SEWAGE TREATMENT
FOR THE
RURAL RESIDENCE

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STATE OF INDIANA
DEPARTMENT OF COMMERCE AND INDUSTRIES
STATE BOARD OF HEALTH

BUREAU OF SANITARY ENGINEERING

SEWAGE TREATMENT FOR THE RURAL RESIDENCE

With the increased use of pressure water systems in rural and suburban homes, there has arisen the perplexing problem of providing for the safe and sanitary disposition of sewage. Those people who are no longer satisfied with the use of privies and who have installed pressure water systems in their homes are faced with the necessity of seeking some other means for the disposal of their wastes. The purpose of this bulletin is to explain and discuss methods for the home treatment of sewage; and to set forth certain minimum requirements and standards for septic tanks and the filters and absorption beds which should be used following septic tanks in cases where tank treatment alone is insufficient.

The discharge of sewage to a deep cesspool where it will readily seep into the surrounding soil, furnishes little or no treatment to the sewage thus disposed of and endangers neighboring water supplies. The unlimited use of cesspools in many small towns throughout Indiana has, in many cases, led to the serious contamination of the ground water supply available to the town. One of the principal objects of this bulletin is to set forth ways and means of eliminating the use of the obnoxious cesspools.

The use of a system consisting of a properly designed and constructed septic tank, discharging to a shallow leaching bed or subsurface irrigation system, is by far more satisfactory than discharging raw or partially treated sewage deep in the ground at a point close to the ground water level.

LIMITED FIELD FOR SEPTIC TANKS

While the use of the septic tank cannot be considered for community or municipal installations, it is the most inexpensive and practical means of preparing small residential sewage flows for final disposition.

In many small Indiana towns, storm sewers or drains are built and property owners are allowed to discharge sanitary sewage into them provided it is passed through septic tanks first. This is a short-sighted and uneconomical procedure since such sewers usually become odorous and create a nuisance at the outlet. It later becomes necessary to rebuild the sewer system and to install municipal sewage treatment works. In this event the residential septic tanks become useless and must be abandoned.

There are many homes, however, situated in sparsely settled districts not accessible to a public sewer. In a situation of this sort, the septic tank is practical.

THEORY OF SEPTIC TANK ACTION

The action which takes place within a septic tank is both mechanical and biological. As the sewage enters the tank its velocity is considerably reduced and its flow is distributed throughout the width of the tank. With this sudden reduction in velocity, the transporting power of the liquid is lost and the heavier solids settle to the bottom while the lighter solids rise to the surface. This material which settles on the bottom is acted upon by anaerobic bacteria (bacteria which live and thrive in the absence of light and air). These bacteria break down the sewage

solids into more stable compounds, part of which are liquid and part of which are gaseous. Gas, entrapped in this solid matter, lightens it considerably, with the result that small pieces break away from the bottom and float to the surface. A septic tank may give off odors, usually similar to hydrogen sulphide gas. At the surface, the gas escapes, part of the solid material remains to form a scum and part returns to the bottom for further digestion. This material which settles on the bottom is spoken of as sludge. The section on "Operation" discusses the removal of sludge.

This vertical motion of the solids continues throughout the length of the tank, and unless the outlet is properly baffled a great amount of this suspended matter will leave with the effluent.

The pathogenic (disease producing) bacteria present in the incoming sewage are not destroyed while in the septic tank. The effluent (discharge) from the tank is almost as dangerous as the raw sewage. The only important change in the sewage has been the reduction in the amount of settleable solids. A clear understanding of this septic tank action will assist in explaining the statement that a septic tank can be considered only as one step in the treatment of sewage.

After sewage has passed through a properly built and operated tank it is better prepared for the necessary secondary or final treatment process described later in this bulletin.

TANK CONSTRUCTION DETAILS

Location: The importance of location cannot be overstressed. When one considers that no tile sewer, regardless of the type of joint, can be made completely water-tight, he will realize that the septic tank and the sewers leading to and from it are an important factor in ground water contamination. The tank, therefore, should be located as far from the drinking water supply well as practical. A minimum distance of 50 feet should be maintained between the well and any part of the sewerage system. A distance of 100 feet is much safer and is recommended by the State Board of Health.

Another item to be considered is the drainage available. The septic tank should be located on the down slope from the house where the drainage is away from the drinking water supply well. It is advisable to keep the sewer lines and tank close to the ground surface, in order to reduce construction costs and to facilitate the final disposition of the sewage. At no time should a septic tank be subject to flood conditions.

Capacity: Residential septic tanks are usually designed to serve a family of five or six people. Water consumption in rural and suburban districts varies greatly. Some families use as little as twenty-five gallons per person while others may use as high as seventy-five gallons per person each day. The sewage flow is approximately equal to the water consumption, but for sewage treatment purposes a flow higher than the average is used in order to allow for the extreme fluctuations in the hourly flow. A retention period of twenty-four hours is required for proper septic tank treatment. This necessitates a tank of at least 300 gallons liquid capacity for a family of six when the sewage flow is estimated at 50 gallons per person daily.

A tank of less capacity than 300 gallons is not recommended even though the water consumption is low and the number in the family small. Smaller tanks are difficult to construct and no great saving in expense will be gained by the use of a small tank.

For larger families, or for multiple dwellings, this capacity should be increased to furnish at least fifty gallons per person.

The capacity of a septic tank is measured below the liquid level. One compartment tanks only are considered in this bulletin. When properly constructed, a single compartment tank is sufficient for primary treatment.

Depth: Of the three dimensions of a septic tank the depth is by far the most important. Through experience and experiment, a minimum liquid depth of forty-two inches is considered necessary. This depth is sufficient to prevent to a large degree, partially, or completely digested sludge from being carried out of the tank by the higher velocities caused by restriction of the cross-section of the liquid by deposited sludge. This matter of depth is the one most often neglected by commercial septic tank manufacturers.

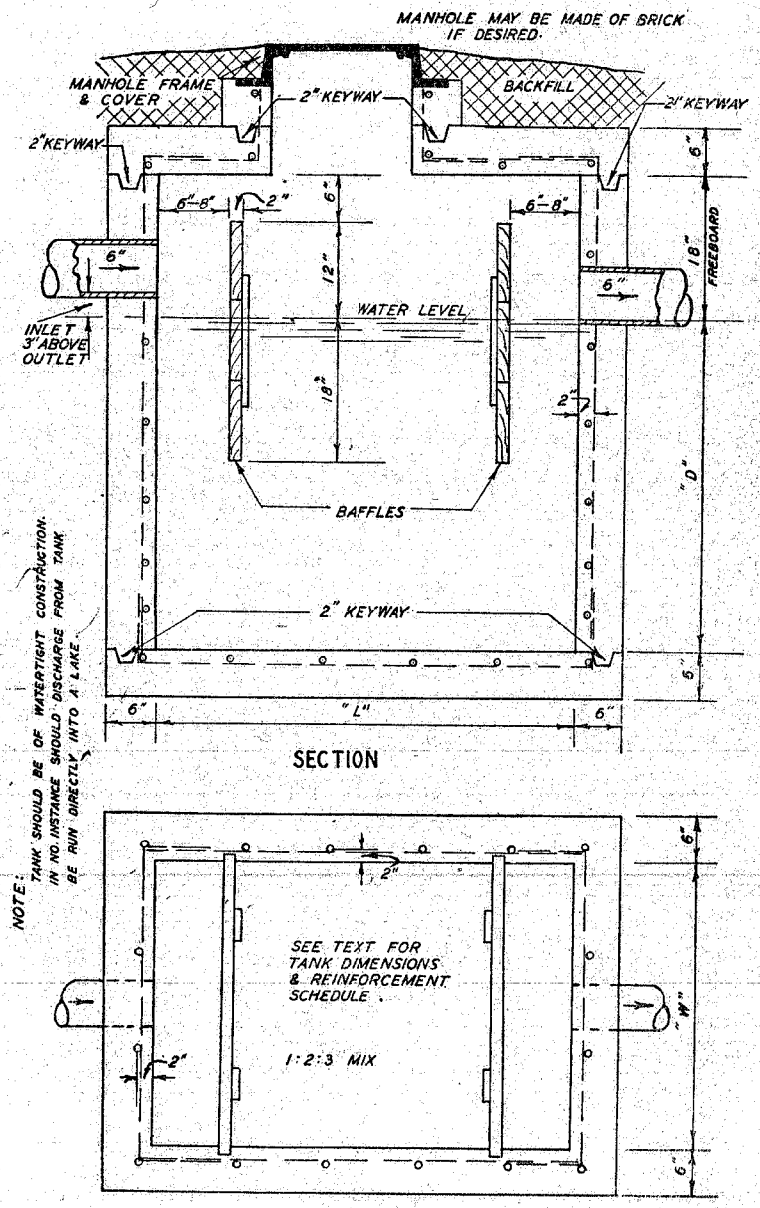
Length and Width: With the depth of the tank prescribed, the necessary length and width can be determined. The proportion of length to width should be in the ratio of at least 1.5 to 1 for the single dwelling house installations and 2 or 2.5 to 1 ratio for tanks of larger construction. In practice, a width of less than thirty-six inches is difficult to attain. With this width and a length of approximately 4.5 feet the volume of the tank would be about 354 gallons. We find, therefore, that for practical construction a 354 gallon tank is the smallest that can be built. Such a tank would serve a family of seven.

Freeboard or Scum Space: To the depth of the liquid should be added a distance of eighteen inches to serve as scum storage space. When less space is provided, the scum may be forced back into the liquid and find its way out with the effluent.

Scum-Boards or Baffles: These scum-boards are of great importance and serve two purposes. They consist of planks spanning the entire width of the tank and are placed vertically about six to eight inches from either end of the tank. The scum-board should be about thirty inches in height and so placed that the lower edge will be about eighteen inches below the liquid level.

These baffles serve first to break up and dissipate the higher velocities at the inlet and outlet and, second, to prevent the scum from being drawn out with the effluent. Plate 1 illustrates the method in which these baffles are placed in the tank.

If desired, cast iron tees, turned down in the liquid and terminating about twelve inches below the liquid level, may be used in residential tanks to break up the inlet velocity and to prevent scum and sludge from leaving the tank at the outlet. If such tees are used the baffles shown in Plate 1 may be omitted. This arrangement is not as good as the baffle construction yet practice accepts the submerged elbow inlet



Septic Tank Details
Plate No. 1

and outlet. It is most important to note that these elbows must be submerged about twelve inches as stated above.

Cover: It is not necessary to provide the tank with an air-tight cover. The anaerobic bacterial action, which takes place in the bottom of the tank, is deprived of its oxygen by the layer of sewage and scum above it. For proper operation of the tank a cover of any sort is not a necessity. They are provided, however, as a safety measure, and in order to retain the sewage odors in the tank. The cover or top of tank should be equipped with a manhole and manhole cover.

Concrete: An attempt has been made in developing the detail plans for septic tanks to arrive at the most economically constructed tank of simple design. Tank wall thicknesses have been set at a minimum of six inches, for the reason that walls of less thickness are quite difficult to build properly.

The concrete mix suggested calls for one part of Portland cement two parts of clean sand, and three parts of gravel. The water tightness of the concrete depends in a great measure on the amount of water used. The wet mix, when heaped up on the mixing board should form a quaking mass, and should not contain so much water as to allow a great slump in the mass. Ordinarily, it should not be necessary to use more than 4-4½ gallons of water in each one sack batch of concrete.

Concrete when placed in the forms should be tamped or spaded in order to produce smooth surfaces and to completely surround the reinforcing steel.

Extension Series Bulletin No. 27, "How to Avoid Faulty Concrete," published by the Engineering Extension Department of Purdue University, will prove to be a very valuable guide in any small concrete work.

Reinforcing Steel: A schedule of steel and steel spacing necessary in tanks of various sizes is given in the table in the following section. The proper placement of steel is quite as important as the proper amount. The details of steel position shown in Plate 1 should be closely followed. It is anticipated that reinforcing steel bars will be used for this purpose. The use of old wire, axle shafts, and castings serves no good purpose.

TANK SIZES AND NECESSARY STEEL

No. of Persons	Capacity (gal.)	Length (inside)	Width (inside)	Tot. Depth (inside)	Slab and wall thickness	Steel size	Steel spacing top and bottom	Walls
6	307	4′-3″	2′-9″	5′-0″	6″	½″ round	10″	10″
9	450	5′-0″	3′-0″	5′-6″	6″	½″ round	10″	10″
12	607	6′-0″	3′-0″	6′-0″	6″	½″ round	10″	7″
15	748	7′-0″	3′-0″	6′-3″	6″	½″ round	10″	7″

Note: In addition to steel listed above, ½″ round bars, spaced 12″ center to center, should be laid at right angles, to serve as reinforcement against temperature stress, and the vertical bars shall be fastened to the horizontal bars with the use of tie or bailing wire.

Steel in top and bottom should be placed across the short dimension of the slab. Steel in the walls should be placed horizontally.

All steel in bottom should be bent to extend 18″ up into walls. Horizontal steel in walls should be bent around corners to extend 18″ into side walls.

Size and Grade of Sewer: The sewer leading to and from the septic tank should be of 6-inch vitrified tile, unless it is located within 50′ of the drinking water supply, in which case the sewer should be laid with cast iron soil pipe with leaded joints. Joints in the vitrified sewer should be of the hemp and mortar type or in case of extremely wet soil, should be sealed with an approved joint compound. To prevent stoppage in the sewer a grade or fall of about ¼ inch per foot should be allowed. Sewers laid on flat grades are frequent causes of discomfort and expense.

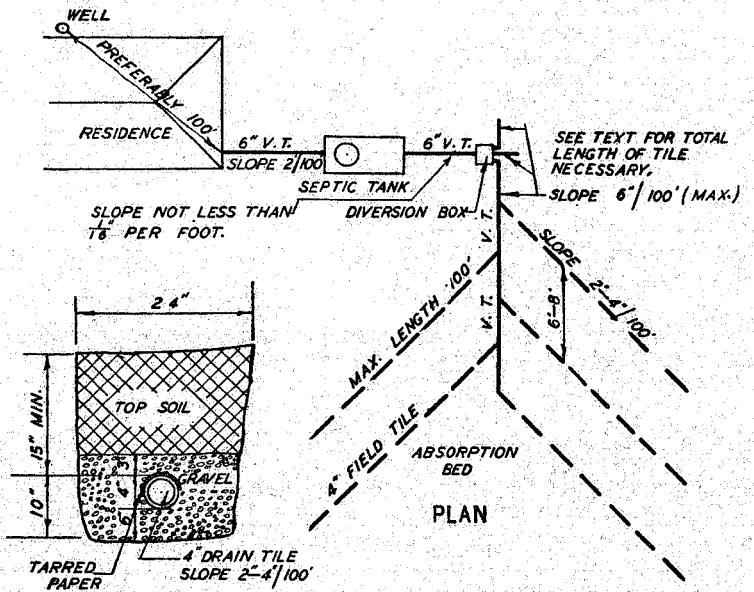
Grease Traps: It is advisable that the kitchen wastes which normally carry an appreciable quantity of greases be run through a grease trap before entering the septic tank. A grease trap is nothing more than a tank of sufficient capacity to allow the waste to cool to a temperature at which the grease congeals and floats to the surface. The cover should be easily removed, in order that grease may be skimmed from the surface at frequent intervals. It is imperative that the waste passing out of the tank be taken from a point near the bottom.

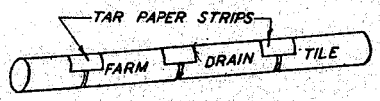
DISPOSAL OF EFFLUENT

Sewage discharged from a septic tank will be practically free from visible solids and relatively clear if the tank has been properly constructed and operated. This sewage, however, contains countless bacteria, many of which may be quite harmful. Moreover, the sewage is completely devoid of all oxygen, and if allowed to discharge into a dry run or a stream furnishing little dilution will decompose and produce a rather unsightly and very odorous nuisance.

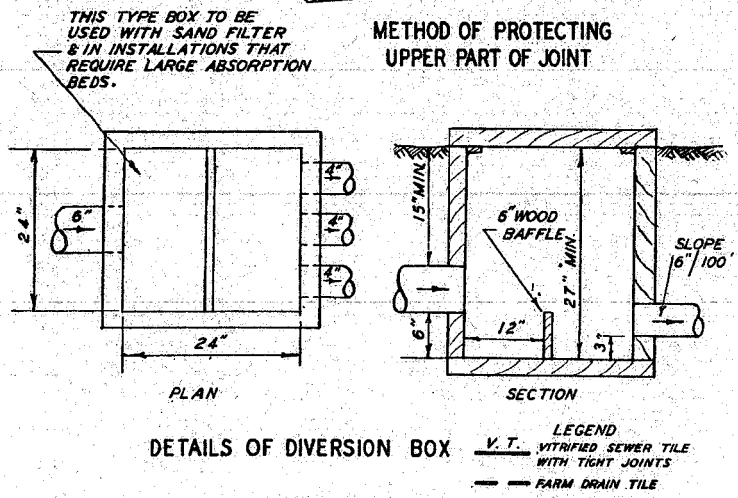
The upper layers of the soil contain innumerable soil bacteria which, if brought into contact with the discharge from the septic tank, will tend to purify and oxidize it. These bacteria are found in great numbers at the surface of the ground and in decreasing numbers at greater depths. Some authorities state that at a depth of seven feet in average soil they disappear. It follows that if these purifying bacteria are to be utilized for further treatment of the discharge from the septic tank, this treatment must take place in the upper layer of soil. This is one reason which precludes the use of a leaching cesspool. It also makes it necessary that the septic tank be placed as close to the ground surface as possible.

Absorption or Leaching Beds: In soils with some capacity for moisture absorption this method of disposing of the septic tank effluent is quite practical. Plates 2 and 3 show, in detail, two methods of construction of an absorption bed. Unglazed farm drain-tile, three or four inches in diameter, laid in shallow trenches two feet wide, serve to distribute the septic tank sewage to the soil. The tile joints are left open about ¼ inch, with the upper part of the joint protected by a strip of roofing paper.





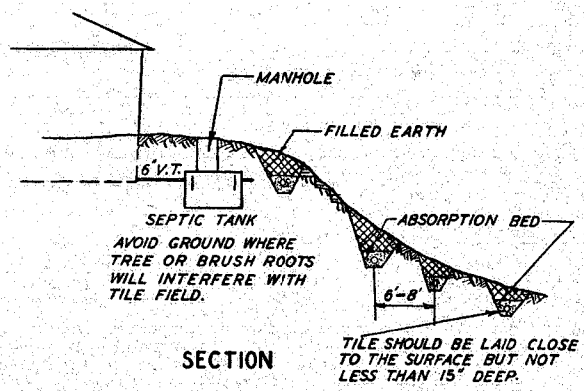
METHOD OF PROTECTING UPPER PART OF JOINT

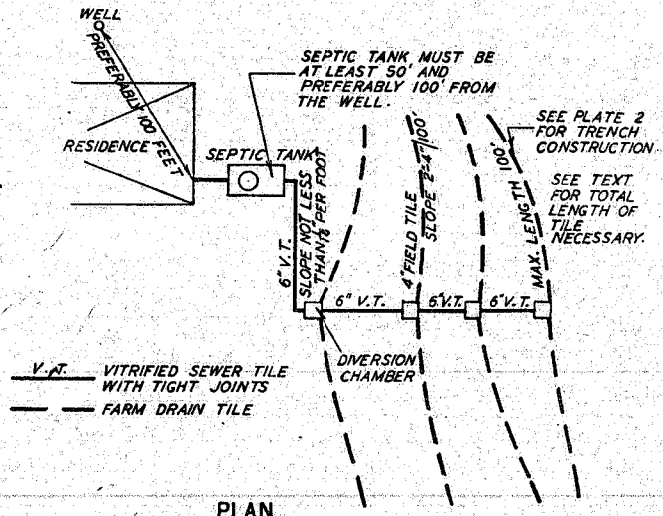


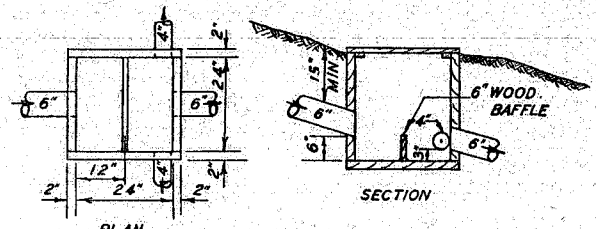
DETAILS OF DIVERSION BOX

LEGEND
V.T. VITRIFIED SEWER TILE WITH TIGHT JOINTS
FARM DRAIN TILE

Absorption Bed Details
Plate No. 2







DETAILS OF DIVERSION BOX

Absorption Bed Details
Plate No. 3

The trenches should be filled throughout the entire width with clean gravel. This gravel, which assists in making the entire width of the trench available for absorption, should extend six inches below and three inches above the tile.

In order that the moisture-absorbing qualities along one line of trench will not interfere with a parallel trench, the lines of tile should be spaced six feet to eight feet apart. Distances of less than six feet will materially reduce the efficiency of the system.

The slope on which this tile distribution system is laid is quite important. A fall of two to four inches per 100 feet is recommended by most authorities. Slopes steeper than the recommended grade will tend to overload the lower sections of the system, while flatter slopes will overload the upper portion.

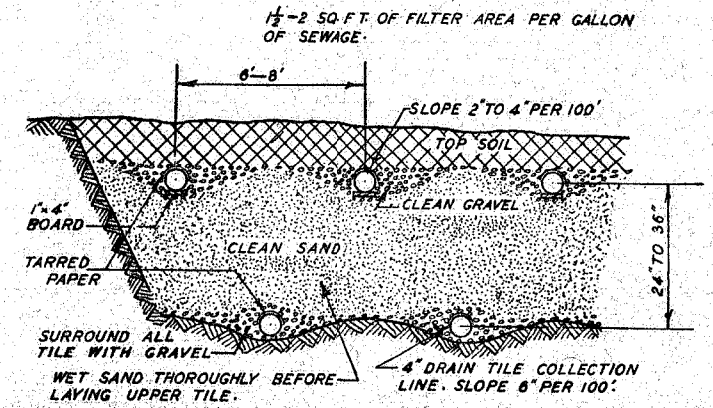
When the only ground available for the installation of a sub-surface irrigation system has slopes exceeding the recommended two to four inches per 100 feet the distribution tile should be laid at right angles to the direction of slope. Plate 3 is devoted to such an installation.

To determine the length of tile necessary, Mr. Henry Ryon, formerly with the New York State Department of Health, has devised a practical test from which the needed amount may be determined. This test is carried out as follows:

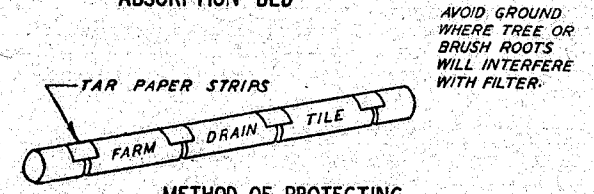
A hole one foot square and a depth equal to the depth of the proposed trenches is dug on the site of the proposed leaching bed. The soil around, and in the bottom, is wetted if the soil appears to be very dry. The hole is then filled to a depth of about six inches and the time required for the level of the water to lower one inch is recorded. This test should be repeated to allow for any effect of a very dry soil. With this information, the length of tile may then be determined from the table below.

Time for water to fall one inch	Length of tile per person required dwelling and resident institutions
10 seconds or less	15 feet
15 seconds	16 feet
30 seconds	17 feet
45 seconds	18 feet
1 minute	20 feet
2 minutes	25 feet
3 minutes	29 feet
4 minutes	33 feet
5 minutes	36 feet
10 minutes	48 feet
15 minutes	60 feet
30 minutes	95 feet
45 minutes	130 feet
1 hour	165 feet

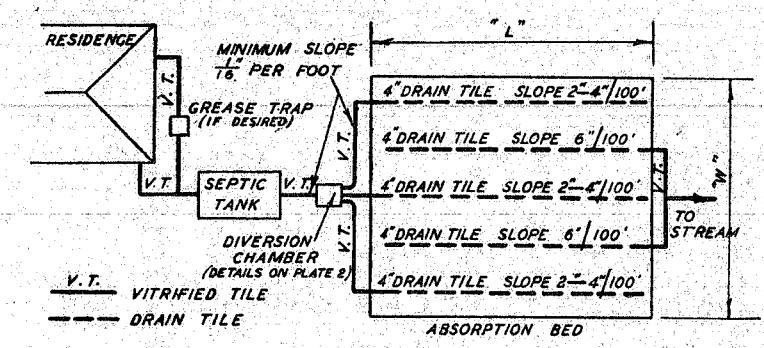
This test should be made with water and soil at a temperature of about 50° F.



SECTION OF ARTIFICIAL ABSORPTION BED



METHOD OF PROTECTING UPPER PART OF JOINT



TYPICAL LAYOUT FOR SINGLE RESIDENCE

Underground Sand Filter
Plate No. 4

For heavy clay soils, it may be found that the amount of tile required is excessive. For these conditions, an alternate system for further treating the septic tank discharge is given in the following section.

Underground Sand-Filters, or Artificial Absorption Beds: These beds are generally constructed by excavating a predetermined area to a depth of about four feet, and back-filling with clean sand to a depth of about three feet, upon which is placed one foot of the top soil.

A system of collection tile, preferably of the farm tile type, is placed in the bottom of the excavation, with the ground sloping to the tile. These collection lines should be four or six inches in diameter and should be spaced about four to six feet, center to center, on any convenient slope greater than six inches per 100 feet. These underdrain lines should not be placed directly under the distribution lines, but spaced midway between them, and should be protected by embedding them in clean gravel. The gravel should cover the underdrain lines so the sand does not carry into the tile. The farm tile of the collection and distribution system in the absorption beds shall be laid with about ⅛ inch spacing between each tile. The top half of tile to be covered with asphalt roofing paper as shown in Plate 4.

Above this underdrain system is placed twenty-four to thirty inches of sand. The sand, to be effective, should be of medium grading and free from clay, silt, or other organic matter. Sand, too fine, will retard the flow, while coarse material will allow the sewage to pass through the filter with little or no treatment.

At the sand surface is placed the distribution tile, protected on the under side by gravel in the same manner as prescribed for the underdrains. The upper parts of the tile joints should be further protected by strips of roofing paper. This distribution tile should consist of three or four inch unglazed drain tile laid on a grade of two to four inches per 100 feet.

Top soil or gravel is backfilled over the distribution system to the natural grade line. The absorption bed should be vented at the inlet as well as the outlet end.

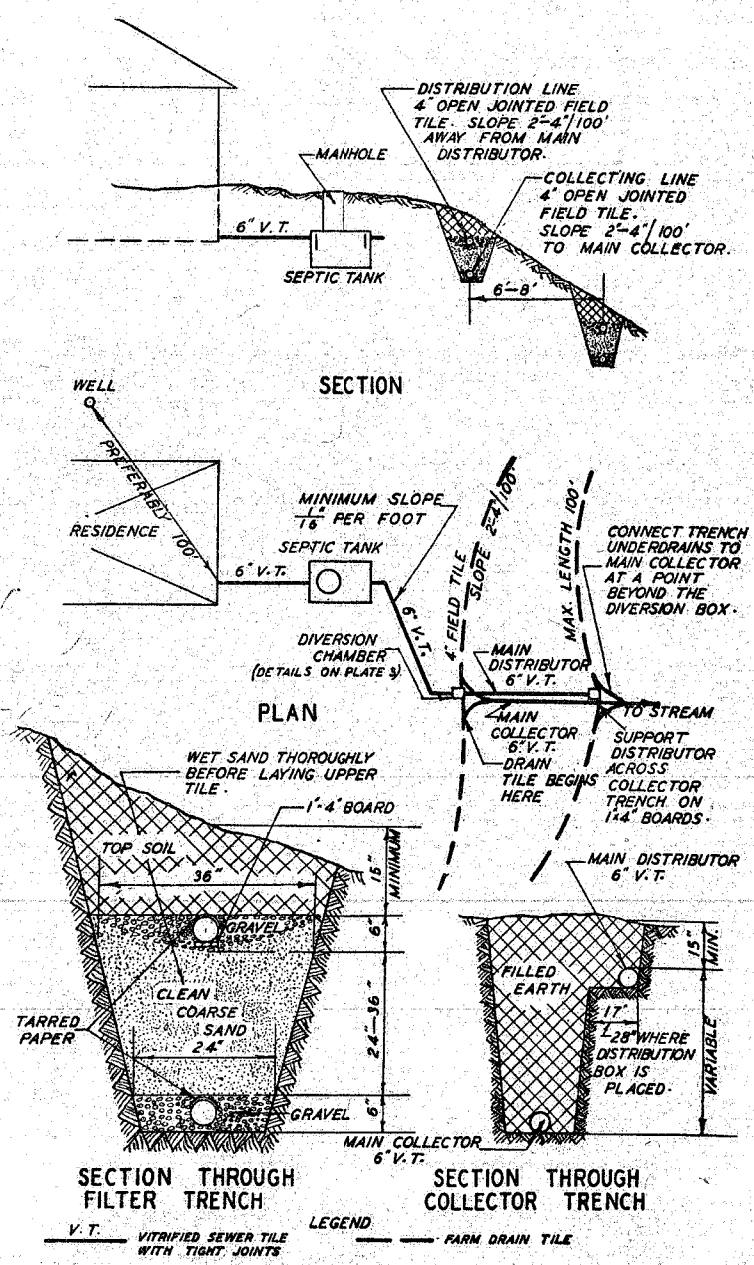
The area of this type of artificial absorption bed should allow at least one square foot per gallon of sewage per day. Thus, for a family of six, using the recommended sewage flow of fifty gallons per person, the total amount of sewage per day will be 300 gallons, requiring a filter area of at least 300 square feet. This would call for a filter approximately fifteen feet by twenty feet.

Sewage from the septic tank should be delivered to the filter distributing tile through a tight vitrified tile manifold or distribution box which will supply the same amount of sewage to each run of tile in the filter. (See detail in Plate 2.)

The underdrains should deliver to a tight vitrified tile line which may be discharged in a small stream with relatively little danger of producing a nuisance.

Plate 4 illustrates the detail method of constructing an artificial absorption or underground sand filter bed in relatively flat areas.

When surface slopes are such that it is impractical to construct a



Trench Filter
Plate No. 5

filter bed, the same results may be accomplished by the use of a trench filter. The details of the construction of such a filter are shown on Plate 5.

Disposal by Dilution: The quantities of running water necessary for sanitary disposition of sewage are so seldom available for the residence that little space in this bulletin is devoted to disposal by dilution. Moreover, with relatively small amounts of tile being required for disposal of sewage by soil absorption, this method is often more economical than the construction of a sewer to a running stream.

DISPOSAL OF SLUDGE

The solid matter, which settles to the bottom of a septic tank, goes through a digestion process which converts only a part of the original material to gas and liquid. The remaining solid material must be periodically removed from the tank. It may be buried in shallow trenches inaccessible to flies or domestic animals, or buried in furrows and turned under as fertilizer. In no case, however, should it be used as fertilizer for crops or vegetables which are eaten raw.

The sludge and scum, after the tank has been in use for a long period, will occupy such a large portion of the tank that the efficiency of the system will be greatly reduced.

A good schedule to follow is removal of sludge and scum at yearly intervals, preferably in the late fall, giving the tank a better opportunity of going through the winter season with no attention.

OPERATION

If the septic tank and treatment leaching bed or underground filter have been properly constructed, operation should devolve itself into annual removal of sludge and scum, and immediate repair of any accidentally broken tile joints.

A periodical examination of the system to determine any needs will give the user an opportunity to skim the surface and remove the scum from the tank.

Roof drainage *must not* pass through the tank. The great amount of water running off the roof surface after a rain would scour the interior of the tank, and ruin the absorption bed or filter.

Chemicals of any kind must not be introduced into the septic tank. This act would, in all probability, destroy the bacterial action in the tank and greatly reduce the efficiency. A careful use of cleaning compounds in the house fixtures should have no harmful effect on the action of a septic tank.

COMMERCIALLY BUILT SEPTIC TANKS

The average precast, commercially built, septic tank has a great many disadvantages. Some are listed here:

a. Shallow Depth: Most tanks offer a liquid depth of only eighteen inches to thirty inches which is inadequate.

b. Small capacity: For a large family installation, the small sectional tanks are set up in multiple units. This practice, while it provides capacity, does not provide a properly proportioned tank. The Bureau of Sanitary Engineering of the State Board of Health sees no advantage for the use of batteries of tanks.

c. Baffles: Baffles are distributed promiscuously throughout many commercial tanks. Unfortunately, most of these baffles produce a high velocity at the bottom of the tank, eliminating a great amount of sludge storage space.

d. Watertightness: The tank which is delivered "knocked-down" can very seldom be set up to form a watertight job. It is almost impossible to procure tight joints in some types of precast tanks.

e. Cleaning: Although many septic tank salesmen proclaim that their tank will never need cleaning, DO NOT BUY A TANK WHICH HAS NO EASY MEANS OF ACCESS TO THE TANK INTERIOR. The tank which needs no cleaning is nothing more than a wide place in the sewer.

Before expending money on a commercially built tank, its details may be checked against those set forth in this bulletin. Some tanks on the market will comply with these recommendations, and we do not wish to criticize them unfairly.

SPECIAL SITUATIONS

The Bureau of Sanitary Engineering of the State Board of Health will gladly assist in solving any special situation not covered in this bulletin.