacturer who has a full-time service man traveling through the area where it is to be used. Jobbers and agents handling chlorinators are seldom qualified to furnish the best technical assistance and are usually unable to render the prompt service that is necessary when a chlorinator gets out of order.

In purchasing a chlorinator for a specific job, advice should be sought from a reputable manufacturer or his full-time representative. A competent representative will usually recommend the most economical machine for the job and will not be a party to the sale of an expensive machine where a cheaper one will function satisfactorily.

A typical apparatus for the application of sodium or calcium hypochlorite solution to sewage after filtration through sand is illustrated in Fig. 18. The apparatus is suitable for the treatment of sand filter effluents in quantities up to about 50,000 gal. per day. Most states, including Florida, require a chlorine contact chamber large enough to retain the sewage for 15 min.

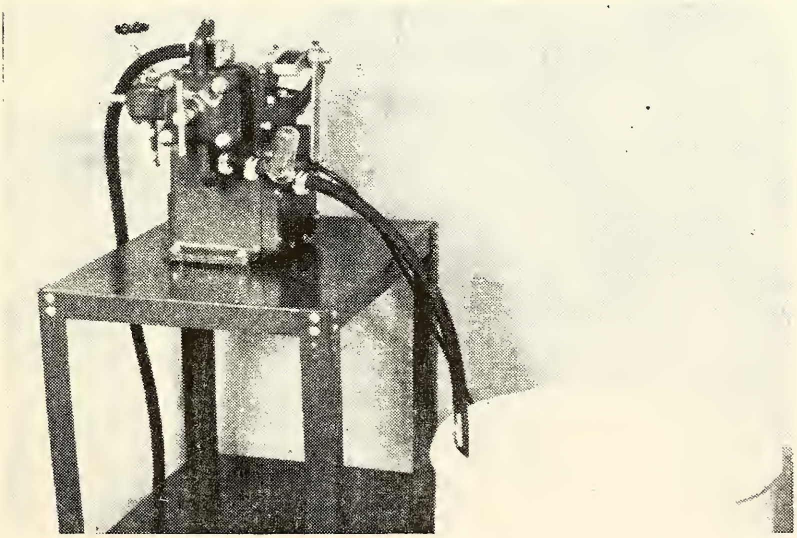


FIG. 18. HYPOCHLORINATOR AND SOLUTION CROCK.
(Courtesy of Wallace & Tiernan Co., Inc.)

PART IV

Permits, Plans and Engineering Services

PERMITS

The Florida State Sanitary Code requires that permits be obtained from the state or local boards of health before sewage disposal systems and septic tanks with capacities up to 1,200 gal. are constructed or installed. For disposal systems and septic tanks of over 1,200 gal., plans and specifications must be submitted to and approved by the State Board of Health before construction may be authorized. In other words, one of the state sanitary engineers should be consulted regarding large disposal systems, and a sanitary engineer either with the state or the appropriate full-time city or county health unit should be consulted regarding small disposal systems.

PLANS AND ENGINEERING SERVICES

All sewage treatment facilities should be competently planned and carefully installed. The services of a registered professional engineer experienced in sewage treatment should be retained for the design and *supervision of the construction* of institutional and large private disposal systems or treatment plants. Detailed plans of the proposed system should be prepared before construction is started. The suggested supervision should be maintained to see that the system is constructed in accordance with the plans. If not so constructed the system should not be expected to work satisfactorily. Many failures have resulted from neglect during construction.

The plans should be carefully prepared and copies should be kept permanently by the owner. Locations and details of construction are usually forgotten before a disposal system has given many years of service. When failures do occur accurate plans may be invaluable in diagnosing the trouble and making repairs at minimum expense. Pencil sketches will usually suffice for small household installations. Accurate blueprints or other types of printed reproductions should be prepared for large or expensive systems.

The following procedure is suggested for anyone contemplating the installation of sewage treatment and disposal facilities at institutions and large private establishments:

1. Obtain the services of a registered professional engineer.
2. Have the engineer prepare a plan showing the locations of all nearby buildings and the proposed arrangements both for water supply and sewage disposal. A general plan, usually to a scale of 20 to 100 ft. per in., should be prepared in addition to a diagrammatic profile of the entire installation and detailed plans showing enlarged cross-sections of the disposal units. The general plan should also show:
    (a) topography by contour lines or elevations of representative points;
    (b) all property lines including streets or roads;
    (c) sizes, slopes and elevations of important sewer lines;
    (d) portions of such existing disposal systems as are to be maintained in use;
    (e) present and estimated future capacities of all buildings;
    (f) sizes of septic tanks and disposal areas;
    (g) kind and number of plumbing fixtures, including showers;
    (h) locations and results of soil percolation tests;
    (i) minimum depth below ground surface at which ground water is encountered;
    (j) any unusual condition or other information of significance or value. (If there is any doubt about the inclusion of any item of information on the plans, the safest procedure is to include it.)
3. If the engineer runs into serious problems or questions, preliminary plans, preferably in pencil, should be taken to the state or local sanitary engineer for a decision before final plans are prepared.

A typical layout plan or "general plan" is illustrated in Fig. 19. The detailed plans showing enlargements and cross-sections should be prepared as illustrated in Figures 6 to 17.

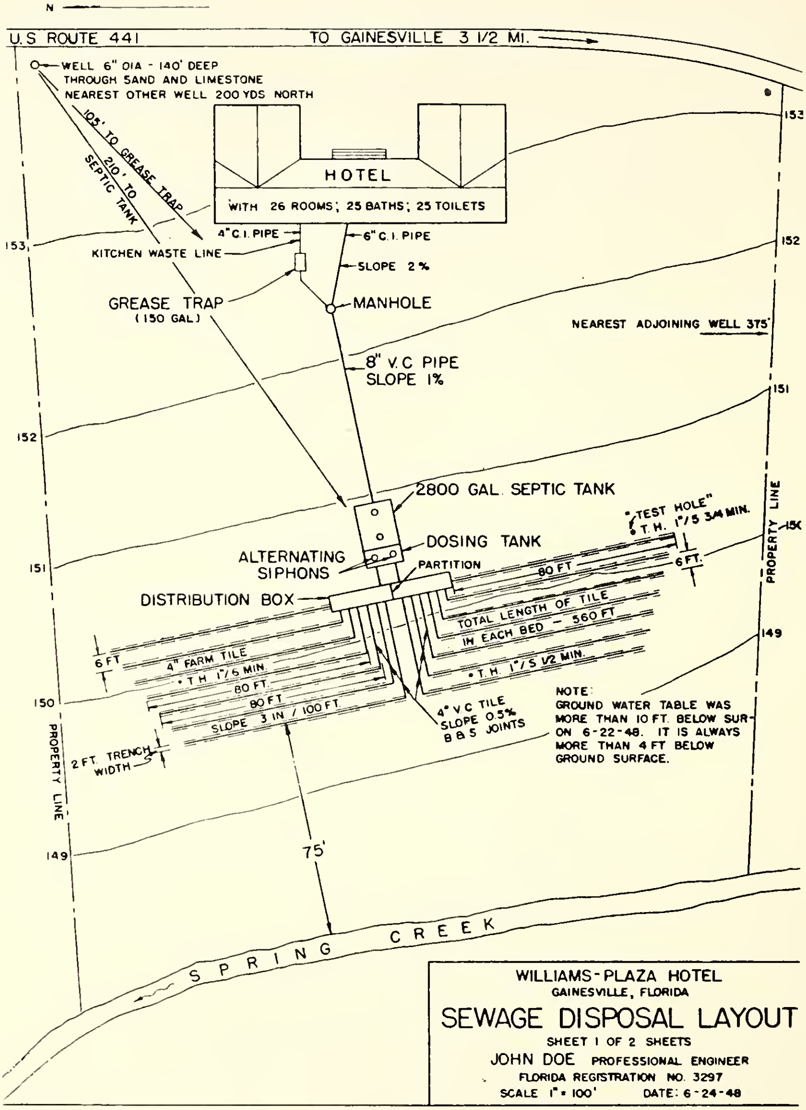


FIG. 19.—TYPICAL LAYOUT PLAN OF A SUB-SURFACE SEWAGE DISPOSAL SYSTEM

DESIGN DATA FOR DISPOSAL SYSTEM ILLUSTRATED IN FIGURE 19

26 Rooms Total

20 rooms with private baths × 2 persons per room × 100 gal. per capita per day = 4,000 gal. per day

6 rooms with connecting baths × 2 persons per room × 50 gal. per capita per day = 600 gal. per day

5 daytime employees × 25 gal. per capita per day = 125 gal. per day

2 night employees × 25 gal. per capita per day = 50 gal. per day

Kitchen wastes: 60 persons × 3 meals per day × 2½ gal. per meal = 450 gal. per day

Total daily sewage flow = 5,225 gal. per day

Required septic tank capacity (from Fig. 2) = 2,800 gal.

Required grease trap capacity (60 persons × 2½ gal.) = 150 gal.

Percolation test: 6 min. per inch drop.

$$C = \frac{6 + 6.24}{29} = 0.42$$

Required trench bottom area = 0.42 × 5,225 = 2,200 sq. ft.

Desired trench width = 2 ft. Total trench length $= \frac{2,200}{2} = 1,100$ ft.

Dosing tank, alternating siphons, and twin fields required.

$$\frac{1,100}{2} = 550 \text{ lineal ft. trench per field.}$$

Max. trench length 100 ft; desired length 50-60 ft.

80-ft. lengths can best be worked into available disposal area.

$\frac{550}{80} = 7\ (-)$ lines of laterals required for each field.

APPENDIX I

REALTY SUBDIVISIONS

In order assuredly to obtain proper standards of design of subsurface sewage disposal systems it is necessary that the subject be adequately considered at the very inception of plans for any building development. Where public sewers are not available, lots should be laid out and property purchased with due regard to the question of sewage disposal. Experience in all sections of the country has proven time and again that unless this is done the lots are likely to be too small for proper disposal of sewage. All too frequently real-estate developments have been permitted in areas where the ground water table is too high, or where the soil throughout is impervious clay, or where there are but a few inches of topsoil overlaying solid rock. In such cases, attempts at subsurface methods of sewage disposal have proven useless. Many public health nuisances have been created and much time and money have been wasted because of lack of foresight and failures to plan adequately for proper sewage disposal facilities and safe water supplies.

As result of such experiences, state and local laws have been enacted in some sections of the country requiring that plans of realty subdivisions, including facilities for water supply and sewage disposal, be approved by registered or properly qualified sanitary or public health engineers in the state or local health departments. No alert planning board will approve plans of a proposed real-estate development in areas where public water and sewers are not available without prior approval by a competent sanitary or public health engineer of the proposed private water and sewerage facilities.

Obviously, the greatest number of problems occur where private water supplies and private sewerage facilities are both to be provided in the area to be subdivided. The lots may have to be unusually large in order to keep subsurface sewage disposal systems adequate distances from private wells. Lots having areas of about one-quarter acre are about the minimum that should be permitted under ideal conditions. Depending upon the topography, percolation coefficient, subsurface conditions, sizes of the houses, shape and relative positions of the lots, the minimum size should be increased to one-half or one acre or more in some cases.

The problems are simplified and the above-mentioned lot sizes can safely be reduced by about one-half if water is to be obtained from a central source or from a public supply. Also, size reductions of approximately the same order can usually be made if private water supplies are used in conjunction with public sewers. In practice, this combination seldom occurs because the installation of public water supplies generally precedes sewers.

The principles involved in the layout of subsurface sewage disposal facilities for real-estate developments are covered in Parts I and II of this bulletin. The additional disposal methods discussed in Part III are not generally applicable to subdivisions. The need for adequate plans and engineering services, discussed in Part IV, is especially important for realty subdivisions.

Each subdivision should be studied separately and a decision reached as to the proposed water supply and sewerage facilities.

Depending upon the facilities to be provided, certain restrictions should be adopted in order to safeguard the health of the future property owners. The following is a typical set of restrictions adopted by a developer for water supply and sewage disposal systems at a large subdivision on difficult terrain:

1. No lots shall be sold or developed in areas where the ground water table is at any time less than 4 ft. below ground level unless provision is made to fill in or build up the disposal area with porous material to obtain the required 4-ft. depth or unless provision is made for the disposal of sewage in a central sewage treatment plant approved by the State Board of Health.
2. No well shall be located in the direct line of drainage from any sewage disposal system or within 100 ft. of any sewage disposal system.
3. All water supplies shall be from a formation greater than 20 ft. below the ground surface and from a source not likely to be polluted by contamination entering through disintegrated, fissured or creviced rock. Well casings shall extend at least 5 ft. and preferably 10 ft. into bedrock and shall be sealed with cement grout.
4. No sewage disposal system shall be installed on the direct line of drainage to any well, or within 100 ft. of any well.
5. Sewer lines passing within 50 ft. of any well shall be of cast-iron pipe with lead-calked joints.
6. Areas for absorption fields shall be completely cleared before disposal systems are installed.
7. Where an absorption field is built up, a porous material for a depth of at least 4 ft. shall be used and the fill extended at least 20 ft. beyond the ends of the laterals.
8. Where an absorption field is built up in part over ledge rock, the fill shall be extended at least 20 ft. beyond the point where the rock terminates and a cutoff wall shall be built to retain the fill.
9. Absorption fields shall be increased by 38 ft. of tile* laid in trenches 2 ft. wide, as shown on the subdivision plans, for each additional bedroom over three in any house. (See Table VII.—Ed.)

****The actual mount of tile to be added for each bedroom will depend upon the amount of sewage and the porosity of the soil as explained in Part II of this bulletin. In trenches 2 ft. wide, 38 ft. of tile will be adequate for a flow of 150 gal. per day where the soil has a percolation coefficient of 0.5. (See Table VII, page 60.)***

10. Seepage pits shall not be used on any lot where the ground water table is less than 10 ft. below ground level or within 2 ft. of the bottom of the pit.
11. Seepage pits shall not be used in any area where hardpan or bedrock is encountered within 10 ft. or within the effective depth of the pit.
12. Each disposal system shall be inspected before it is backfilled, as required by local sanitary regulations.
13. Where other than a one-family residence is constructed, a plan showing the proposed water supply and sewage disposal system shall be prepared and approved by the State Board of Health before construction is started.
14. No sewage disposal system shall be located closer than 50 ft. to any watercourse or lake.

APPENDIX II

COMPARISONS OF AREA AND VOLUME REQUIREMENTS

As previously explained, the sizes of septic tanks and the amount of disposal area in absorption beds are governed by the amount of sewage and by the soil absorption characteristics as represented by the percolation coefficient and determined by percolation tests.

Requirements vary in computing the sizes of septic tanks. Some states and some city and county health departments arbitrarily require that the capacity of septic tanks be increased by 200 gal. for every bedroom over three in any house. This requirement is generally based upon the assumptions that each bedroom normally holds two persons, that the maximum amount of sewage contributed by each person is 75 gal. per day, and that the sludge storage capacity should amount to 33 per cent of the net septic tank volume or of the daily sewage flow. The same health departments may require that the absorption fields provide for the disposal of 75 gal. per person or 150 gal. per bedroom. Smaller absorption fields are sometimes permitted on the premise that the absorption fields can be extended as required, while septic tanks cannot be enlarged so easily. Some health departments even specify that sufficient additional area be available for the complete relocation of the absorption facilities if necessary. The requirements of different agencies are so varied that it would not be feasible to list them all in one bulletin. Furthermore, the variations are usually of a minor nature. Proper construction under one set of standards will satisfy most of the requirements under other standards.

The requirements in Florida are believed to be among the best that are to be found. In any event they agree closely with standards the author has drawn up and used in several municipalities elsewhere. This close agreement is illustrated in Table VII which shows at a glance the septic

TABLE VII

SEPTIC TANK CAPACITIES AND DISPOSAL AREAS

No. Bed-rooms	*Required Size of Septic Tank in Gallons*		*Square feet of absorption area required* with percolation coefficients as follows:*										
	Florida	City "X"	0.3	0.4	0.5	0.6	0.7	0.8	0.9	1.0	1.1	1.2	1.3
1	500	500	45	60	75	90	105	120	135	150	165	180	195
2	500	500	90	120	150	180	210	240	270	300	330	360	390
3	600	600	135	180	225	270	315	360	405	450	495	540	585
4	700	800	180	240	300	360	420	480	540	600	660	720	780
5	800	1,000	225	300	375	450	525	600	675	750	825	900	975
6	900	1,200	270	360	450	540	630	720	810	900	990	1,080	1,170
7	1,050	1,400	315	420	525	630	735	840	945	1,050	1,155	1,260	1,365
8	1,200	1,550	360	480	600	720	840	960	1,080	1,200	1,320	1,440	1,560
9	1,350	1,600	405	540	675	810	945	1,080	1,215	1,350	1,485	1,620	1,755
10	1,500	1,660	450	600	750	900	1,050	1,200	1,350	1,500	1,650	1,800	1,950
15	2,063	1,875	675	900	1,125	1,350	1,575	1,800	2,025	2,250	2,475	2,700	2,925
20	2,250	2,000	900	1,200	1,500	1,800	2,100	2,400	2,700	3,000	3,300	3,600	3,900
30	2,625	3,000	1,350	1,800	2,250	2,700	3,150	3,600	4,050	4,500	4,950	5,400	5,850

**Based upon estimated sewage flow of 75 gal. per capita per day.*

Note: To compute the length of trenches, divide the areas shown by 1.5 for 18-in. trenches, 2.0 for 24-in. trenches, and 2.5 for 30-in. trenches.

tank capacities and absorption areas for dwellings and apartment houses of various sizes. The indicated absorption areas are based upon an estimated flow of 75 gal. per person per day from two persons in each bedroom. The Florida septic tank sizes are based upon similar estimates. The sizes shown in column 2 allow for 24 hours detention for flows up to 2,000 gal. per day. Beyond 2,000 gal. per day, the capacities were computed as illustrated on page 17. The septic tank capacities shown in column 3 for City "X" are based upon a total volume of 100 gal. per person per day (i. e., 75 gal. plus 25 gal. sludge storage capacity) ; 24 hours detention for flows up to 1,500 gal. per day; 12 hours detention for flows exceeding 4,000 gal. per day, and for interpolated values between these two figures.

In Florida, the septic tank sizes listed in column 2 should be used. Anyone preparing standard plans to be used in a number of states should compare the Florida tank sizes with those for City "X" and use the higher of the two figures for the number of bedrooms listed.

For an example illustrating the use of Table VII, consider the disposal of sewage from an eight bedroom apartment house. It is desired to determine the minimum septic tank capacity, the required absorption area, and the net length of tile to be used in the absorption field.

From Column 2, it is readily seen that a 1,200-gal. septic tank is the minimum size acceptable.

Let it be assumed that the percolation test, conducted as explained on page 24, showed a drop of 1 in. in 8 min.

From Fig. 5, page 26, the percolation coefficient is found to be 0.5 [$C = (8+6.24) \div 29 = 0.5$].

In the above table, under the column headed 0.5, it is seen that 600 sq. ft. of absorption area (i. e. bottom trench area) is required for an eight bedroom apartment.

On page 30, it is suggested that a trench 24 in. wide be used for percolation coefficients between 0.4 and 1.0.

If the trench is to be 24 in. or 2 ft. wide, the net length of tile in the absorption field will be $600 \div 2 = 300$ ft.

APPENDIX III

SEEPAGE PITS, DRY WELLS AND CESSPOOLS

While this bulletin is written primarily for Florida, other auxiliary disposal methods are sometimes permissible in some parts of the country, and no bulletin on the subsurface disposal of sewage would be complete without some mention of them. As indicated in Part II, seepage pits, dry wells, and cesspools are generally prohibited in Florida because of a generally high water table and soil conditions which do not provide adequate protection against contamination of the ground water supply. Seepage pits and cesspools are especially dangerous in the soft limerock which is so prevalent in Florida.

The terms "seepage pit," "dry well" and "cesspool" are sometimes used synonymously. There is no general agreement as to their definitions. The most widely accepted usage of the three terms, and the function, location and construction of these types of disposal units, are adequately covered in the United States Public Health Service reprint No. 2461 entitled *Individual Sewage Disposal Systems.* The following is quoted from recommendations of the Joint Committee on Rural Sanitation as they appear in that reprint.

SEEPAGE PIT

A seepage pit is a covered pit with open-jointed lining through which septic tank effluent or laundry wastes may seep or leach into the surrounding porous soil.

FUNCTION:

The function of seepage pits is primarily to facilitate the disposal of liquid wastes. They are supplemental (or in some cases alternative) to tile drains, which are laid in specially constructed trenches, for the handling of effluent from a septic tank or laundry wastes.

LOCATION:

Seepage pits, when used as supplemental to a subsurface tile field, should be located at minimum distances of 100 ft. from any source of water supply, 20 ft. from buildings, and 10 ft. from lot lines. If seepage pits are used instead of the fields, the distance between any two pits should be at least three times the diameter of the larger pits. Seepage pits should never be used where there is a likelihood of contaminating underground waters, nor where adequate subsurface tile disposal fields can be provided. When seepage pits are to be used in place of a subsurface tile field, the same limitations with respect to location should apply as for cesspools, in addition to the above requirements. Pit excavations should not extend into the ground water table.

CONSTRUCTION:

In the construction of a seepage pit, provision of a hole 3 ft. or more in diameter through at least 6 ft. of porous soil is recommended. It should be lined with stone, brick, or concrete blocks laid up dry with open joints that are backed with at least 3 in. of clean, coarse, bank-run gravel to the elevation of the inlet. Above the inlet level, the joints should be sealed with cement mortar.

It is customary to draw in the upper section of the lining, thereby reducing the size of the cover required over the top. A reinforced concrete slab should be provided on all pits. It should be located 1 ft. to 2 ft. below the surface or finished grade. Where slab covers in excess of 30 in. square must be constructed, a manhole approximately 20 in. square should be provided therein. All removable slabs or manhole covers should be sealed in place so as to be watertight.

Coarse gravel at least 1 ft. deep should be placed in the bottom of the pit before the lining is installed. If necessary, gravel also may be used under the lining to stabilize the foundation. Tight-jointed sewer pipe should be used for making connections to the pit. When conditions require that seepage pits be located in close proximity to trees, they may be constructed without lining. In such cases the entire pit should be filled with loose rock. This type of construction will provide means whereby roots may enter the pit without damaging it. Tree roots often assist and prove advantageous in the disposal of effluent.

DRY WELL

A dry well is a covered pit with open-jointed lining through which drainage from roofs, basement floors, or areaways may seep or leach into the surrounding porous soil.

Although drainage from roofs, areaways, and basement floors is not sewage waste, a discussion of the method of its disposal by using dry wells is believed advisable in order to discourage its disposal with the sanitary sewage.

FUNCTION:

Dry wells are intended to provide means for soil absorption of drainage from basement floors and areaways and occasionally roof drainage, thereby eliminating these non-sewage wastes from the septic tank and subsurface drainage system. They should never be used for the disposal of sanitary sewage, septic tank effluent, or laundry wastes.

LOCATION:

Dry wells should be located at least 50 ft. from any source of water supply and 20 ft. from any disposal field, cesspool, or seepage pit, and at least 10 ft. from the building foundation.

CONSTRUCTION:

Two types of dry wells may be considered: Small pits serving individual drains, and large pits receiving roof drainage from an entire building. Where a single pit is provided to serve a basement drain or areaway drain, it may be constructed by using a 3-ft. length of 15- or 18-in.-diameter vitrified clay or cement pipe, provided a reasonably coarse foundation is encountered at the 3-ft. depth. This tile is filled with coarse gravel or crushed stone, thus providing sufficient voids to receive a quantity of water before overflowing, and permitting the water to leach out of the bottom into the soil.

The large dry wells are similar in size and construction to seepage pits. In many instances, however, the pits are not curbed but are entirely filled with very coarse gravel or crushed stone. Where it is not practicable to use one pit for all downspouts, individual pits may be provided for each downspout. The pits should be of ample size for the amount of water they may receive at any single period. The dry wells should have a solid concrete slab cover and be constructed so as to prevent the entrance of surface drainage from the surrounding soil. Dry wells should not be provided for roof drainage where surface discharge is feasible.

CESSPOOL

A cesspool is a covered pit with open-jointed lining into which raw sewage is discharged, the liquid portion of which is disposed of by seepage or leaching into the surrounding porous soil, the solids or sludge being retained in the pit.

FUNCTION:

A cesspool is not recommended as a substitute for a septic tank, as the raw sewage discharged into the cesspool tends to seal the openings in the lining and porous formation, thereby reducing the leaching area and often causing the cesspool to overflow.

Cesspools are considered dangerous and often present a definite health hazard when excavated to excessive depth and into water-bearing formations: Their use should be permitted only when septic tanks are impractical and the possibility of contaminating any ground water supply is extremely remote. Many states have regulations prohibiting the installation of cesspools.

LOCATION:

Cesspools should be located at least 150 ft. from wells, 15 ft. from seepage pits and property lines, and 20 ft. from dwelling foundations. They should never be used in the vicinity of shallow wells, and in any case only where approved by the state health department.

CONSTRUCTION:

In the construction of a cesspool, a hole 3 ft. or more in diameter and of sufficient depth to encounter a porous formation should be provided. Open-joint curbing, similar to the curbing of seepage pits should be used. A slab cover with a manhole opening should be provided to permit access. All cesspools should be constructed with an overflow to a properly designed and constructed seepage pit. The overflow pipe to the seepage pit should have a submerged connection, and the elevation of this overflow should be at least 6 in. lower than the elevation of the inlet.

Abandoned wells, drill holes, or abandoned mines should never be used either as cesspools or seepage pits for sewage disposal.

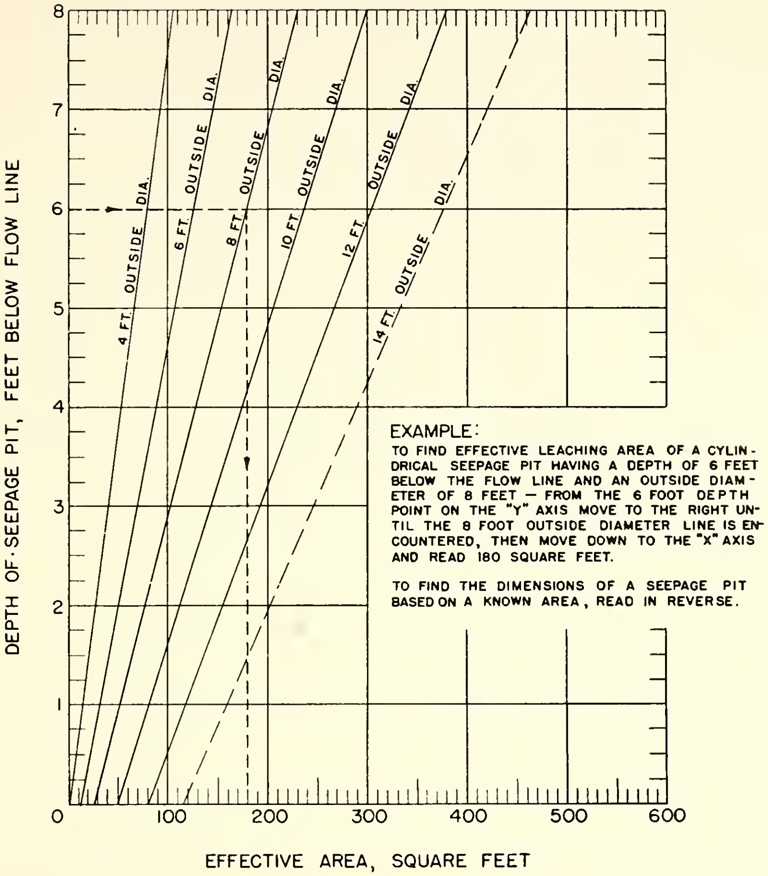
CAPACITIES

From the foregoing, it will be apparent that computations of capacities of seepage pits, dry wells and cesspools will be different. Briefly, the capacity of a seepage pit should be computed on the basis of percolation tests in holes dug approximately to the depth of the proposed pit, or to one-half the depth of the proposed pit if the soil is uniform. In making the test, the principles explained in Part II of this bulletin should be followed. Experience has shown that for seepage pits an absorptive area equal to 75 per cent of that required in an absorption field is generally satisfactory. Thus the effective leaching area or the percolation coefficient for soil in which seepage pits are located may be computed as follows:

$$C = 0.75\left(\frac{t+6.24}{29}\right) \qquad \text{or} \qquad C = \frac{t+6.24}{21.75}$$

Seepage pits are usually circular in plan, but they may also be made square or rectangular. The effective area of a seepage pit is the outside area of the walls measured below the flow line, plus the inside area of the pit bottom. To obtain the wall area of a circular pit, multiply the outside diameter of the wall in feet by three times the depth below the flow line. A convenient chart for determining the leaching area of circular or cylindrical pits with sidewalls 1 ft. thick is given in Fig. 20.

As indicated by the Joint Committee on Rural Sanitation, the capacity of a dry well should be such as to accommodate the amount of water it may receive at any single period. Obviously, however, the required size will depend in some measure upon the porosity of the soil, hence percolation tests may be used to good advantage in evaluating the various influencing factors. The size of a cesspool, on the other hand, is governed almost entirely by volumetric considerations. The capacity of a cesspool should be computed in exactly the same manner as for a septic



EXAMPLE:

TO FIND EFFECTIVE LEACHING AREA OF A CYLINDRICAL SEEPAGE PIT HAVING A DEPTH OF 6 FEET BELOW THE FLOW LINE AND AN OUTSIDE DIAMETER OF 8 FEET — FROM THE 6 FOOT DEPTH POINT ON THE "Y" AXIS MOVE TO THE RIGHT UNTIL THE 8 FOOT OUTSIDE DIAMETER LINE IS ENCOUNTERED, THEN MOVE DOWN TO THE "X" AXIS AND READ 180 SQUARE FEET.

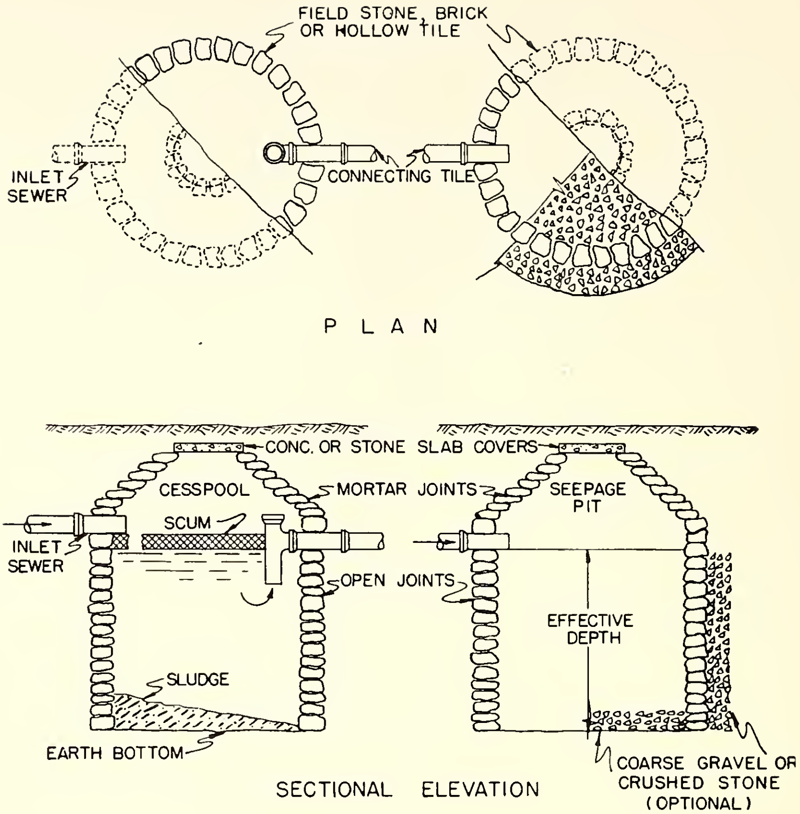
TO FIND THE DIMENSIONS OF A SEEPAGE PIT BASED ON A KNOWN AREA, READ IN REVERSE.

FIG.20.-EFFECTIVE AREAS OF ROUND SEEPAGE PITS PRECEDED BY SEPTIC TANKS OR CESSPOOLS.

(DEVELOPED BY J. A. SALVATO JR.)

tank. In fact, a cesspool, as defined by the Joint Committee, is nothing more than an improvisation or poor substitute for a septic tank. This is illustrated in Fig. 21 which shows typical cesspool and seepage pit construction. As stated previously, *many states, including Florida, have regulations prohibiting cesspools.*

A dry well may be constructed exactly as shown for the seepage pit.



P L A N

SECTIONAL ELEVATION

NOTE:
BOTTOM OF SEEPAGE PIT TO BE KEPT AT LEAST 2 FEET ABOVE GROUND WATER LEVEL.

FIG. 21.-TYPICAL CESSPOOL AND SEEPAGE PIT

Instead of being optional, however, the gravel or crushed stone shown at the bottom of the hole is usually required in the case of a dry well. Unless the equivalent of this is provided, the side walls may gradually become undermined because the well is filled and emptied alternately. A concrete apron or metal plate on the bottom of the dry well under the inlet would serve the same purpose.

SUMMARY

It is to be reiterated that cesspools and seepage pits should always be prohibited where the ground water is high, where limerock or limestone formations are encountered, and where other conditions make their use dangerous. In general, seepage pits are only applicable where impervious soil for the top 3 ft. or 4 ft. or more is underlaid with porous sand or fine gravel. Whenever possible, they should be avoided in localities where water supplies are obtained from private wells. The bottoms of seepage pits should be kept at least 2 ft. above the ground water table.

Where limestone is prevalent there may be many sinkholes with connections to underground solution channels through which pollution may be carried for great distances. Sewage entering these sinkholes has been traced long distances to wells used as public water supplies. In one very recent case, the addition of uranine or water-soluble fluorescein dye to a sewage effluent was traced rather spectacularly to a well serving a Florida community. Sewage should never be permitted to enter a sinkhole or a limestone formation, either directly or through seepage pits in the formation.

REFERENCES

Phelps, Earle B., *Public Health Engineering,* Vol. I, 1948, John Wiley & Sons, Inc.

Chapter V, Florida State Sanitary Code (Revised 2-10-48), Florida State Board of Health, P. O. Box 210, Jacksonville 1, Florida.

War Department Technical Manual TM5-665, *Operation of Sewerage and Sewage Treatment Facilities,* Supt. of Documents, U. S. Gov't. Printing Office, Washington 25, D. C.

Rules and Regulations for Preparation and Submission of Plans for Systems of Sewerage and Sewage and Waste Disposal, Bulletin No. 1, N. Y. State Dept. of Health, Albany, N. Y.

Recommended Minimum Requirements for Use in Connection with the Design of Sanitary Facilities, National Park Service, Regional Office, 801 Grace Securities Bldg., Richmond, Virginia, March 8, 1937.

Metcalf and Eddy, *American Sewerage Practice,* Vol III, "Disposal of Sewage," McGraw-Hill Book Co., Inc., New York and London 1935.

Individual Sewage Disposal Systems, Recommendations of Joint Committee on Rural Sanitation, 1947, United States Public Health Service Reprint No. 2461, Supt. of Documents, U. S. Gov't. Printing Office, Washington 25, D. C.

Sewage Disposal Plans, Form Pk. 47, State Dept. of Health, District Office, Poughkeepsie, N. Y.

Federick, Joseph C., "Solving Disposal Problems in Unsewered Areas," *Sewage Works Engineering,* Vol. 19, No. 6, June, 1948.

"Individual Sewage Disposal — Small Septic Tanks for the Housing Program," *Public Works Magazine,* Vol. 78, No. 8, Aug. 1947, pp. 28-30.

Seelye, Elwyn E., "Design," *Data Book for Civil Engineers,* Vol. 1, p. 5-64, John Wiley & Sons, Inc.

Standards for Healthful Housing, "Planning the Neighborhood," 1948, A.P.H.A. Committee on the Hygiene of Housing, Public Administration Service, 1313 E. 60th St., Chicago 37, Illinois.

Nottingham, M. C., and Ludwig, H. F., "Septic Tank Performance as Related to Tank Length, Width and Depth," *Water & Sewage Works,* Vol. 95, No. 12, December, 1948.

Miscellaneous Florida State Board of Health policy memoranda.

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